# The Clean Energy Industry in California: An Economic Analysis Assessing the Current Market in the Global Economy

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**About EBI Inc.**

Environmental Business International Inc. (EBI) is a publishing and research company that generates strategic market intelligence on the environmental industry, climate change industry, the green economy, and health & wellness market. Founded in 1988, EBI specializes in defining emerging markets and generating strategic market intelligence for companies, investors and policymakers. At the core of EBI's business model are business newsletters, research reports, and contract research.

Through editorial research, proprietary industry surveys, and data analysis, EBI identifies and tracks these evolving markets, aggregating company performance, estimating market size, and forecasting growth within the context of business and regulatory trends. Subscription-based newsletters are central to the EBI business model, providing a foundation for detailed market research, climate change news, and analysis used by executives, investors and policymakers.

EBI principals and analysts have nearly 200 years combined experience in the environmental industry in strategy development, planning, management, finance, marketing and technology assessment. EBI also publishes detailed sector research reports, in addition to conducting contract research on behalf of private companies and state and federal governments.

**About This Report**

This Report was submitted in fulfillment of ARB Contract No: 07-315: The Clean Energy Industry in California: An Economic Analysis Assessing the Current Market and Prospects for Growth in the Global Economy by Environmental Business International, Inc. under the sponsorship of the California Air Resources Board. Work was completed as of February 28, 2011, and the final report was reviewed and accepted by ARB's Research Screening Committee on April 28, 2011.

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## Abstract

The clean energy industry was a $27-billion industry in California in 2009, 12% of the U.S. total and 2.5% of the global total, employing 123,000 Californians. The objective of this economic research report is to define, quantify, profile and forecast the growth and development of the clean energy industry in California, the United States and globally and to offer an informed assessment of California's competitive position. The clean energy industry is divided and quantified into nine major segments and 48 sub-segments, each shaped by dynamic business trends and with state and federal policies playing a major role in their evolution. California plays a leading role in some segments and lags noticeably in others, partially due to the influence of government policy. The report concludes that the competitiveness of an industry in a nation or state is largely driven by domestic policy and the corresponding consistency of market demand. In the emerging clean energy industry, California's pioneering policies have often created a framework for competitive advantage not always fully leveraged by consistent implementation or accompanying federal programs and initiatives, yet California still is home to some of the world's most innovative companies in the business of clean energy and greenhouse gas emissions reduction. As California enters the new era of AB 32 and emissions trading, this study serves as an important benchmark of a growing industry still in its infancy.

## Executive Summary

### Background

The objective of this study is to define, profile, analyze, quantify and forecast the growth, development and competitiveness of the clean energy industry in California and its markets worldwide. Perspective on the clean energy industry provides state agencies in charge of implementing energy security, greenhouse gas emissions reduction and climate change initiatives a framework for assessing the positive economic impacts of their regulatory actions in terms of market, business and job creation. This study can also help state agencies to gain perspective on possible roles in fostering market drivers, technology development and other programs and policy in support of the clean energy industry in the State of California.

### Methods

Research for this study was performed by Environmental Business International, Inc., a research and publishing firm based in San Diego, and consisted primarily of interviews and surveys of industry participants and aggregation of reliable secondary market data. In the first phase, research consisted of conducting interviews with experts in government, academia and the private sector to reach consensus on a definition and quantitative framework of segments in the clean energy industry. Databases of companies in each of the identified segments were then compiled from numerous sources and surveys, and further interviews were performed with those companies on a segment-by-segment basis. Secondary market data, business information, research reports and company information were compiled in each segment and aggregated into economic models of each segment or sub-segment of the industry. Market size estimates were generally derived from these market models combining statistics on company sales, power output, client demand, project volume, average prices and other inputs, depending on segment. Employment estimates were generally the product of average revenues per full-time-equivalent employee in each segment obtained from surveys and interviews, and the market size estimate of that segment or sub-segment. Estimates of exports and growth forecasts were largely a product of surveys and interviews with segment participants, with the support of government trade statistics in certain categories. All figures were reconciled with existing government or private reports where available. Industry totals are the sum of the segments quantified.

### Results

The clean energy industry was a $27-billion industry in California in 2009, 12% of the U.S. clean energy industry of $223 billion and 2.5% of the global total of $1.1 trillion. In economic terms, the $27-billion clean energy industry in California represented 1.4% of the California economy in 2009, employing an estimated 122,900 Californians, or 1.1% of the state's 12.6 million jobs. This employment estimate is somewhat less than a Next10/Collaborative Economics' estimate of 174,000 jobs in California's Core Green Economy that includes goods and services EBI classifies as part of the Environmental Industry such as water & wastewater equipment and services, recycling, waste management and environmental consulting. Another prominent state estimate of 433,000 green jobs by the Employment Development Division also includes environmental sectors and green consumer categories, but its two core renewable energy and energy efficiency sectors total 142,000 jobs. Suffice it to say these estimates are all in the same ballpark, but there is still a lot of work and communication required in order to reach consensus on a clear definition of a green or clean energy job.

The major contributors to clean energy industry revenues and employment in California are transportation systems, fuels & equipment, energy efficiency equipment & services, green building supplies & services and renewable energy systems & services. Together these four segments made up 96% of the California and U.S. clean energy revenues in 2009 (globally their share was 85% due largely to revenue from carbon credits). Trends and market drivers shaping these key segments, and emerging segments like energy storage, carbon capture & storage, climate adaptation and specialty consulting & research services, are varied, but each is experiencing growth partially as a result of global or regional clean energy and climate policy in some form or from voluntary efforts in energy security or to reduce greenhouse gas emissions.

The positive trends that have fueled growth in California and elsewhere largely continue, but the global recession has had a notable impact on the clean energy industry. Growth slowed from double-digit annual growth of 16-24% in 2005-2008 to 5% globally, 1% in the United States and -1% in California due mostly to the recession in 2009. California's comparatively lower 2009 growth is mostly attributable to more pronounced downturns in green buildings and hybrid automotive sales, higher growth in wind and solar energy in Europe and developing economies, and growth of clean transportation and carbon credits in Japan and Europe. Interim data leads to an estimate of 8% growth in California's clean energy industry in 2010 California's growth, or lack thereof, in the 48 sub-segments of the clean energy industry quantified in this report is often related to regulatory programs or financial incentives among a suite of market drivers.

California's Global Warming Solutions Act, AB 32, the Air Resources Board Scoping Plan and a number of other state programs are expected to increase both the growth prospects and the competitiveness of the California clean energy industry in the coming decade. Economic growth and the addition of carbon credits is expected to return annual California clean energy industry growth to the 15-25% annual range from 2012-2020, reaching $140 billion in 2020.

**Global, U.S. and California Clean Energy Industry in 2010 ($bil and % share)**

| Segment | USA | Global | % USA | Calif. | CA % of USA | CA % of Global |
|---|---|---|---|---|---|---|
| Low-Carbon Power | 31.4 | 204.1 | 15% | 6.1 | 19% | 3% |
| Carbon Capture & Storage | 0.1 | 2.4 | 4% | 0.0 | 0% | 0% |
| Energy Efficiency & Demand Response | 57.5 | 180.1 | 32% | 5.6 | 10% | 3% |
| Energy Storage | 3.7 | 11.2 | 33% | 0.8 | 21% | 7% |
| Green Buildings | 54.5 | 165.0 | 33% | 9.3 | 17% | 6% |
| Transportation | 77.2 | 431.7 | 18% | 7.1 | 9% | 2% |
| Carbon Markets | 0.5 | 153.3 | 0% | 0.0 | 10% | 0% |
| Adaptation | 0.5 | 1.6 | 33% | 0.1 | 18% | 6% |
| Consulting & Research | 3.0 | 8.6 | 36% | 0.3 | 10% | 3% |
| **Clean Energy Industry** | 228.4 | 1,158 | 20% | 29.3 | 13% | 3% |

*Source: EBI Inc. derived from a variety of sources*

**Conclusions**

The California clean energy industry finds itself at a crossroads, if not perhaps on a launching pad, at the beginning of 2011. Decades of relatively progressive (although many argue not always consistent or broadly coordinated) policy in air, water, waste, energy efficiency and renewable energy have led to the evolution and emergence of a clean energy industry. This study represents a first step towards defining the clean energy industry, quantifying its market size and economic contribution, and an initial assessment of California's role in the global clean energy market. The years 2011-2012 will see the implementation of AB 32, in addition to other clean energy and greenhouse gas initiatives in the State of California that promise to stimulate more new demand for clean energy industry products and services. Policy and implementation decisions will impact near- and long-term future markets, investment and business strategy and play a significant role in the economic future of California as it competes globally in clean energy markets. This assessment of clean energy industry economic data in 2008-2009 will serve as a useful benchmark as ongoing research seeks to capture growth and competitive trends in the emerging global clean energy industry.

# 1. Introduction

Global efforts to address greenhouse gas emissions, climate change and energy security have created a clean energy industry. Economic sectors have emerged that are dedicated to the production of energy and electricity with reduced emissions of greenhouse gases (GHG); to the development of goods or services with significantly less GHG emissions; and to measuring, reducing, mitigating or adapting to the impacts of climate change.

These economic sectors are not all entirely new nor are they exclusively driven by energy and climate change policy. They all, however, share common market drivers in the pursuit of clean energy and emissions reductions in greenhouse gases in their many forms that are expected to become more influential over time and serve to coalesce these sectors into a more cohesive clean energy industry.

The purpose of this report is to structure a definition of the clean energy industry, to complete an economic analysis of this industry and its subsectors with quantifications of market size on a global, national and state levels including estimates of number of private companies and total employment, and to assess future prospects for growth, competitiveness and trade in this emerging sector.

Following the development of a clean energy industry definition with broad stakeholder input from industry, government, non-profits and academia, the basic research methodology in this report was to compile existing secondary market research in various segments, build databases of companies in each segment, and survey and interview those companies. The resulting information was used to develop an economic model, business metrics and an accurate picture of market trends in each segment. Industry semantic classifications, segment conclusions and market estimates were shared with selected experts and industry participants and modified in some cases. Segment totals were then summed to represent a total clean energy industry as portrayed in this report.

## 1.1. Materials and Methods

### EBI’s Market Research Method

Since pioneering its analysis of the environmental industry in 1988, Environmental Business International, Inc. (EBI) has consistently executed a method for performing research on industry segments and environmental and clean energy companies that is both efficient and comprehensive. The users of EBI’s work has historically been subscribers to EBI’s journals, market research report buyers and specific contract research assignments. For this reason, the data, interpretation and analyses have been crafted primarily to directly serve the needs of industry executives in the private sector for their use in developing marketing and strategic plans for their individual business operations and expansions. Since businesses routinely refer to EBI’s data in crafting business plans and making strategic decisions, EBI researchers have been very conscious and conscientious in collecting, processing and interpreting the data and assuring its relevance to short- and long-term business planning and corporate development exercises.

Any market can be viewed as a population of sales events between a buyer and a seller. From that perspective, a market research analyst can either count purchases by individual buyers or, alternatively, count the revenues or sales of the sellers. Since buyers typically out-number sellers, and since buyers don't always keep good track of their purchases, it is usually easier to study revenue generated rather than purchases made in a given market. That is, it's typically less costly and more accurate to survey the sell side of a market. This has been the method employed by EBI in surveying the environmental industry. Basically, EBI "adds up" the revenues generated by companies/entities in each business segment to determine individual segment and then total industrial size.

It does this by taking the following steps:

1) Generating and maintaining company databases in defined segments
2) Developing survey instruments and executing surveys, in addition to conducting secondary research on companies, to populate databases with revenue figures
3) Identifying the total population or universe of participating companies and the top 30-100 companies in each segment
4) Modeling each business segment based on these compiled revenues and reliable secondary data, reconciled with existing spending estimates, government reports, etc. to in effect triangulate a market estimate by approaching it from three different sides
5) Conducting detailed and ongoing editorial research (executive and expert interviews to test and verify assumptions)

While this bottom-up or sell-side approach is preferred, it becomes more effective as the research process matures with years of experience, and the segments themselves become more mature with established players. As an example, EBI has maintained a database, conducted surveys and evolved a market model on the environmental consulting & engineering segment of the environmental industry since 1989 and depth of revenue capture and accuracy increases every year. As statisticians will tell you, the ideal survey is a census of all the target population, which we attempt in our segments, but absent that using statistical sampling of a defined population provides acceptably accurate results in most cases.

EBI generally evolves a hybrid model in each segment where the top 20-50 or more companies are captured in a census, and then results from size categories below are used as the representative set of the group of companies in that size category in the segment universe model whereby the unsurveyed group are modeled based on the responses of like companies.

It is important to note that revenue surveys, segment databases and accurate counts and distributions of companies in each segment universe are still immature in the clean energy industry. As an example, we may have an accurate assessment of the top 10 solar photovoltaic manufacturers but not yet the next 11-40 companies and not a very accurate picture of the total population of manufacturers. In other segments like green building even less detail on top companies has been able to be generated as most green design and construction practices or green building supply are subsets of larger conventional practices or supply, so identifying and quantifying the leaders, as well as the total number of participants, is incomplete.

In clean energy segments therefore, the triangulation of data sources using 1) this evolving revenue model; 2) best available user, demand-side, buy-side or existing market estimates and 3) economic models using total output, prices, shares, energy capacity installed or generated or other relevant statistics must be used and re-evaluated as new sources of data become available.

*A note on the sourcing of tables:* Many data tables included in this report cite EBI Inc. or "EBI Inc. derived from a variety of sources". In these cases (especially where all nine clean energy industry segments are portrayed), multiple sources were used to derive the most accurate estimate available in each segment and not all are listed in each chart. In each section devoted to a specific segment or sub-segment, however, the first source reference contains the main sources that contributed mostly to the estimation model or inputs to EBI's estimation or forecast. More details on these citations and a list of other sources are included in the References section at the end of this report.

**Survey Instruments**

EBI designs and implements its own surveys on the clean energy industry. Based on its years of experience in performing these surveys in the environmental industry EBI has evolved a method to receive revenue figures and some financial data from companies willing to fill out and return the survey instruments. EBI collects at least the following information from each company in the various business segments:

- *Financial Information*
  - Company contact information, ownership, number of offices or locations
  - Gross revenues - past two years, most recent year and one year future estimate
  - Segment specific revenues by year
  - Employees, operating income
  - International revenues or export percentages
- *Product or service line revenue breakdown*
  - this revenue breakdown is specific to the business segment
- *Market or client type revenue breakdown*
  - this includes government and private client breakdowns
- *Geographic revenue breakdown*
- *Other segment specific categories*
- *Opinions, trends and market drivers, business scenarios, specific programs*

These surveys are emailed, faxed or sent out with a letter that describes the survey, why we're doing it and what they can expect to receive for filling out their survey (usually a brief summary of results). The survey data is kept confidential in EBI's files. What are published about each company are generally the total gross and segment-specific revenues, unless firms have participated in a detailed interview. The aggregate data, however, is used to form market size estimates based on the primary data collected from these surveys. In some on-line surveys, revenue and other information is reported in ranges where the respondent clicks on a certain range rather than reporting an exact figure.

# 2. Results

## 2.1. Clean Energy Industry Definition

This introduction presents Environmental Business International Inc.'s (EBI) definition of the clean energy industry used in this report and its nine major business segments, in addition to a synopsis of the industry's size, growth trajectory and most influential market drivers.

We also take the opportunity to compare the clean energy industry to the environmental industry that in some ways preceded it and today co-exists alongside it with only modest overlap. We also provide EBI's best estimate of where both these industries fit in the context of the larger green economy or the broader sets of sectors that contribute to green jobs.

Environmental Business International initiated research into the climate change industry in 2007, 20 years after developing and institutionalizing a widely adopted definition of the environmental industry. Whereas EBI continues to use the term climate change industry in some circumstances, for the purposes of this report the term clean energy industry serves the same purpose. We believe the evolution of the environmental industry, which EBI has tracked in detail since 1987, provides valuable precedents for and insights into the clean energy industry and the challenges and opportunities it faces as an industry propelled by multiple market drivers, many of which result directly from national, regional, state or local government policy.

The environmental industry traces its roots to the National Environmental Policy Act (NEPA) of 1970 and the birth of the Environmental Protection Agency, which heralded an era of policy and regulation governing pollution control, waste management and cleanup. Similarly, the clean energy industry is developing in response to a wave of global, national and regional energy policy and climate change policy focused on control of carbon and greenhouse gas (GHG) emissions.

In the United States the clean energy industry still lacks a central governing clean energy or climate change policy and has no NEPA equivalent. However, we believe more progressive clean energy policy and GHG regulation is inevitable, and the clean energy industry will be largely driven by government programs, compliance regimes, and selected market mechanisms in its early stages, much like the environmental industry that preceded it.

As government initiatives and market mechanisms are put in place, some at the state level like AB32, California's Global Warming Solutions Act, EBI believes the business segments that comprise the clean energy industry will increasingly coalesce into a closely connected group of sectors with enough common issues to represent an industry which will earn broad recognition amongst policymakers, regulators, academia, the non-profit community and the industry itself.

In general EBI defines the clean energy industry as including any business or revenue-generating entity or enterprise whose sales and market prospects are driven primarily, substantially or significantly by policy to stimulate development or investment in clean energy or energy efficiency, and/or by policy to control, mitigate or eliminate greenhouse gas or carbon emissions or adapt to the circumstances of climate change.

**Figure 1 Nine Segments of the Climate Change Industry**

| | |
|---|---|
| **1. Low-Carbon Power** | Renewable & Conventional Power Sales; Specialty Equipment & Services |
| **2. Carbon Capture & Storage** | Systems, Equipment and Operations |
| **3. Energy Efficiency & Demand Response** | Appliances, Devices, Equipment & Services including Smart Grid |
| **4. Energy Storage** | Equipment & Systems: Utility-Scale, Batteries and Fuel Cells |
| **5. Green Buildings** | Design & Development; Construction, Building Materials & Supply |
| **6. Transportation** | Vehicles, Fuels & Systems, Transit, Planning & Engineering |
| **7. Carbon Markets** | Credit & Offset Trading; Project Development, Verification and Registration |
| **8. Adaptation** | Risk Assessment, Planning, Engineering & Construction |
| **9. Consulting & Research** | Consulting & Engineering; Professional Services; Research |

*EBI Inc.*

### 2.1.1. Why the Clean Energy Industry?

What prompted EBI to define and quantify the clean energy industry?

First, it was clear to us that multiple emerging opportunities in the business of clean energy and in mitigating and managing climate change were in need of definition and quantification, and segments which initially appeared disparate and unrelated in fact fell under the same clean energy and climate change umbrella. Like the environmental industry before it, the components of the clean energy industry lack uniform recognition by government or international industry coding systems. Thus EBI set itself the task of creating an identity for the clean energy industry—just as we originally gave shape to the environmental industry in 1988 by creating a definitional framework that has since been widely adopted by the private sector and government agencies worldwide.

EBI's interest in the clean energy industry arose naturally from the overlap between the cleanup-oriented environmental industry (whose vast majority of revenues have been concerned with environmental infrastructure, pollution control, waste management and remediation) and the clean energy industry. The industries share some common ground in consulting & engineering and renewable energy, although the latter has always been a bit of an outlier in EBI's environmental industry analysis. Consulting & engineering is populated by companies central to both the environmental and the clean energy industries because they operate as service providers in virtually every segment of both industries.

However, the majority of business segments in EBI's definition of the clean energy industry represent a new universe of markets that are still in their infancy but until now have lacked a coherent framework for analysis. By providing such a framework this report aims to create a strategic context for those seeking to participate in, or support development of, business opportunities associated with clean energy and climate change—opportunities that increasingly share common market drivers and competitive economic issues.

Second, EBI believes that the need for a comprehensive definition of the clean energy industry is going to become increasingly obvious as clean energy standards, renewable energy credits, carbon trading and other market and regulatory systems are established worldwide. The 2011-2012 implementation of California's AB 32 is the latest prominent manifestation of this. As carbon markets emerge and merge globally, EBI's nine clean energy industry segments are expected to become even more responsive to the CO2 and greenhouse gas imperatives that will serve to complement other clean energy market drivers like energy security, environmental protection, and sustainable development.

Third, both clean energy and climate change are now permanently on the political and policy agenda of world governments, if not always in the specific vernacular of politically conscious leaders or elected representatives. Regulatory engines and clean energy incentive programs may fire in fits and starts, but EBI and most of the industry believes they'll only move in one direction, i.e., towards bringing EBI's 9 segments together into a more closely comparable framework that share market drivers and increasingly an identity.

For example, carbon capture and storage (CCS) developers may not consider themselves directly competitive with tidal power companies or green building supply companies, but increasingly policymakers, investors and companies will regard them as more closely related. Climate change policy in 2011 (much like environmental policy in 1970 when the U.S. EPA was founded) will emphasize long-term climate issues in some eras and short-term economic issues in others, but it is very unlikely to be eliminated or fundamentally derailed regardless of political leadership, political majorities or the trajectory of global climate negotiations or trade agreements. Renewable energy and energy efficiency policy is likewise increasingly resistant to political sways and as they mature will only support the clean energy economy merging more closely with the economy at large.

Lastly, why did we choose the "clean energy industry" rather than "climate change" or "cleantech" industry, "green industry" or another term already in use? Mostly it was because our definition is far broader than terms already being used by market researchers. "Cleantech" was coined for the benefit of the investment community to resonate with investors' IT, infotech or biotech roots. EBI's broader definition of the clean energy industry includes all markets related to clean energy generation, storage, energy efficiency, carbon or greenhouse gas emissions, carbon capture & storage, climate change adaptation, design and construction, climate research, and even conventional low carbon power sources like nuclear, hydroelectric generation and cogeneration whose growth prospects have brightened in the clean energy and climate change era. (Note: These conventional low-carbon power subsegments are excluded from the clean energy industry figures used in this report, but are presented in the industry comparison section.) We believe this broader sweep captures more accurately the long-term market fundamentals and opportunities fully arising from clean energy and climate change policy and regulation and driven by tools to be used in the implementation of California's AB 32.

The body of this report includes market and economic data summaries of all nine major segments of the clean energy industry, in addition to detailed subsegment analysis of the 48 subsegments that comprise the nine segments.

In addition, dedicated narrative and data sets are presented on 13 market segments representing five subsegments of renewable energy and the remaining eight segments:

1. Low Carbon Power
    a. Solar Energy
    b. Wind Energy
    c. Bioenergy
    d. Geothermal
    e. Wave & Tidal
2. Carbon Capture & Storage
3. Energy Efficiency & Demand Response
4. Energy Storage
5. Green Building
6. Transportation
7. Carbon Markets
8. Climate Change Adaptation
9. Consulting & Engineering and Professional Services

## 2.2. Definition of the Clean Energy Industry

Note: The following list was derived from collecting input on all possible business activities and sorted into segments to help frame the segments eventually used.

**Figure 2 Clean Energy Industry Segment Descriptions**

| 1. Low-Carbon Power |
|---|
| *Renewable or Clean Energy Systems, Equipment & Power Sales* |
| Solar Power: Photovoltaic, Concentrated Solar, Solar Thermal, etc. |
| Wind Power |
| Biomass, Biogas |
| Hydro Power, Mini-Hydros |
| Geothermal |
| Wave & Tidal |
| Microturbines |
| Fuel Cells |
| *Low Carbon Conventional Energy* |
| Waste-to-Energy, Landfill Gas |
| Nuclear power |
| Coal, gas or IGCC with carbon capture/storage |
| *Note: Quantified by equipment & systems sales, value of power generated and specialty services in each subcategory on an annual basis* |
| **2. Carbon Capture & Storage (CCS)** |
| Technology Development, Design & Construction, Operation & Maintenance |
| Carbon Capture Technology & Systems |
| Pipelines & Other CO2 Transport Infrastructure & Services |
| Geological Storage, Enhanced Oil & Gas Recovery |
| Other Storage: Oceans, Mineral Carbonation |
| *Note: Quantified by revenues generated by equipment and service providers* |
| **3. Energy Efficiency & Demand Response** |
| *Energy Efficiency Services* |
| Energy Audits, Feasibility Studies and Related Technical Services |
| Project Development, Measuring and Verification |
| Design and Construction of Energy Retrofits |
| Consumer/user education |
| *Energy and Water Efficiency Equipment/Supply* |
| Lighting |
| Building Materials, Insulation |
| Machinery & Motors |
| Appliances: Residential & Commercial |
| Co-generation systems; on-site power reuse |
| Water/wastewater reuse systems and equipment |
| *Demand Response & Smart Grid Systems and Services* |
| Smart transmission, smart grid systems |
| Metering, monitoring and control devices |
| Demand response: Curtailment or Usage reduction at peak |
| *Quantified by EE&DR Equipment: Energy Efficiency Appliances, Devices & Equipment; Smartgrid/DR equipment & systems; EE&DR Services: Energy Service Companies (ESCOs); Energy Service* |

| |
|---|
| *Providers; Consulting engineering firms with EE/DR practices; Demand Response Services; Water Efficiency, Recycling and Reuse Equipment & Services* |
| 4. Energy Storage: Equipment & Systems |
| Chemical: Hydrogen, etc.<br>Electrochemical: Batteries<br>Electrical: Capacitor, Superconducting magnetic energy storage (SMES)<br>Mechanical: Flywheels, Compressed air energy storage (CAES), Pumped air & water<br>Thermal: Molten salt, Solar Ponds, Cryogenic liquid air or nitrogen. Seasonal thermal<br>*Note: Quantified by Utility Energy Storage Market; Transportation Batteries; and Fuel Cells* |
| 5. Green Buildings |
| Green Building Design<br>Green Building Construction & Contracting<br>Green Development<br>Green Building Materials:<br>Energy efficiency devices: power and heat<br>Water conservation & reuse devices<br>Smart building systems<br>*Note: Quantified by Green Building Design and CM/PM; Green Building Materials; Green Building Construction* |
| 6. Transportation |
| *Transportation Vehicles*<br>Low-carbon Vehicles: Hybrid, Electric, Fuel-efficient internal-combustion vehicles<br>Electrified transport (plug-in hybrids)<br>Vehicle motors, parts, components systems<br>*Transportation Fuels*<br>Grain Biofuels<br>Non-grain Biofuels<br>Hydrogen fuels (from nuclear or renewables)<br>Other low-carbon fuels<br>*Transportation Systems*<br>Urban Design/Land Use/Planning<br>Public Transportation<br>High Speed Rail<br>Telecommuting & Carpooling<br>Traffic Engineering<br>Non-motorized transport: bicycles |
| *Note: Quantified by Hybrid Electric Vehicles (HEVs); Other Alternative Fuel Vehicles (AFVs: CNG/LNG: Cars, Trucks, Buses); Electric Vehicles (EV); Flex Fuel Vehicles (FFVs); Biofuels (ethanol, biodiesel) Alternative Fuels (CNG, LNG); Transportation Planning & Engineering (only portion driven by GHG reduction); Public Transit; High-Speed Rail; Non-Motorized Transport (Bicycles: commuters only)* |
| 7. Carbon Markets |
| The Voluntary Market: Carbon Offsets<br>The Regulatory Market: Carbon Emission Credits<br>Carbon Credit & Offset Trading: Brokering, Banking, Futures |

| |
|---|
| Project Development: CDM & JI, Forestry, Agriculture, Landfill Gas, Renewable Energy, Low-Carbon Energy, etc. |
| Project Verification Services & Registries |
| *Note: Quantified by value of regulated credits and voluntary offsets sold on an annual basis* |
| 8. Adaptation |
| Coastal building and reconstruction; Walls, Breaks, etc. |
| Emergency response & preparedness systems |
| Agricultural and natural resource adaptive management |
| Water resource planning |
| Utility/other infrastructure planning |
| Relocation; Population transfer & redevelopment |
| *Note: Quantified by Consulting & Engineering: Assessment & Analysis; Planning; Design, Engineering & Construction; Equipment & Systems: Analytical & Information Systems; Construction Materials & Supplies* |
| 9. Services |
| Consulting & Engineering: emission inventories, studies, compliance, trading, sustainability |
| Climate Science & Studies: Government, Academic, Non-profit, Corporate, etc. |
| Research & Development |
| *Note: Quantified by consulting & engineering revenues derived in climate change unrelated to services accounted for in prior segments; Consulting: advisory, inventories, footprints, compliance, trading Climate Science & Studies: Government, Academic, Non-profit* |

*SOURCE: Environmental Business International, Inc., San Diego, Calif.*

**Figure 3 Clean Energy Industry: Quantification Sub-Segments**

**1. Low-Carbon Power:** Renewable & Conventional Power Sales; Specialty Equipment & Services
Wind Turbines
Wind power Electricity Sales
Wind Consulting & Engineering
Wind Construction
Wind Operation & Maintenance

Wave & Tidal Systems
Wave & Tidal Electricity Sales
Photovoltaic Systems Manufacturing
Concentrated Solar Power Systems
Solar Thermal Systems
PV Electricity Value
CSP Electricity Value
ST Power Value
Solar Planning, Design & Installation
Biomass Electricity
Specialty Services: Biomass: Wood & Waste
Specialty Services: Landfill Gas
Geothermal Electricity Sales
Geothermal Equipment Sales
Geothermal Services

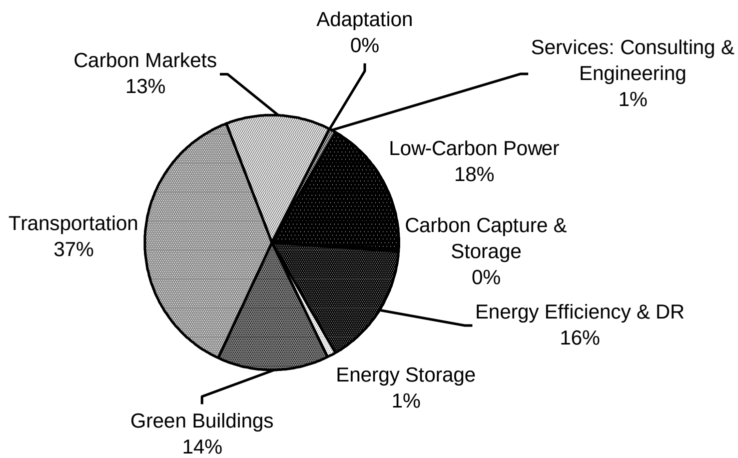
***1b. Low-Carbon Power:*** *Conventional Power Sales & Specialty Services*
*Specialty  Services: Nuclear, Hydroelectric, CHP*
*Electricity Sales: Combined Heat and Power*
*Electricity Sales: Nuclear*
*Electricity Sales: Hydroelectric*
**2. Carbon Capture & Storage (CCS)**
Carbon Capture & Storage Equipment & Services
**3. Energy & Resource Efficiency and Demand Response**
Energy Efficiency Appliances, Devices & Equipment
Energy Efficiency Services (ESCO, ESP, C&E)
Smartgrid/DR equipment & systems
Demand Response Services
Water Efficiency, Recycling and Reuse Equipment & Services
*Materials Recovery & Recycling*
**4. Energy Storage**
Utility Energy Storage Market
*Transportation Batteries*
Fuel Cells
**5. Green Buildings**
Green Building Design and CM/PM
Green Building Materials
Green Building Construction
**6. Transportation**
Hybrid Electric Vehicles (HEVs)
Other Alternative Fuel Vehicles (AFVs: CNG/LNG: Cars, Trucks, Buses)
Electric Vehicles (EV)
Flex Fuel Vehicles (FFVs)
Biofuels (ethanol, biodiesel)
Alternative Fuels (CNG, LNG)
Transportation Planning & Engineering (only portion driven by GHG reduction)
Public Transit (only fare revenue)
High-Speed Rail
Non-Motorized Transport (Bicycles: commuters only)
**7. Carbon Markets**
Carbon Market
**8. Adaptation**
Adaptation Services: Analysis, Modeling, Planning
Adaptation Construction: Infrastructure, Relocation, Protection
**9. Consulting & Research Services**
Consulting: advisory, inventories, footprints, compliance, trading
Climate Science & Studies: Government, Academic, Non-profit

*SOURCE: EBI Inc., San Diego, Calif. Note: Italicized subsegments not counted in the segment and industry quantification summaries in this report.*

# 3. Clean Energy Industry Statistics & Review

EBI estimates peg the clean energy industry at $228 billion in the United States and $1,160 billion worldwide in 2010. Largest contributors to these totals are transportation (both alternative fuels and vehicles), energy efficiency, and green buildings with low-carbon power (mostly renewables) being the only other significant contributor of revenues.

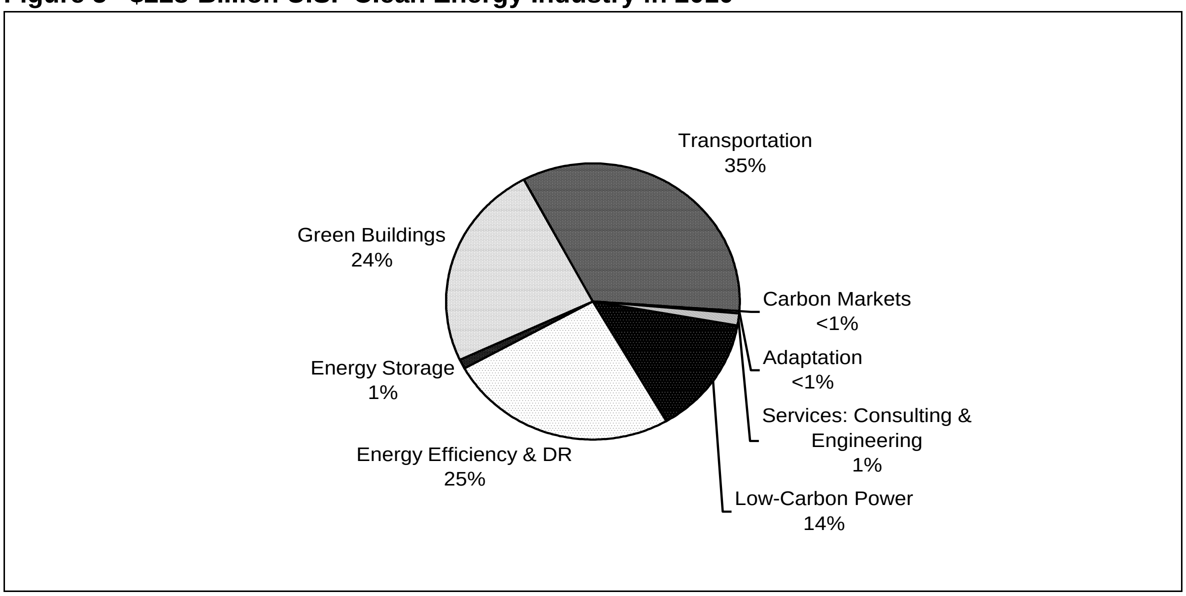
**Figure 4 $1.16-Trillion Global Clean Energy Industry in 2010**




*Source: EBI Inc., clean energy industry industry model derived from a variety of sources*

Carbon markets, which account for 13% of the global total, hardly register in the United States.

**Figure 5 $228-Billion U.S. Clean Energy Industry in 2010**




*Source: EBI Inc., clean energy industry industry model derived from a variety of sources*

### 3.1.1. The U.S. Clean Energy Industry

The clean energy industry is emerging from infancy at a time of huge economic disruption in the United States and around the world. It is also emerging at a time of political polarization that has made consensus on energy policy and government funding challenging. Nevertheless a number of federal and state programs exist to support clean energy development and infrastructure and the Obama Administration has identified clean energy as a vehicle for job creation and economic recovery. As such, it has been a major recipient of stimulus spending. Determined to lead the country to find “promise amid peril and claim opportunity from ordeal,” President Obama stated early in his tenure: “It begins with energy.” With a commitment to save or create 3.5 million jobs and double the supply of renewable energy in three years, the President’s ambitions positioned renewable or clean energy (read clean energy industry) as a key contributor to economic recovery and energy security. Analysis to the end of 2010 indicates that stimulus spending has buffered some parts of the clean energy industry from the worst of the recession, notably renewable energy categories within low-carbon power and energy efficiency.

The U.S. clean energy industry amounted to $228 billion in 2010, or 20% of the $1,160 billion global market. The industry is forecasted to hit $310 billion in the United States and $1,450 billion worldwide in 2012. While the 2009 market was flat as global economies stopped growing or contracted, annual growth is expected to be in the 10-20% range from 2010-2012 as renewable energy maintains its march forward, transportation continues its evolution to low-carbon vehicles, green buildings take chunks of share, and emerging specialty segments grow at high rates.

Segments like green buildings and transportation, which are more closely connected to depressed industries, will struggle to return to pre-crisis momentum. On the other hand, government funding of energy efficiency and the power infrastructure will boost those segments compared to the current market left to its own devices. As government stimulus and other funding wanes, policy will increasingly attempt to motivate private capital into renewables, efficiency, vehicle and fuel alternatives and other clean energy industry segments.

So indeed it is a new world economy for the clean energy industry as it takes form in this era of political ordeal, but also great economic opportunity. For companies seeking to achieve commerical success in clean energy the challenges multply as policies change, customers change, sources of capital or research investment change and the rules of the game change. But in competitive industries, many say that change is for the good or that change creates opportunity, and the clean energy industry is prepared for, and seems accustomed to, change.

California’s AB32 likely will serve as a new centerpiece of climate change policy in the United States in 2011 and beyond as its role in reducing emissions and impacting the economy will be broadly studied.

EBI forecasts the U.S. clean energy industry will grow to $310 billion in 2012. The development of carbon markets in California and the United States are expected to have a significant impact on the forecasted industry size numbers to 2012 and in future years.

**Figure 6 U.S. Clean Energy Industry Forecast: 2005-2012 ($bil)**

| | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|
| Low-Carbon Power | 11.6 | 14.3 | 21.8 | 31.6 | 36.9 | 31.4 | 45.6 | 55.7 |
| Carbon Capture & Storage | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.2 | 0.4 |
| Energy Efficiency & Demand Response | 37.0 | 41.0 | 44.8 | 50.0 | 53.0 | 57.5 | 61.1 | 63.2 |
| Energy Storage | 1.9 | 2.1 | 2.6 | 2.7 | 3.1 | 3.7 | 4.5 | 5.8 |
| Green Buildings | 23.9 | 33.2 | 44.7 | 53.7 | 54.9 | 54.5 | 63.5 | 76.6 |
| Transportation | 45.2 | 60.4 | 69.3 | 80.7 | 71.3 | 77.2 | 87.1 | 101.4 |
| Carbon Markets | 0.1 | 0.1 | 0.2 | 0.4 | 0.6 | 0.5 | 0.5 | 1.7 |
| Adaptation | 0.1 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 |
| Services: Consulting & Engineering | 2.3 | 2.1 | 2.4 | 2.5 | 3.5 | 3.0 | 3.7 | 4.0 |
| **Total U.S. Clean energy industry** | 122.2 | 153.4 | 186.0 | 222.0 | 223.6 | 228.4 | 266.8 | 309.6 |
| USA Growth | 24.0% | 25.5% | 21.3% | 19.4% | 0.7% | 2.2% | 16.8% | 16.0% |
| USA % of Global | 20% | 21% | 22% | 21% | 20% | 20% | 21% | 21% |

*SOURCE: EBI Inc., San Diego, Calif. Low-Carbon Power does not include conventional nuclear, CHP and hydro and EEDR does not include scrap or resource recovery. Figures are derived from separate research on each segment by EBI based on compilations of company infomation, government and private research and other secondary data, augmented by surveys and interviews of providers in each segment*

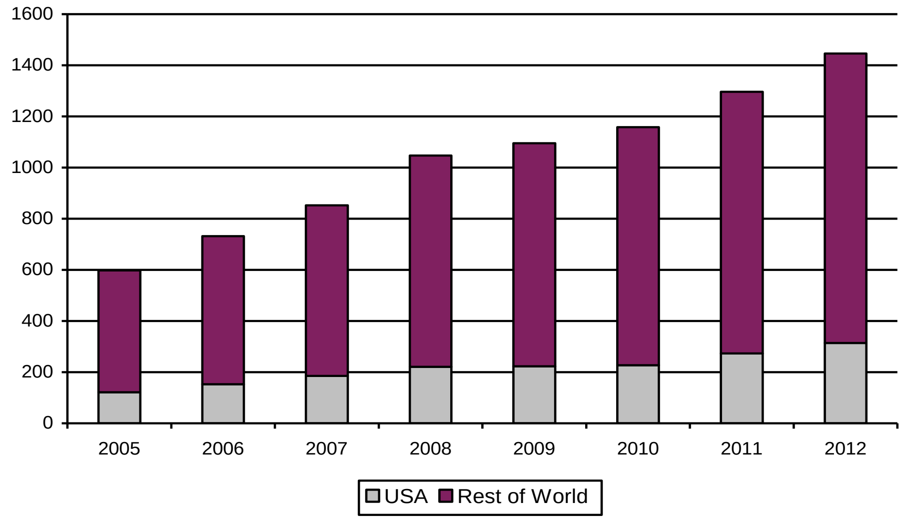
**Figure 7 U.S. Clean Energy Industry 2006-2012 (% growth)**

| | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|
| Low-Carbon Power | 23% | 53% | 45% | 17% | -15% | 45% | 22% |
| Carbon Capture & Storage | 0% | 0% | 0% | 0% | 0% | 93% | 149% |
| Energy Efficiency & Demand Response | 11% | 9% | 12% | 6% | 9% | 6% | 4% |
| Energy Storage | 11% | 21% | 4% | 13% | 20% | 23% | 27% |
| Green Buildings | 39% | 35% | 20% | 2% | -1% | 17% | 21% |
| Transportation | 34% | 15% | 17% | -12% | 8% | 13% | 16% |
| Carbon Markets | -22% | 129% | 138% | 30% | -15% | 11% | 219% |
| Adaptation | 50% | 50% | 50% | 24% | 29% | 16% | 16% |
| Services: Consulting & Engineering | -8% | 13% | 5% | 38% | -13% | 20% | 8% |
| **Total U.S. Clean energy industry** | 25% | 21% | 19% | 1% | 2% | 17% | 16% |

*Source: EBI Inc.*

### 3.1.2. The Global Clean Energy Industry

**Figure 8 Global Clean Energy Industry 2005-2012 ($bil)**




*Source: EBI Inc., clean energy industry model derived from a variety of sources*

The global clean energy industry grew 23% in 2008 and 5% in 2009 to $1.1-trillion, and has increased $500 billion in size from $600 billion in 2005. While 2009 and 2010 growth was at only 5-6%, annual growth is expected to be in the 10-12% range in 2011-2012.

Leading growth in the past has been carbon markets by percentage, but in absolute value low-carbon power will have added more than $220 billion in annual sales in global markets from 2005-2012, growing from $72 billion in 2005 to $292 billion in 2012. Other segments adding significant dollar value were transportation and green buildings.

**Figure 9 Global Clean Energy Industry 2005-2012 ($bil)**

| | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|
| Low-Carbon Power | 72.1 | 94.0 | 117.3 | 155.2 | 189.9 | 204.1 | 245.9 | 292.9 |
| Carbon Capture & Storage | 0.0 | 0.0 | 0.0 | 0.8 | 1.6 | 2.4 | 3.1 | 4.2 |
| Energy Efficiency & Demand Response | 116.7 | 129.1 | 140.8 | 156.9 | 164.9 | 180.1 | 192.4 | 200.3 |
| Energy Storage | 5.2 | 5.6 | 6.3 | 7.1 | 8.7 | 11.2 | 14.1 | 18.3 |
| Green Buildings | 104.0 | 132.7 | 165.6 | 185.2 | 177.0 | 165.0 | 181.4 | 207.0 |
| Transportation | 281.3 | 332.0 | 349.8 | 394.9 | 396.8 | 431.7 | 473.9 | 522.4 |
| Carbon Markets | 11.3 | 32.2 | 64.7 | 138.6 | 147.4 | 153.3 | 174.7 | 190.4 |
| Adaptation | 0.3 | 0.4 | 0.7 | 1.0 | 1.2 | 1.6 | 1.9 | 2.2 |
| Services: Consulting & Engineering | 6.59 | 6.10 | 6.80 | 7.10 | 8.17 | 8.56 | 10.11 | 10.83 |
| Global Clean energy industry | 597.5 | 732.2 | 852.0 | 1046.8 | 1095.7 | 1157.9 | 1297.6 | 1448.5 |
| Global Growth | 25% | 23% | 16.4% | 22.9% | 4.7% | 5.7% | 12.1% | 11.6% |

*SOURCE: EBI Inc., San Diego, Calif. Low-Carbon Power does not include conventional nuclear, CHP and hydro and EEDR does not include scrap or resource recovery. Figures are derived from separate research on each segment by EBI based on compilations of company infomation, government and private research and other secondary data, augmented by surveys and interviews of providers in each segment*

**Figure 10 Global Clean Energy Industry 2006-2012 (% growth)**

| | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|
| Low-Carbon Power | 30% | 25% | 32% | 22% | 7% | 20% | 19% |
| Carbon Capture & Storage | 0% | 0% | 0% | 91% | 50% | 31% | 34% |
| Energy Efficiency & Demand Response | 11% | 9% | 11% | 5% | 9% | 7% | 4% |
| Energy Storage | 7% | 13% | 12% | 23% | 29% | 26% | 30% |
| Green Buildings | 28% | 25% | 12% | -4% | -7% | 10% | 14% |
| Transportation | 18% | 5% | 13% | 0% | 9% | 10% | 10% |
| Carbon Markets | 186% | 101% | 114% | 6% | 4% | 14% | 9% |
| Adaptation | 50% | 50% | 50% | 24% | 29% | 16% | 16% |
| Services: Consulting & Engineering | -7% | 11% | 4% | 15% | 5% | 18% | 7% |
| **Global Clean energy industry** | 23% | 16% | 23% | 5% | 6% | 12% | 12% |

*SOURCE: EBI Inc.*

## 3.1.3. The California Clean Energy Industry

**Figure 11 California Clean Energy Industry 2007-2012 ($bil)**

| | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|
| Low-Carbon Power | 3.14 | 3.85 | 4.85 | 6.12 | 9.14 | 13.14 |
| Carbon Capture & Storage | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.02 |
| Energy Efficiency & Demand Response | 4.40 | 4.87 | 5.15 | 5.61 | 5.96 | 6.13 |
| Energy Storage | 0.50 | 0.56 | 0.65 | 0.78 | 0.95 | 1.18 |
| Green Buildings | 8.05 | 9.56 | 9.33 | 9.26 | 10.79 | 13.02 |
| Transportation | 8.28 | 8.09 | 6.59 | 7.06 | 8.21 | 9.87 |
| Carbon Markets | 0.02 | 0.04 | 0.06 | 0.05 | 0.22 | 1.56 |
| Adaptation | 0.04 | 0.06 | 0.07 | 0.10 | 0.11 | 0.13 |
| Services: Consulting & Engineering | 0.20 | 0.23 | 0.30 | 0.30 | 0.36 | 0.41 |
| **Total Clean energy industry** | 24.62 | 27.26 | 27.00 | 29.28 | 35.74 | 45.44 |
| Growth | | 11% | -1% | 8% | 22% | 27% |
| California % of USA | 13.2% | 12.3% | 12.1% | 12.8% | 13.4% | 14.7% |

*SOURCE: EBI Inc., San Diego, Calif. Low-Carbon Power does not include conventional nuclear, CHP and hydro and EEDR does not include scrap or resource recovery. Figures are derived from separate research on each segment by EBI based on compilations of company infomation, government and private research and other secondary data, augmented by surveys and interviews of providers in each segment*

**Figure 12 California Clean Energy Industry 2008-2012 (% growth)**

| | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|
| Low-Carbon Power | 23% | 26% | 26% | 49% | 44% |
| Carbon Capture & Storage | 0% | 0% | 100% | 200% | 300% |
| Energy Efficiency & Demand Response | 11% | 6% | 9% | 6% | 3% |
| Energy Storage | 14% | 15% | 20% | 22% | 25% |
| Green Buildings | 19% | -2% | -1% | 17% | 21% |
| Transportation | -2% | -18% | 7% | 16% | 20% |
| Carbon Markets | 138% | 30% | -15% | 346% | 619% |
| Adaptation | 59% | 31% | 29% | 16% | 16% |
| Services: Consulting & Engineering | 15% | 31% | -1% | 22% | 13% |
| **Total** | 11% | -1% | 8% | 22% | 27% |

*Source: EBI Inc.,, San Diego, Calif.*

Of note in the current forecast for the California clean energy industry:

- The large percentage gain in carbon markets: EBI and other analysts like Point Carbon and experts convened by think-tank Next10 expect the value of carbon credits traded to be near $1.5 billion in 2012 and $10 billion, or substantially higher, by 2015. This is a direct result of the cap-and-trade program in AB 32.
- Ongoing and increasing growth in renewable energy as utility-level solar ramps up, commercial, retail, industrial and residential solar installations increase, wind installations increase from a slow spell in the state, and geothermal plants come on line. The renewable energy standard is a major driver here.
- Green buildings will take a significant increase in share of new buildings, especially at the institutional and commercial level, but increasing in residential as well. Although the new construction sector is expected to be compromised for some time still, the increasing portion of green buildings will drive the growth. A suite of policies, and energy prices, has already impacted building and design practices to the effect that most projects are greener and ultimately the green standards being set will be the norm rather than the exception.
- Transportation growth is expected to be driven mostly by the increasing share of electric cars and hybrid cars, and the birth of high speed rail in the state.

The table below shows that each of the four segments noted above will generate more than an additional $20 billion in annual revenues in 2020 than it did in 2010, and the total California clean energy industry will more than triple from 2012 to 2020 when it will account for more than 5% of the state economy, up from about 1.5% in 2010.

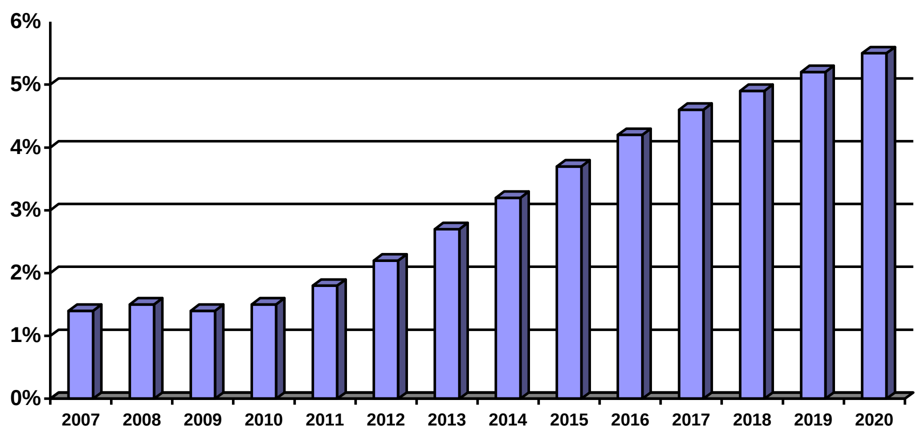
**Figure 13 California Clean Energy Industry: Growth Scenario to 2020 ($bil)**

| Segment | 2010 | 2011 | 2012 | 2015 | 2020 | Added 2010-2020 |
|---|---|---|---|---|---|---|
| Low-Carbon Power | 6.12 | 9.14 | 13.14 | 22.66 | 30.21 | 24.09 |
| Carbon Capture & Storage | 0.00 | 0.01 | 0.02 | 0.40 | 2.09 | 2.08 |
| Energy Efficiency & Demand Response | 5.61 | 5.96 | 6.13 | 7.30 | 9.31 | 3.70 |
| Energy Storage | 0.78 | 0.95 | 1.18 | 1.94 | 3.29 | 2.51 |
| Green Buildings | 9.26 | 10.79 | 13.02 | 20.85 | 38.41 | 29.15 |
| Transportation | 7.06 | 8.21 | 9.87 | 18.06 | 33.93 | 26.87 |
| Carbon Markets | 0.05 | 0.22 | 1.56 | 10.93 | 21.93 | 21.88 |
| Adaptation | 0.10 | 0.11 | 0.13 | 0.30 | 1.53 | 1.43 |
| Services: Consulting & Engineering | 0.30 | 0.36 | 0.41 | 0.60 | 0.97 | 0.67 |
| **Total Clean Energy Industry** | **29.28** | **35.74** | **45.44** | **131.69** | **141.66** | **112.39** |
| Growth* | 8% | 22% | 27% | 22% | 15% | 284% |

*SOURCE: EBI Inc., San Diego, Calif. Growth is average annual growth rate in 2012-2015 and 2010-2020. Numerous sources were assessed and compiled in each segment and estimates were derived from a consensus of opinions.*

Trends shaping the longer term forecast of clean energy industry segments are discussed in more detail in segment sections later in this report.

**Figure 14 California Clean Energy Industry: Percentage of State GDP 2007-2020**




*SOURCE: EBI Inc., San Diego, Calif. State GDP forecasted at 3% annual growth*

### 3.1.4. Clean Energy Industry Shares

California accounts for 13% of the U.S. clean energy industry, with considerable variances between segments. Similarly the USA accounts for 20% of the global clean energy industry with variances between segments.

**Figure 15 Global, U.S. and California Clean Energy Industry 2010 ($bil and % share)**

| Segment | USA | Rest of World | Global | % USA | % ROW | Calif. | CA % of USA |
|---|---|---|---|---|---|---|---|
| Low-Carbon Power | 31.4 | 172.7 | 204.1 | 15% | 85% | 6.1 | 19% |
| Carbon Capture & Storage | 0.1 | 2.3 | 2.4 | 4% | 96% | 0.0 | 0% |
| Energy Efficiency & Demand Response | 57.5 | 122.5 | 180.1 | 32% | 68% | 5.6 | 10% |
| Energy Storage | 3.7 | 7.6 | 11.2 | 33% | 67% | 0.8 | 21% |
| Green Buildings | 54.5 | 110.6 | 165.0 | 33% | 67% | 9.3 | 17% |
| Transportation | 77.2 | 354.5 | 431.7 | 18% | 82% | 7.1 | 9% |
| Carbon Markets | 0.5 | 152.8 | 153.3 | 0% | 100% | 0.0 | 10% |
| Adaptation | 0.5 | 1.1 | 1.6 | 33% | 67% | 0.1 | 18% |
| Consulting & Research | 3.0 | 5.5 | 8.6 | 36% | 64% | 0.3 | 10% |
| **Clean energy industry** | 228.4 | 929.5 | 1,158 | 20% | 80% | 29.3 | 13% |

*SOURCE: EBI Inc.*

**Figure 16 Global, U.S. and California Clean Energy Industry 2007-2012**

| | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|
| California Clean energy industry ($bil) | 25 | 27 | 27 | 29 | 36 | 45 |
| U.S. Clean energy industry | 186 | 222 | 224 | 228 | 267 | 310 |
| Global Clean energy industry | 852 | 1,047 | 1,096 | 1,158 | 1,298 | 1,449 |
| **Share** | | | | | | |
| California Clean energy industry | 2.9% | 2.6% | 2.5% | 2.5% | 2.8% | 3.1% |
| U.S. Clean energy industry | 21.8% | 21.2% | 20.4% | 19.7% | 20.6% | 21.4% |
| Global Clean energy industry | 100% | 100% | 100% | 100% | 100% | 100% |
| **Growth** | | | | | | |
| California Clean energy industry | | 11% | -1% | 8% | 22% | 27% |
| U.S. Clean energy industry | 21% | 19% | 1% | 2% | 17% | 16% |
| Global Clean energy industry | 16% | 23% | 5% | 6% | 12% | 12% |

*SOURCE: EBI, Inc.*

California's 2.5% share of the global clean energy industry in 2009 is expected to increase to 3.1% in 2012, while the USA share grows from 20.4% in 2009 to 21.4% in 2012.

### 3.1.5. Clean Energy Industry Employment & Exports

The California clean energy industry employed an estimated 123,000 full time equivalents in 2009, with between 4,000 to 5,000 companies engaged in a specific commercial activity related to climate change.

**Figure 17 U.S. and California Clean Energy Industry: Employment in 2009**

| | USA 2009 Market $bil | Calif. 2009 Market $bil | USA Employment | California Employment |
|---|---|---|---|---|
| **1. Renewable Energy** | | | | |
| Wind Energy | 25.43 | 1.06 | 106,869 | 2,552 |
| Wave & Tidal | 0.03 | 0.01 | 408 | 162 |
| Solar Energy | 4.52 | 1.95 | 29,699 | 13,520 |
| Biomass | 5.34 | 0.63 | 14,571 | 1,748 |
| Geothermal | 1.58 | 1.20 | 3,585 | 2,495 |
| 2. Carbon Capture & Storage | 0.01 | 0.00 | 200 | 20 |
| 3. Energy & Resource Efficiency and Demand Response | 52.99 | 5.15 | 243,680 | 24,014 |
| 4. Energy Storage | 3.06 | 0.65 | 9,000 | 2,237 |
| 5. Green Buildings | 54.89 | 9.33 | 279,976 | 47,907 |
| 6. Transportation | 71.27 | 6.59 | 406,963 | 25,042 |
| 7. Carbon Markets | 0.57 | 0.06 | 1,426 | 171 |
| 8. Adaptation | 0.42 | 0.07 | 3,192 | 632 |
| 9. Services | 3.48 | 0.30 | 26,769 | 2,417 |
| **Clean Energy Industry** | **223.57** | **27.00** | **1,126,610** | **122,917** |

*SOURCE: EBI Inc. Employment figures derived from the product of segment size in revneues and and aggregate $/employee ratio for survey and interview respondents in each segment.*

**Figure 18 California Clean Energy Industry: Number of Companies and Jobs in 2009**

| Clean energy industry segment | California 2009 Market $bil | California Employment | California Number of Companies |
|---|---|---|---|
| 1. Renewable Energy | | | |
| Wind Energy | 1.06 | 2,552 | 300-400 |
| Wave & Tidal | 0.01 | 162 | 30-40 |
| Solar Energy | 1.95 | 13,520 | 1200-1500 |
| Biomass | 0.63 | 1,748 | 100-120 |
| Geothermal | 1.20 | 2,495 | 70-100 |
| 2. Carbon Capture & Storage | 0.00 | 20 | 10-20 |
| 3. Energy & Resource Efficiency and Demand Response | 5.15 | 24,014 | 600-800 |
| 4. Energy Storage | 0.65 | 2,237 | 80-100 |
| 5. Green Buildings | 9.33 | 47,907 | 1000-1200 |
| 6. Transportation | 6.59 | 25,042 | 300-400 |
| 7. Carbon Markets | 0.06 | 171 | 30-40 |
| 8. Adaptation | 0.07 | 632 | 20-30 |
| 9. Services | 0.30 | 2,417 | 200-300 |
| **Clean energy industry** | **27.00** | **122,917** | **4000-5000** |

*SOURCE: EBI Inc.*

Out of state and export activity in the California clean energy industry is estimated to account for 10% and 2% of total revenue generation. The novelty of a number of segments and subsegments accounts for the relative lack of export activity but global market have shown that quality expertise is in demand.

**Figure 19 California Clean Energy Industry: Export Estimates in 2009**

| | California 2009 Market $bil | Out of State Export % | Out of State Export $mil | Global Export % | Global Export $mil |
|---|---|---|---|---|---|
| 1. Renewable Energy | | | | | |
| Wind Energy | 1.06 | 2% | 21 | 0.3% | 3.2 |
| Wave & Tidal | 0.01 | 30% | 4 | 10.0% | 1.2 |
| Solar Energy | 1.95 | 15% | 293 | 4.0% | 78.0 |
| Biomass | 0.63 | 8% | 50 | 8.0% | 50.5 |
| Geothermal | 1.20 | 35% | 419 | 5.0% | 59.9 |
| 2. Carbon Capture & Storage | 0.00 | 205 | 0 | 0% | 0.0 |
| 3. Energy & Resource Efficiency and Demand Response | 5.15 | 15% | 772 | 3.0% | 154.4 |
| 4. Energy Storage | 0.65 | 2% | 11 | 0.5% | 2.8 |
| 5. Green Buildings | 9.33 | 8% | 746 | 1.5% | 140.0 |
| 6. Transportation | 6.59 | 3% | 198 | 0.3% | 16.5 |
| 7. Carbon Markets | 0.06 | 20% | 11 | 5.0% | 2.9 |
| 8. Adaptation | 0.07 | 40% | 30 | 12.0% | 9.0 |
| 9. Services | 0.30 | 35% | 105 | 10.0% | 29.9 |
| **Clean Energy Industry** | **27.00** | **9.9%** | **2,661** | **2.0%** | **548** |

*Source: EBI Inc.*

### 3.1.6. California Clean Energy Industry Size and Employment Segment Detail

**Figure 20 Clean Energy Industry 2008-2009: Segment Detail**

| Segment | Global $bil | USA $bil | California $bil | Calif. % of Global | Calif. % of USA |
|---|---|---|---|---|---|
| **1. Low-Carbon Power: Renewable** | | | | | |
| Wind Turbines | 58.1 | 15.2 | 0.42 | 0.7% | 2.8% |
| Wind power Electricity Sales | 29.5 | 5.2 | 0.42 | 1.4% | 8.0% |
| Wind Consulting & Engineering | 2.0 | 0.5 | 0.02 | 1.0% | 3.8% |
| Wind Construction | 14.9 | 3.9 | 0.15 | 1.0% | 3.8% |
| Wind Operation & Maintenance | 3.9 | 0.6 | 0.06 | 1.5% | 9.0% |
| Wave & Tidal Systems | 0.1 | 0.0 | 0.01 | 10.0% | 40.0% |
| Wave & Tidal Electricity Sales | 0.0 | 0.0 | 0.00 | 7.5% | 30.0% |
| Photovoltaic Systems Manufacturing | 18.9 | 1.1 | 0.15 | 0.8% | 13.1% |
| Concentrated Solar Power Systems | 2.2 | 1.1 | 0.57 | 25.6% | 53.0% |
| Solar Thermal Systems | 5.4 | 0.4 | 0.14 | 2.6% | 31.1% |
| PV Electricity Value | 7.6 | 0.6 | 0.39 | 5.1% | 66.7% |
| CSP Electricity Value | 0.7 | 0.4 | 0.33 | 49.0% | 84.9% |
| ST Power Value | 4.1 | 0.1 | 0.02 | 0.6% | 27.8% |
| Solar Planning, Design & Installation | 6.5 | 0.8 | 0.35 | 5.4% | 44.0% |
| Biomass Electricity | 30.2 | 5.1 | 0.61 | 2.0% | 11.8% |
| Specialty Services: Biomass: Wood & Waste | 0.4 | 0.1 | 0.01 | 2.5% | 11.8% |
| Specialty Services: Landfill Gas | 0.6 | 0.1 | 0.01 | 2.1% | 10.2% |
| Geothermal Electricity Sales | 3.7 | 1.1 | 0.93 | 25.2% | 85.5% |
| Geothermal Equipment Sales | 0.4 | 0.2 | 0.12 | 28.2% | 56.0% |
| Geothermal Services | 0.6 | 0.3 | 0.14 | 22.6% | 52.6% |
| ***1b. Low-Carbon Power: Conventional*** | | | | | |
| *Specialty Services: Nuclear, Hydroelectric, CHP* | *7.3* | *1.7* | *0.15* | *2.0%* | *8.6%* |
| *Electricity Sales: Combined Heat and Power* | *112.9* | *29.1* | *3.10* | *2.7%* | *10.7%* |
| *Electricity Sales: Nuclear* | *157.5* | *49.0* | *1.95* | *1.2%* | *4.0%* |
| *Electricity Sales: Hydroelectric* | *202.3* | *16.7* | *1.85* | *0.9%* | *11.1%* |
| **2. Carbon Capture & Storage** | | | | | |
| Carbon Capture & Storage Equipment & Services | 1.6 | 0.0 | 0.00 | 0.0% | 0.0% |
| **3. Energy Efficiency and Demand Response** | | | | | |
| Energy Efficiency Appliances, Devices & Equipment | 130.9 | 40.9 | 3.60 | 2.8% | 8.8% |
| Energy Efficiency Services (ESCO, ESP, C&E) | 16.1 | 5.0 | 0.39 | 2.4% | 7.8% |
| Smartgrid/DR equipment & systems | 14.1 | 4.8 | 0.63 | 4.5% | 13.0% |
| Demand Response Services | 0.9 | 0.5 | 0.04 | 3.9% | 7.0% |
| Water Efficiency and Reuse | 2.8 | 1.7 | 0.49 | 17.3% | 29.0% |
| *Materials Recovery & Recycling* | *71.2* | *33.9* | *4.07* | *5.7%* | *12.0%* |
| **4. Energy Storage** | | | | | |
| Utility Energy Storage Market | 7.2 | 2.0 | 0.49 | 6.8% | 24.5% |
| Vehicle Traction Batteries | 1.5 | 0.7 | 0.09 | 5.9% | 13.3% |
| Fuel Cells | 1.5 | 0.4 | 0.07 | 4.7% | 18.0% |
| **5. Green Buildings** | | | | | |
| Green Building Design and CM/PM | 8.0 | 2.5 | 0.42 | 5.3% | 17.0% |
| Green Building Materials | 97.4 | 30.2 | 5.13 | 5.3% | 17.0% |

| | | | | | |
|---|---|---|---|---|---|
| Green Building Construction | 71.7 | 22.2 | 3.78 | 5.3% | 17.0% |
| **6. Transportation** | | | | | |
| Hybrid Electric Vehicles (HEVs) | 20.4 | 9.0 | 1.89 | 9.3% | 21.0% |
| Alternative Fuel Vehicles | 49.4 | 0.9 | 0.16 | 0.3% | 18.2% |
| Electric Vehicles (EV) | 0.3 | 0.2 | 0.08 | 28.8% | 48.0% |
| Flex Fuel Vehicles (FFVs) | 37.5 | 26.2 | 2.36 | 6.3% | 9.0% |
| Biofuels (ethanol, biodiesel) | 46.7 | 20.3 | 0.86 | 1.8% | 4.2% |
| Alternative Fuels (CNG, LNG) | 20.9 | 0.4 | 0.15 | 0.7% | 36.4% |
| Transportation Planning & Engineering | 1.2 | 0.5 | 0.08 | 6.4% | 16.0% |
| Public Transit | 120.4 | 12.0 | 0.84 | 0.7% | 7.0% |
| High-Speed Rail | 88.6 | 1.1 | 0.05 | 0.1% | 4.0% |
| Non-Motorized Transport | 11.5 | 0.6 | 0.13 | 1.1% | 22.0% |
| **7. Carbon Markets** | | | | | |
| Carbon Market | 147.4 | 0.6 | 0.06 | 0.0% | 10.0% |
| **8. Adaptation** | | | | | |
| Services: Analysis, Modeling, Planning | 1.2 | 0.4 | 0.07 | 6.0% | 18.0% |
| Construction: Infrastructure, Protection | 0.0 | 0.0 | 0.00 | | |
| **9. Services** | | | | | |
| Consulting: advisory, inventories, footprints, compliance, trading | 2.2 | 0.8 | 0.15 | 6.6% | 19.0% |
| Climate Science & Studies: Government, Academic, Non-profit | 5.9 | 2.7 | 0.15 | 2.5% | 5.6% |
| **Total Clean Energy Industry** | **1648.5** | **353.9** | **38.12** | **2.3%** | **10.8%** |
| **Total minus Conventional Low Carbon & Materials Recovery** | **1097.2** | **223.6** | **27.00** | **2.5%** | **12.1%** |

*SOURCE: EBI Inc. Segments in italics are not quantified in the reaminder of this report*

**Figure 21 California Clean Energy Industry 2009-2010: Employment Detail**

| Segment | California $bil 2009 | California $bil 2010 | 2010 Est. Growth | 2009 Employ-ment | Est. 2010 Employ-ment | Jobs Added in 2010 |
|---|---|---|---|---|---|---|
| **1. Low-Carbon Power: Renewable** | | | | | | |
| Wind Turbines | 0.42 | 0.20 | -51% | 322 | 157 | (166) |
| Wind power Electricity Sales | 0.42 | 0.49 | 17% | 378 | 442 | 64 |
| Wind Consulting & Engineering | 0.02 | 0.03 | 49% | 192 | 286 | 94 |
| Wind Construction | 0.15 | 0.07 | -52% | 1,372 | 655 | (716) |
| Wind Operation & Maintenance | 0.06 | 0.08 | 40% | 288 | 403 | 115 |
| Wave & Tidal Systems | 0.01 | 0.02 | 117% | 158 | 343 | 185 |
| Wave & Tidal Electricity Sales | 0.00 | 0.00 | 223% | 4 | 14 | 9 |
| Photovoltaic Systems Manufacturing | 0.15 | 0.18 | 18% | 487 | 574 | 87 |
| Concentrated Solar Power Systems | 0.57 | 1.12 | 96% | 4,486 | 8,794 | 4,308 |
| Solar Thermal Systems | 0.14 | 0.16 | 18% | 1,510 | 1,782 | 272 |
| PV Electricity Value | 0.39 | 0.54 | 39% | 1,385 | 1,921 | 536 |
| CSP Electricity Value | 0.33 | 0.56 | 73% | 816 | 1,408 | 592 |
| ST Power Value | 0.02 | 0.03 | 24% | 114 | 141 | 27 |
| Solar Planning, Design & Installation | 0.35 | 0.62 | 76% | 4,721 | 8,326 | 3,604 |
| Biomass Electricity | 0.61 | 0.63 | 4% | 1,520 | 1,581 | 61 |
| Specialty Services: Biomass: Wood & Waste | 0.01 | 0.01 | 2% | 108 | 110 | 2 |
| Specialty Services: Landfill Gas | 0.01 | 0.01 | 5% | 121 | 127 | 6 |
| Geothermal Electricity Sales | 0.93 | 0.98 | 5% | 1,037 | 1,090 | 53 |
| Geothermal Equipment Sales | 0.12 | 0.14 | 11% | 320 | 356 | 36 |
| Geothermal Services | 0.14 | 0.24 | 67% | 1,137 | 1,895 | 758 |
| ***1b. Low-Carbon Power: Conventional*** | | | | | | |
| *Specialty Services: Nuclear, Hydroelectric, CHP* | 0.15 | 0.17 | 18% | | | |
| *Electricity Sales: Combined Heat and Power* | 3.10 | 3.14 | 1% | | | |
| *Electricity Sales: Nuclear* | 1.95 | 1.97 | 1% | | | |
| *Electricity Sales: Hydroelectric* | 1.85 | 1.84 | -1% | | | |
| **2. Carbon Capture & Storage** | | | | | | |
| Carbon Capture & Storage Equipment & Services | | | | 20 | 24 | 4 |
| **3. Energy Efficiency and Demand Response** | | | | | | |
| Energy Efficiency Appliances, Devices & Equipment | 3.60 | 3.72 | 3% | 15,794 | 16,308 | 513 |
| Energy Efficiency Services (ESCO, ESP, C&E) | 0.39 | 0.48 | 22% | 2,312 | 2,821 | 509 |
| Smartgrid/DR equipment & systems | 0.63 | 0.89 | 41% | 2,818 | 3,966 | 1,148 |
| Demand Response Services | 0.04 | 0.05 | 30% | 205 | 267 | 62 |
| Water Efficiency and Reuse | 0.49 | 0.48 | -1% | 2,884 | 2,854 | (30) |
| *Materials Recovery & Recycling* | 4.07 | 4.19 | 3% | | | |
| **4. Energy Storage** | | | | | | |
| Utility Energy Storage Market | 0.49 | 0.55 | 12% | 1,225 | 1,372 | 147 |
| Vehicle Traction Batteries | 0.09 | 0.09 | -2% | 292 | 285 | (7) |
| Fuel Cells | 0.07 | 0.14 | 100% | 720 | 1,440 | 720 |
| **5. Green Buildings** | 0.00 | 0.00 | | | | |
| Green Building Design and CM/PM | 0.42 | 0.42 | -1% | 3,421 | 3,394 | (27) |
| Green Building Materials | 5.13 | 5.09 | -1% | 14,255 | 14,142 | (113) |

| | | | | | | |
|---|---|---|---|---|---|---|
| Green Building Construction | 3.78 | 3.75 | -1% | 30,231 | 29,992 | (239) |
| **6. Transportation** | | | | | | |
| Hybrid Electric Vehicles (HEVs) | 1.89 | 1.92 | 1% | 3,290 | 3,336 | 46 |
| Alternative Fuel Vehicles | 0.16 | 0.23 | 42% | 704 | 997 | 293 |
| Electric Vehicles (EV) | 0.08 | 0.08 | 5% | 350 | 366 | 16 |
| Flex Fuel Vehicles (FFVs) | 2.36 | 2.57 | 9% | 5,133 | 5,577 | 443 |
| Biofuels (ethanol, biodiesel) | 0.86 | 0.92 | 7% | 4,592 | 4,914 | 322 |
| Alternative Fuels (CNG, LNG) | 0.15 | 0.16 | 6% | 508 | 539 | 30 |
| Transportation Planning & Engineering | 0.08 | 0.08 | 12% | 637 | 714 | 77 |
| Public Transit | 0.84 | 0.87 | 4% | 9,081 | 9,408 | 327 |
| High-Speed Rail | 0.05 | 0.09 | 100% | 113 | 225 | 113 |
| Non-Motorized Transport | 0.13 | 0.14 | 9% | 634 | 694 | 60 |
| **7. Carbon Markets** | | | | | | |
| Carbon Market | 0.06 | 0.05 | -15% | 171 | 146 | (25) |
| **8. Adaptation** | | | | | | |
| Services: Analysis, Modeling, Planning | 0.07 | 0.10 | 29% | 632 | 818 | 186 |
| Construction: Infrastructure, Protection | | | | | | |
| **9. Services** | | | | | | |
| Consulting: advisory, inventories, footprints, compliance, trading | 0.15 | 0.18 | 21% | 1,254 | 1,511 | 257 |
| Climate Science & Studies: Government, Academic, Non-profit | 0.15 | 0.12 | -22% | 1,163 | 905 | (258) |
| **Total** | **38.12** | **40.58** | **6%** | | | |
| **Total minus Conventional Low Carbon & Materials Recovery** | **27.00** | **29.27** | **8%** | **122,917** | **137,419** | **14,502** |

*SOURCE: EBI Inc. Segments in italics are not quantified in the reaminder of this report. Note: Employment is in full time equivalents*

## 3.1.7. Investment in the California Clean Energy Industry

The California clean energy industry benefits from the advantage of having the most seasoned venture capital (VC), and to a lesser extent, private equity (PE) investors interested in its industry segments and companies that have investment funds specifically for this industry. (Equity investors differ from VC investors in that they typically invest in later stage of profitable companies while VCs will invest in early stage, or even pre-revenue companies.)

According to the Cleantech Group, from 2006 through June 2010, California clean technology companies accounted for the most venture capital funding by far of any state, both by number of deals and total dollars raised. California companies received 40% of all dollars that have flowed into what they define as the cleantech industry. Portions of EBI's clean energy industry are included in versions of the ‘cleantech' industry, a term coined mostly for the benefit of the investment community to resonate with its IT or biotech roots.

We believe our broader definition of the clean energy industry more accurately captures the long-term market fundamentals increasingly driven by climate change policy like AB 32 in the form of market mechanisms and regulation, and includes segments like consulting & research, CCS and adaptation.

**Figure 22 Top Cleantech Venture Capital States by Number of Companies**

| State | Venture-Backed Companies | Share |
|---|---|---|
| California | 227 | 40% |
| Massachusetts | 61 | 11% |
| Texas | 38 | 7% |
| Washington | 25 | 4% |
| New York | 21 | 4% |
| Others | 200 | 35% |
| **Total** | **572** | |

*Source: Cleantech Group; 2006 through June 2010*

In venture investing in 2010, California accounted for a noteworthy 38% of clean technology capital raised worldwide in 2010 as tracked by Cleantech Group. Cleantech Group reported clean technology venture investments in North America, Europe, China and India totaled $7.8 billion across 715 deals in 2010, up 28% from 2009 but still behind 2008's $8.8 billion. North American companies raised $5.3 billion in 2010, up 45% with 391 investment rounds. California led the way with investments of $3 billion or 58% share in North America.

California's largest deals in 2010 were $350 million invested in Better Place in electric vehicle charging infrastructure, $175 million in solar thin film company Solyndra that replaced a planned IPO, and $150 million in a Series D funding of utility-scale solar thermal power plant developer Bright Source Energy.

## 3.2. Clean Energy Industry Competitiveness

In an attempt to put global clean energy industries in competitive context, EBI has constructed a rating and weighting system to offer a preliminary assessment of clean energy industry competitiveness.

Nations or regions were rated subjectively based on a number of factors. A simple product of the rating and a weighting factor in the table below demonstrates that overall climate change industries are remarkably competitive in 2010, with no region showing clear leadership across all segments.

Just as EBI has found in the environmental industry before and as other global industries often demonstrate, the competitiveness of an industry in a nation or state is largely driven by domestic or local policy and the corresponding consistency of market demand for the products and services of that industry.

Clean energy industry examples include transportation where fuel pricing created the production of more fuel efficient vehicles in Japan and Europe, and programs for high speed rail were accelerated. In renewable energy we have seen consistent application of subsidies, incentives or feed-in-tariffs leading to demand consistent enough for companies and investors to build the world's biggest firms in wind and solar outside the United States, where items like renewing the Production Tax Credit bounced with political or budget seasons. In the green building segment, local, state and sometimes national codes, and often national non-profit standards-setting organizations, have driven local talent and suppliers to home designs, production and construction of a new generation of buildings. In carbon markets the European

Union Emission Trading System has created a carbon trading sector noticeably ahead of the rest of the world. Consulting & Research is one segment that the USA is most competitive, due partly to the commercial orientation of its professional expertise (much of engineering and other professional services are internal functions in Japan and European companies for instance) and also to budget allocations to research, adaptation and other areas upon which service companies build foundations of experience.

**Figure 23 Relative Competitiveness of Clean Energy Industries**

| | Calif. | US | EU | Japan | China | Dev. ROW | Weight |
|---|---|---|---|---|---|---|---|
| Low-Carbon Power | GE | G | GE | GE | GE | M | 5 |
| Carbon Capture & Storage | MP | M | OM | M | MP | P | 2 |
| Energy Efficiency & Demand Response | G | G | G | G | O | MP | 3 |
| Energy Storage | OG | O | O | OG | OM | M | 2 |
| Green Buildings | G | G | GE | G | OM | M | 3 |
| Transportation | G | G | G | GE | OG | M | 4 |
| Carbon Markets | OM | M | G | M | P | P | 3 |
| Adaptation | O | O | O | O | MP | MP | 2 |
| Consulting & Research | GE | GE | G | O | OM | MP | 3 |
| **Weighted Rating** | 100 | 96 | 105 | 97 | 75 | 45 | |

*SOURCE: EBI Inc. Source: Environmental Business International, Inc., San Diego,, E-excellent, G-good, O-OK, M-mediocre, P-poor; Based on subjective ratings of technology, commercial orientation, management, investment & finance, global presence, government support and labor derived from interviews; Rating is derived from a scale of 1 to 5 (poor to excellent) multiplied by the weighting factor.*

A review of the world's top companies in solar photovoltaics and wind turbines demonstrate how competitiveness has developed and evolved in those segments.

While the USA's First Solar led in production in 2009, the thin-film leader only took over from Germany's Q-Cells and Japan's Sharp as past annual production leaders. First Solar is a global company with manufacturing in the USA, Germany and the majority in Malaysia but its competitive position is largely a function of its technology development, its capitalization (both venture and public markets) and business management. Q-Cells and Sharp before has similar traits in technology and business but also the benefit of strong domestic markets headed by demand drivers like subsidies and feed-in tariff programs.

**Figure 24 Top-10 Suppliers of Solar Cells in 2008 and 2009 (production in MW)**

| Supplier | HQ | 2008 Production (MW) | Share (%) | 2009 Production (MW) | Share (%) |
|---|---|---|---|---|---|
| First Solar | USA:AZ | 503 | 7.5% | 1100 | 12.8% |
| Suntech | China | 494 | 7.3% | 595 | 6.9% |
| Sharp | Japan | 511 | 7.6% | 580 | 6.8% |
| Q-Cells | Germany | 574 | 8.5% | 540 | 6.3% |
| Yingly | China | 282 | 4.2% | 430 | 5.0% |
| JA Solar | China | 277 | 4.1% | 400 | 4.7% |
| SunPower | USA:Calif. | 236 | 3.5% | 390 | 4.6% |
| Kyocera | Japan | 300 | 4.5% | 390 | 4.6% |
| Motech | Taiwan | 272 | 4.0% | 360 | 4.2% |
| Gintech | Taiwan | 220 | 3.3% | 350 | 4.1% |
| Others | | 3065 | 45.5% | 3435 | 40.1% |
| **Total** | | **6,734** | | **8,570** | |

*Source: iSuppli Corp. September 2009*

**Figure 25 Photovoltaic Production by Top Ten Producing Companies, 2006 in MW**

| Company | 2006 Production (MW) | Share (%) |
|---|---|---|
| Sharp (Japan) | 434 | 17% |
| Q-Cells (Germany) | 253 | 10% |
| Kyocera (Japan) | 180 | 7% |
| Suntech (China) | 158 | 6% |
| Sanyo (Japan) | 155 | 6% |
| Mitsubishi (Japan) | 111 | 4% |
| Motech (Taiwan) | 102 | 4% |
| Deutsche Solar/Shell (US, Germany) | 86 | 3% |
| SunPower (USA, Philippines) | 63 | 2% |
| First Solar (United States) | 60 | 2% |
| Other | 919 | 36% |
| **Total** | **2,521** | |

*Source: Prometheus Institute*

In wind European leadership was driven largely by domestic policy and markets in Denmark, Germany and Spain. Wind power provided 19% of electricity production and 24% of generation capacity in Denmark in 2008. Denmark was a pioneer in developing commercial wind power during the 1970s, and by 2006 still half of the wind turbines operating in the world were produced by Danish manufacturers. Denmark policy was driven by early concerns over global warming in the 1980s with many coal-fired power plants that had become the norm after the 1973 and 1979 energy crises. Denmark adopted a target of cutting carbon emissions by 22% from 1988 levels by 2005 and in 1988, two years after the Chernobyl disaster; the Danes passed a law forbidding the construction of nuclear power plants. Planning of wind power was also deliberately streamlined by authorities in order to minimize hurdles. Denmark also provided 30%

of initial capital cost of wind installations in the early years which was gradually reduced to zero, but it still maintains a feed-in tariff.

Spain reports that the Spanish wind energy industry has over 500 companies, with about 150 wind turbine production plants and their machinery across the Spanish regions. It estimated total number of jobs supported by Spain's wind industry had reached more than 30,000 at the end of 2005 and expected to double that to 60,000 by 2010. The business framework for the installed capacity of wind power in Spain includes manufacturers (wind turbines, blades, towers, generators, multipliers, electrical equipment, etc.), suppliers (hydraulic and electrical equipment and equipment for controlling and regulating), mechanical construction and public works companies, installation companies and maintenance, exploitation, and engineering companies. Spain is noted for its private wind developers, the largest producer at the end of 2009 was Iberdrola, with 26% percent of Spanish capacity, followed by Acciona with 21% and EDP Renewables with 8%. Each of these firms has significant international business in the continent, in North America and in the developing world.

Spain's domestic demand in wind, like in solar, was driven by a generous feed-in-tariff system. This system is generally regarded as too generous and a cautionary tale for policy makers. To encourage development of solar power and reduce dependence on fossil fuels, Europe has generally relied on feed-in tariffs, through which governments pay a premium for electricity from renewable resources. (The United States has mostly used renewable energy standards.) When it was announced in the summer of 2007, Spain's premium payment for solar power was the biggest at 58 cents per kilowatt-hour. Although Spain's long-term goal had been to produce 400 megawatts of electricity from solar panels by 2010, it reached that milestone by the end of 2007 and the continued program led to a kind of boom-and-bust where there was overcapacity in solar panels that coincided with the global recession. The program was modified and feed in tariffs are still generally effective tools given appropriate pricing.

**Figure 26 Global Wind Energy Turbines: 2009 Installations in MW**

| | MW Installed | MW Share |
|---|---|---|
| Vestas: Denmark | 4,780 | 12.5% |
| GE Energy: USA | 4,740 | 12.4% |
| Sinovel: China | 3,520 | 9.2% |
| Enercon: Germany | 3,250 | 8.5% |
| Goldwind: China | 2,750 | 7.2% |
| Gamesa: Spain | 2,560 | 6.7% |
| Dongfang: China | 2,480 | 6.5% |
| Suzlon: India | 2,450 | 6.4% |
| Siemens: Germany | 2,250 | 5.9% |
| Repower: Germany | 1,300 | 3.4% |
| Others | 8,140 | 21.3% |
| **Total** | **38,210** | |

*Source: EBI model of the global wind industry derived from GWEC, AWEA, EER, BTM and individual company reports*

**Figure 27 Global Wind Energy Turbines: 2007 Installations in MW**

| | MW Installed | MW Share |
|---|---|---|
| Vestas: Denmark | 6,420 | 32% |
| Enercon: Germany | 3,010 | 15% |
| Gamesa: Spain | 3,010 | 15% |
| GE Wind: USA | 2,810 | 14% |
| Siemens: Germany | 1,410 | 7% |
| Suzlon: India | 1,200 | 6% |
| Nordex: Germany | 800 | 4% |
| Repower: Germany | 600 | 3% |
| Mitsubishi: Japan | 400 | 2% |
| Ecotecnia: Spain (now Alstom) | 400 | 2% |
| Total | 20,076 | |

*Source: EBI model of the global wind industry derived from GWEC, AWEA, EER, BTM and individual company reports*

The most significant development in solar and wind competitiveness has been the emergence of Asia suppliers, particularly in China.

According to renewable energy industry experts, the competitive advantage does not result from cheap labor as many policymakers are led to believe. Andy Paterson, EBI's federal markets and energy analyst based in Washington D.C. said: "It's not labor costs. Labor is less than 10% of costs; probably less than 5% in solar PV and a similar proportion for wind turbines and other manufactured components. The big draw to Asia is the 5-year to 10-year income tax holiday on the high tech, highly automated (minimal labor) products that nations like Malaysia, Singapore, Vietnam and the Philippines are offering." EBI conducted a study for Asia-Pacific Economic Cooperation (APEC) on the environmental industry in Malaysia, including renewable energy, and discovered that Malaysia offered First Solar a 17.5 year tax holiday to put it manufacturing in Malaysia. Paterson noted that by the end of these tax holidays, the capital equipment is fully depreciated, and that in addition, some of the developing countries throw in no-interest loans.

Paterson offers general recommendations, and commentary on the limitations and obstacles to such policy, to support the competitiveness of the U.S. clean energy industry:

1) Clear, sustained policy to guide investment (e.g., long term mandates like the biofuel standard, building codes for energy efficiency (EE) like LEED). Currently U.S. policy is widely regarded by the industry as terrible with its "on-off" tax policy for renewable energy (RE). China is authoritarian about it with its succession of 5-year plans.

U.S. Congress cannot provide clear guidance because there are big regional winners and losers, and very different energy use patterns (climate, urbanization) and vastly different access to fuels. Large democracies inherently face difficulty providing clear energy policy unless there is a broad-based cultural commitment (e.g., Germany, Scandinavia and Brazil). Paterson cites the cultural commitment is the USA as "Life, liberty, and the pursuit of happiness in suburbs (affordable electricity, cheap gas and SUVs), throwing in symbolic media icons Walker-Texas Ranger, Dallas, Starsky & Hutch, NASCAR, and the Kardashians.

2) Taxes on fossil fuels. Nothing defeats EE and RE time and again, like cheap oil and gas (1970s, 1986, 1998, 2008). If you have cheap fossil (USA vs. EU), as a percent of income, then all payback periods are pushed out.

Cheap fossil is harvesting our heritage from Earth (energy sources built up over millions of years) and setting them on fire in some contraption (car engine, turbine, or boiler), stealing that heritage from future generations. U.S. policy wants other countries to have access to (RE and other) energy so they grow economically and standards of living are improved (including reduced epidemics and blunted terrorism in failed states).

Neo-cons would say that taxes on fossil don't make us competitive, which is a first-order analysis, but if those tax receipts help reverse our deficits they can prevent fiscal drag and a run on the currency later, if used well. The point is that nothing competes well with cheap fossil. Recent history has proved this many, many times. So, we have a roller coaster knee-jerk energy policy (i.e., no strategic, multi-generational energy policy).

Fossil fuel taxes don't need global warming as justification. They are justified by: 1) "heritage tax"; stealing bounty from future generations; 2) reducing national deficits to defend the currency; 3) reducing pollution generally. Reaganites Charles Krauthammer and Art Laffer already agree on this, "We might as well tax fossil, so we keep the money ourselves, rather than sending those dollars to hostile regimes."

3) Lower capital costs and access to credit – RE and EE are inherently capital intensive, so lower capital costs (for both equity and debt) are essential. China's government essentially provides very, very cheap debt and equity (state ownership), and they have large domestic scale, so they win. We have low interest costs now, but a very risk averse banking sector for RE, EE, so the capital is still constrained.

4) Better technology: Deployed and not just developed. For RE and EE to be effective, better and cheaper storage is needed and other controls (Smart Grid) to deal with intermittency and bad weather. As an example, nuclear and fossil are much more robust against weather. Chicago uses high density load-serving nuclear in the winter, not wind or solar or biomass. Geothermal is not available in Chicago.

The proposed Clean Energy Deployment Administration (CEDA) and the DOE and USDA loan programs aim to deploy technology, but face budget challenges and political infighting. To meet the competitive challenge, the U.S. needs to triple public investment in energy technology, and the returns are high. President Obama made the administration's intention to support technology in clean energy clear in the 2011 State of the Union.

**Figure 28 Business Barriers to Renewable Energy**

**Barriers to Innovative Renewable Energy**

1. High Costs (capital and operating costs or maintenance)

2. Lack of Track Record (not much performance data at scale)

3. Uncertain Off-take Markets (need a long term purchase agreement)

4. Fragmentation of end use and market distribution (Diseconomies of Scale)

5. Inadequate Loan Security (e.g., integration with property)

**Barriers to Conventional Renewable Energy**

6. Cheap Fossil Fuels

7. Output Variability (e.g., cloud cover for solar, lack of wind)

8. Uncertain Feedstock Supply (biomass, wind)

9. Permitting or Siting Difficulty (regulatory confusion, and competing jurisdictions)

10. Lack of Transmission Access (particularly for wind, utility-scale solar)

*Source: Verdigris Capital study for the Clean Energy Deployment Administration*

## 3.3. Clean Energy Industry: Market Drivers

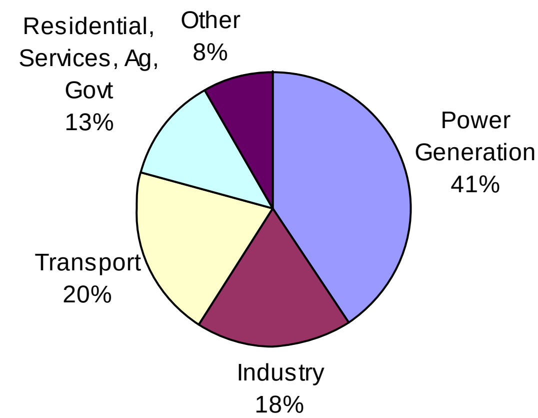
### 3.3.1. Global Policy Context: Carbon Trading

As EBI weighed the merits of using the term climate change industry and as it refines its definition of the clean energy industry as used in this report, we are well aware that renewable energy and climate change policy are not the only two drivers of growth in many segments. Energy security, environmental policy, fiscal policy, industrial policy, incentive programs, subsidies and other market drivers also play a role. However, we do expect the clean energy imperative to be influential if not central to all segments included in the EBI definition of the clean energy industry.

Responding to the worldwide need to produce clean energy and reduce carbon emissions, stakeholders across the economy, from investors and entrepreneurs to the world's largest corporations and to government and non-profits, will play a role either as customers and competitors or both in the clean energy industry.

The pie chart below illustrates the source of CO2 emissions by major sector, indicating both the dominant role of power generation but also the likelihood that no group of major emitters can be left out of the policy and regulatory equation. Europe's carbon trading system covered just the largest stationary emitters in power and industry in its initial phases, but it and other programs are busy with the details of adding transport, aviation, structures and even citizens in the future.

**Figure 29 Global CO2 Emissions (% of total)**




*Source: International Energy Agency*

Making reductions in carbon emissions without slowing the economy is a challenge faced by policymakers in all nations. Solutions will most likely be incremental improvements in power generation, transport, and buildings, but each major sector has its revolutionary concepts and innovative projects that indicate the transition to a low-carbon future won't necessarily be strictly evolutionary.

The table below shows the leading regional emitters and hence those markets where emission reduction initiatives will likely predominate. Although Europe has taken much of the initiative in carbon policy, critics of its trading program are correct in observing it has yet to stimulate the active emission reductions envisioned by policymakers. In its defense, Phase I of the EU trading system from 2005-2007 was a trial period, and while the market was 'long' (meaning too many allocations were given out), it is likely better for political reasons to have been long than short. The EU learning process will undoubtedly help accelerate the learning curve for national and regional trading schemes, and in spite of the political and economic speed bumps of 2008-2010, many experts expect to see a global system in effect by 2016-2018 in spite of the relative lack of progress towards such an agreement in Copenhagen in December 2009 or Cancun in 2010.

**Figure 30 Global CO2 emissions in 2007 (Mt CO2 and % of total)**

| | | |
|---|---|---|
| China | 6,071 | 21% |
| Asia | 2,898 | 10% |
| OECD Europe | 4,064 | 14% |
| Former Soviet Union | 2,412 | 8% |
| Middle East | 1,389 | 5% |
| OECD North America | 6,780 | 23% |
| OECD Pacific | 2,157 | 7% |
| Other | 3,191 | 11% |
| **Total** | **28 962** | |

*Source: International Energy Agency*

The understandable conflict between developed and developing nations is also apparent from looking at the global emissions profile. The developing world not only contributes a larger portion than previously thought, but emissions are also growing much faster. Current mechanisms like the Clean Development Mechanism (CDM) and Joint Implementation (JI) allow for technology transfer from north to south—and in effect emissions transfer from south to north—but possibly an equitable global market with clear incentives for local emissions reduction is the ultimate goal.

While the expectation that global carbon trading is inevitable is less widely agreed in 2011, programs continue and new ones emerge and the world will be watching California in 2011 and 2012.

### 3.3.2. Expectation of Which Segment Will Contribute Most to GHG Emission Reductions

While all segments of the clean energy industry are expected to play a role in reducing GHG emissions, in one survey EBI asked respondents to rank segments by their importance to reducing global carbon emissions to 2050. Understandably all issues are important but five or six rose to the top and another five or six posted significant numbers in the not important ratings.

**Figure 31 Significance to reducing global carbon emissions**

Please rate the following in terms of its significance to reducing global carbon emissions to 2050: Please pick the option "Most Important" only once. However, you may pick multiple responses to "Very Important", "Important", "Not Very Important" and "Meaningless".

| | Most important (pick 1) | Very important | Important | Not very important | Meaningless |
|---|---|---|---|---|---|
| Energy efficiency | 31% | 50% | 13% | 0% | 6% |
| Wind energy | 13% | 50% | 25% | 13% | 0% |
| Nuclear power | 19% | 31% | 31% | 13% | 6% |
| Alternative vehicles (hybrid, electric, plug-in) | 13% | 38% | 38% | 6% | 6% |
| Energy storage and demand response | 19% | 25% | 38% | 13% | 6% |
| Conservation | 6% | 38% | 50% | 6% | 0% |
| Public transportation | 0% | 38% | 56% | 6% | 0% |
| Solar energy | 0% | 50% | 31% | 13% | 6% |
| Hydroeletricity | 0% | 33% | 53% | 7% | 7% |
| Green buildings | 0% | 31% | 56% | 6% | 6% |
| Geothermal energy | 0% | 0% | 81% | 19% | 0% |
| Biofuels for transportation | 13% | 6% | 44% | 19% | 19% |
| Carbon capture and storage | 0% | 31% | 38% | 13% | 19% |
| Bioenergy for electricity | 0% | 13% | 47% | 33% | 7% |
| Wave and tidal energy | 0% | 6% | 44% | 44% | 6% |
| Vegetarianism | 0% | 6% | 19% | 50% | 25% |

*Source: CCBJ's Wind Energy Market Survey 2010.*

### 3.3.3. Companies Rank Market Drivers

What policies or non-policy factors are currently most impacting the clean energy business, and what factors are most likely to do so in the near term? To address this question EBI surveyed companies in specific segments to enable a ranking of the most influential market drivers for their business.

Factors driving the growth of the clean energy industry are numerous and vary by segment. The following three examples present company ratings of market drivers of their business in three segments.

**Figure 32 Ranking of Market Drivers in Clean Energy Consulting: 2008**

| | Very Strong: Positive | Strong: Positive | No Impact | Strong: Negative | Very Strong: Negative |
|---|---|---|---|---|---|
| Carbon markets (regulated credits & voluntary offsets) | 41.3% | 47.8% | 10.9% | 0.0% | 0.0% |
| Renewable energy standards or mandates | 33.3% | 57.8% | 8.9% | 0.0% | 0.0% |
| High price of oil | 26.8% | 65.9% | 0.0% | 7.3% | 0.0% |
| U.S./Regional/State climate change policy development | 32.6% | 53.5% | 11.6% | 0.0% | 2.3% |
| Consumer concern about climate change | 22.7% | 72.7% | 4.5% | 0.0% | 0.0% |
| Global corporations pursuit of carbon-reduction strategy | 34.1% | 47.7% | 13.6% | 2.3% | 2.3% |
| Incentives/subsidies for renewable energy | 27.9% | 55.8% | 16.3% | 0.0% | 0.0% |
| Cost of electricity | 22.7% | 65.9% | 4.5% | 6.8% | 0.0% |
| Existing climate change programs/regulation | 28.9% | 53.3% | 17.8% | 0.0% | 0.0% |
| New int'l climate change policy development | 15.9% | 63.6% | 18.2% | 0.0% | 2.3% |
| Heightened activity in power sector | 15.0% | 50.0% | 27.5% | 7.5% | 0.0% |
| Costs of renewable energy technology | 15.9% | 31.8% | 34.1% | 15.9% | 2.3% |
| Changing weather patterns/increased storms | 4.9% | 31.7% | 58.5% | 4.9% | 0.0% |
| December '07 USA Energy Bill | 2.4% | 35.7% | 52.4% | 4.8% | 4.8% |
| Activity in resource extraction industries | 5.3% | 26.3% | 55.3% | 10.5% | 2.6% |
| Global war on terror | 0.0% | 4.9% | 78.0% | 14.6% | 2.4% |
| Rate of inflation | 2.5% | 17.5% | 55.0% | 22.5% | 2.5% |
| Declining property values | 0.0% | 10.0% | 52.5% | 30.0% | 7.5% |
| Sub-prime mortgage crisis | 0.0% | 2.6% | 44.7% | 39.5% | 13.2% |
| Federal budget cuts | 2.4% | 7.1% | 31.0% | 52.4% | 7.1% |
| State budget cuts | 2.5% | 2.5% | 35.0% | 45.0% | 15.0% |
| Economic downturn/recession | 6.8% | 6.8% | 11.4% | 63.6% | 11.4% |

*Source: CCBJ/EBJ Climate Change Consulting Survey conducted November-December 2008. Question was: Rate the impact of the following market drivers on your ability to generate revenues from climate change consulting assignments in 2008.*

**Figure 33 Impact of Market Drivers on Revenues From Clean Energy Consulting: 2010**

| Rate the impact of the following market drivers on your ability to generate revenues from climate change consulting assignments in 2009: | Very Strong: Positive | Strong: Positive | No Impact | Strong: Negative | Very Strong: Negative |
|---|---|---|---|---|---|
| U.S./Regional/State climate change policy development | 25.9% | 51.9% | 11.1% | 7.4% | 3.7% |
| Existing gov't climate change programs/regulation | 21.7% | 56.7% | 15.0% | 5.0% | 3.3% |
| Corporate sustainability initiatives | 22.8% | 52.6% | 15.8% | 3.5% | 5.3% |
| Renewable energy standards or mandates | 21.1% | 47.4% | 24.6% | 5.3% | 1.8% |
| Incentives/subsidies for renewable energy | 19.2% | 51.9% | 25.0% | 3.8% | 3.8% |
| Federal budgets | 13.0% | 61.1% | 14.8% | 7.4% | 3.7% |
| New int'l climate change policy development | 20.7% | 37.9% | 31.0% | 6.9% | 3.4% |
| Price of carbon in USA (regional schemes or offsets) | 17.0% | 41.5% | 24.5% | 13.2% | 3.8% |
| Consumer concern about climate change | 15.3% | 45.8% | 32.2% | 3.4% | 3.4% |
| Cost of electricity | 10.7% | 58.9% | 17.9% | 8.9% | 3.6% |
| Price of oil | 10.5% | 52.6% | 26.3% | 10.5% | 1.8% |
| Global corporations specific pursuit of carbon-reduction strategy | 11.5% | 46.2% | 32.7% | 3.8% | 5.8% |
| Heightened activity in power sector | 5.6% | 46.3% | 37.0% | 7.4% | 3.7% |
| Changing weather patterns/increased storms | 8.6% | 22.4% | 58.6% | 8.6% | 3.4% |
| Activity in resource extraction industries | 2.0% | 28.0% | 56.0% | 10.0% | 4.0% |
| Price of carbon in EU | 7.7% | 19.2% | 59.6% | 7.7% | 5.8% |
| Property values | 5.9% | 13.7% | 62.7% | 11.8% | 5.9% |
| State budgets | 9.4% | 45.3% | 26.4% | 18.9% | 3.8% |
| Costs of renewable energy technology | 9.8% | 27.5% | 39.2% | 19.6% | 3.9% |
| Global war on terror | 3.9% | 13.7% | 56.9% | 17.6% | 7.8% |
| State of the economy | 12.3% | 35.1% | 10.5% | 31.6% | 12.3% |

*Source:CCBJ's Climate Change Consulting Survey 2010*

**Figure 34 Ranking Importance of Market Drivers in Wind Energy**

| | Most important | Very important | Important | Not very important | Meaningless |
|---|---|---|---|---|---|
| Rising cost of oil and conventional power | 33.3% | 60.6% | 3.0% | 0.0% | 3.0% |
| Government subsidies/financial incentives | 33.3% | 33.3% | 33.3% | 0.0% | 0.0% |
| Specific government renewable energy requirements (e.g. % by 2020) | 21.2% | 36.4% | 39.4% | 0.0% | 3.0% |
| More available financing | 3.0% | 45.5% | 39.4% | 9.1% | 3.0% |
| Specific policies to limit or affix a price on carbon emissions | 3.0% | 42.4% | 18.2% | 24.2% | 12.1% |
| Capital flowing into 'cleantech' | 3.1% | 40.6% | 31.3% | 21.9% | 3.1% |
| Climate change concerns | 6.3% | 31.3% | 53.1% | 6.3% | 3.1% |
| Energy security | 3.1% | 37.5% | 28.1% | 25.0% | 6.3% |
| Public demand for green power | 9.4% | 18.8% | 59.4% | 9.4% | 3.1% |
| Expansion of wind energy to new regions | 3.0% | 30.3% | 42.4% | 21.2% | 3.0% |
| More favorable regulatory environment for siting | 0.0% | 34.4% | 43.8% | 15.6% | 6.3% |
| Political statements of long-term wind energy goals | 6.3% | 15.6% | 40.6% | 28.1% | 9.4% |
| Accumulated critical mass of knowledge on wind power | 0.0% | 27.3% | 48.5% | 18.2% | 6.1% |
| Advent of interest in offshore wind energy | 0.0% | 15.2% | 30.3% | 42.4% | 12.1% |

*Source: CCBJ Wind Energy Survey in 2008. Question was: Please rate the importance of the following market drivers for the wind energy business in 2008*

**Figure 35 Ranking Importance of Market Drivers in Wind Energy**

| | Most important (pick 1) | Very important | Important | Not very important | Meaningless |
|---|---|---|---|---|---|
| Government subsidies/financial incentives | 40% | 40% | 20% | 0% | 0% |
| RPS, RES or specific government renewable energy requirements (e.g. % by 2020) | 28% | 48% | 17% | 3% | 3% |
| More available financing | 11% | 68% | 11% | 11% | 0% |
| Rising cost of oil and conventional power | 14% | 41% | 34% | 7% | 3% |
| More favorable regulatory environment for siting | 3% | 41% | 52% | 3% | 0% |
| Specific policies to limit or affix a price on carbon | 10% | 31% | 38% | 21% | 0% |
| Energy security | 3% | 38% | 38% | 21% | 0% |
| Stimulus spending in government (ARRA in the USA) | 3% | 31% | 48% | 14% | 3% |
| Climate change concerns | 4% | 29% | 50% | 14% | 4% |
| Capital flowing into 'cleantech' | 3% | 38% | 38% | 14% | 7% |
| Public demand for green power | 0% | 32% | 43% | 21% | 4% |
| Advent of interest in offshore wind energy | 7% | 23% | 43% | 17% | 10% |
| Accumulated critical mass of knowledge on wind power | 3% | 21% | 55% | 14% | 7% |
| Political statements of long-term wind energy goals | 3% | 33% | 17% | 40% | 7% |
| Expansion of wind energy to new regions | 3% | 24% | 34% | 31% | 7% |

*Source: CCBJ's Wind Energy Market Survey 2010*

**Figure 36 Ranking Importance of Market Drivers in Solar Energy**

| | Most important (pick 1) | Very important | Important | Not very important | Meaning-less |
|---|---|---|---|---|---|
| Government incentives | 40% | 30% | 25% | 0% | 5% |
| Government requirements for renewable energy | 29% | 26% | 26% | 16% | 3% |
| Cost of oil | 13% | 43% | 25% | 20% | 0% |
| Energy self-sufficiency / energy independence | 16% | 32% | 34% | 18% | 0% |
| Corporate image | 0% | 27% | 54% | 14% | 5% |
| Environmental regulations on power sources | 3% | 26% | 43% | 23% | 6% |
| Carbon cap-and-trade | 8% | 25% | 25% | 33% | 8% |
| Carbon tax | 9% | 23% | 29% | 26% | 14% |
| Carbon offset buyers | 3% | 20% | 29% | 29% | 20% |
| Voluntary green power programs | 3% | 15% | 29% | 35% | 18% |

*Source: CCBJ Solar Energy Survey in 2008. Question was: Please rate the following solar market drivers in terms of their impact driving your sales in 2008*

**Figure 37 Ranking Importance of Market Drivers in Green Building**

| | Most important (pick 1) | Very important | Important | Not very important | Meaning-less |
|---|---|---|---|---|---|
| Energy costs | 54% | 38% | 9% | 0% | 0% |
| Current or impending regulations and policies | 12% | 43% | 33% | 9% | 3% |
| Rebates and incentives | 10% | 40% | 33% | 16% | 0% |
| A “Green” Image | 13% | 28% | 44% | 12% | 3% |
| Reducing water consumption | 3% | 41% | 34% | 19% | 3% |
| Availability of more materials & services in GB supply chain | 3% | 35% | 45% | 12% | 6% |
| Reducing carbon footprints | 12% | 27% | 37% | 19% | 4% |
| Using more recycled materials | 3% | 30% | 41% | 25% | 1% |
| Obtaining value from carbon offsets | 3% | 23% | 26% | 29% | 19% |

*Source: CCBJ Green Building Survey in 2008. Question was: Please rate the importance of the following market drivers for the green building business in 2008*

### 3.3.4. Recovery Funding as a Driver

In an initial review of the unprecedented economic recovery package approved by Congress and signed by President Obama in mid-February 2009 under the American Recovery and Reinvestment Act (ARRA), EBI endeavored to summarize the plan and to gauge the expectations of myriad companies eyeing opportunities for contracts and investment support. In March 2009, CCBJ and sister publication Environmental Business Journal conducted surveys of companies in their respective industries and found that 60% of the 179 respondents are devoting significant business development resources to the ARRA, with 10% saying it represented a majority and 3.4% the 'centerpiece' of their focus.

**Figure 38 Importance of the Stimulus Package**

| | # of responses | % of total |
|---|---|---|
| Meaningless | 12 | 6.8% |
| A marginal impact on our business plan | 59 | 33.3% |
| One of a few key initiatives for new business development | 83 | 46.9% |
| The majority of our new business efforts | 17 | 9.6% |
| The centerpiece of our focus | 6 | 3.4% |
| **Total** | **177** | **100.0%** |

*Source: Climate Change Business Journal February & March 2009 survey of the Stimulus Package (ARRA); Survey question was: How would you rate the relative importance of the stimulus package and resulting programs to your business in 2009-2010?.*

The ARRA is so vast that it was no easy task to quantify the provisions related to energy and climate change. Clean energy trade media and analysts published figures in the $45-70 billion range. But sifting the program with a finer filter that counts such things as the energy-efficiency elements mandated in public housing upgrades and estimates of climate change capital spending by various federal departments, EBI tallies ARRA's funding for the clean energy industry at $76 billion: $52 billion in direct spending and $24 billion in tax provisions.

Responsibility for implementing the ARRA was spread across Washington, from the Department of Energy (DOE), Housing and Urban Development (HUD), Department of Defense (DOD), Department of the Interior (DOI) and others. The Department of the Treasury is overseeing some $20 billion in tax credits and grants related to energy and climate change. States will also determine priorities—with new levels of accountability, according to the Obama Administration—for, among other things, $3.1 billion dedicated to state energy agencies like the California Energy Commission.

Federal agencies have been under enormous pressure to develop rules and procedures to disburse cash in grants, loans, contracts and internal hiring. Perhaps no agency is feeling the heat as much as the DOE, which received $16.8 billion for programs under its Energy Efficiency & Renewable Energy (EERE) division, $6 billion to loan to technology developers, $4.5 billion for grid modernization, $3.4 billion for fossil energy R&D and other big pots of money. Congress gave the DOE varying degrees of discretion in how it channels funds. Out of $2.5 billion for advanced technology research, for example, $800 billion must go to biomass, $400 million to geothermal and $50 million for information and communication, while the remaining $1.25 billion can be spent as DOE sees fit.

**Figure 39 Energy & Climate Change Spending Programs in the ARRA ($bil)**

| | Spending ($bil) | Total ($bil) |
|---|---|---|
| Department of Energy: Energy Efficiency (EE) & Renewable Energy (RE) | | |
| Weatherization Assistance | 5 | |
| State Energy Programs # | 3.1 | |
| Energy Efficiency & Conservation Block Grants # | 3.2 | |
| RE Research, Development, Demo & Deployment* | 2.5 | |
| Advanced Batteries & Components (grants) | 2 | |
| Energy Star program & matching grants for state rebates | 0.3 | |
| Plug-in Electric Drive Vehicle Program | 0.4 | |
| Assistance for state & local govt's to acquire alternative fuel vehicles | 0.3 | 16.8 |
| Other DOE Programs | | |
| Grid modernization | 4.4 | |
| Grid modernization worker training | 0.1 | |
| Fossil energy R&D | 3.4 | |
| Non-Defense Environmental Cleanup | 0.5 | |
| Uranium Enrichment Decontamination & Decomm. Fund. | 0.4 | |
| Science programs | 1.6 | |
| Advanced Research Projects Agency-Energy | 0.4 | |
| Innovative technology loan guarantees | 6 | |
| BPA and WAPA transmission upgrades | 6.5 | |
| WAPA Conservation & Renewable Energy | 0.02 | |
| Leading edge biofuel projects | 0.5 | 23.8 |
| Department of Labor | | |
| Job training, research & labor exchange for EE and RE industries | 0.5 | 0.5 |
| Federal Transit Administration | | |
| Energy and greenhouse gas reduction for public transit | 0.1 | 0.1 |
| General Services Administration | | |
| EE and Alt. Fuel/Hybrid/Elec. Vehicle Procurement | 0.3 | |
| Green Building Upgrades | 4.5 | 4.8 |
| Department of Education | | |
| Green building modernization of public buildings & schools ** | 2 | 2 |
| Department of Defense | | |
| EE upgrades ** | 0.8 | 0.8 |
| Department of Interior | | |
| EE upgrades to facilities ** | 0.2 | 0.2 |
| Environmental Protection Agency | | |
| Green and energy-efficient water infrastructure # | 1.2 | 1.2 |
| Housing and Urban Development | | |
| EE renovations & upgrades for public & tribal housing *** | 1.7 | |
| Energy retrofits for Sec. 8 Housing **** | 0.3 | 2 |
| Clean energy industry Spending | | 52 |

*Sources: EBI Inc. review of ARRA text, ProPublica.org, Office of Cong. Mike Thompson, federal websites, and other sources; * Including. $800 mil biomass, $400 mil geothermal, $50 IT & communications; **Estimate based on 20% of total capital program where energy efficiency or green buildings are mentioned but not mandatory; *** Estimate based on $1B required to be spent on EE plus 20% of remaining $3.5 billion being spent on EE (mentioned but not required); **** $2.5B for RD&D at universities, firms, nat'l labs "to foster energy independence, reduce carbon emissions and cut utility bills." # Indicates top three opportunities identified by respondents to the CCBJ survey.*

**Figure 40 ARRA Tax Programs that Pertain to the Clean energy industry**

| | $ bil | total |
|---|---|---|
| Joint Committee on Taxation estimates of the impacts of ARRA tax policies over 10 years | | |
| Renewable Energy Tax Credits | | |
| Extension & modification of RE production tax credit* | 13.14 | |
| Election to claim RE investment tax credit (ITC)* | 0.29 | |
| Grants in lieu of investment tax credits * | 0.01 | |
| Removal of ITC caps for distributed RE systems | 0.87 | |
| Clean Renewable Energy Bonds | 0.58 | |
| Energy Conservation Bonds | 0.8 | |
| EE home improvements | 2.03 | |
| Alternative Refueling Property | 0.05 | |
| Plug-in Electric Drive Vehicle Credit | 2.01 | |
| Parity for Employee Transit Benefits | 0.19 | 19.97 |
| Business Tax Credits | | |
| Advanced Energy Investment Credit | 1.66 | 1.65 |
| Infrastructure Financing | | |
| School Construction Bonds (EE/green building)** | 1.98 | 1.98 |
| Clean energy industry Tax Programs | | 23.6 |
| All Tax Programs in ARRA | | 288 |
| CC Industry Spending Programs (see p.4) | | 52.1 |
| ARRA Energy & Climate Change Funding | | 75.7 |
| ARRA Total Funding | | 787 |

** As noted in accompanying text the amounts estimated for RE tax credit programs are likely wrong due to assumptions about tax credit capacity among investors. **Estimate based on 20% of $9.877B devoted to EE and green building. Sources: CCBJ review of ARRA text, ProPublica.org, Office of Cong. Mike Thompson, federal websites, and other sources*

### CCBJ Survey of Stimulus Funding

In accessing government money, contractors say that the crucial element is a flexible contract vehicle. The speed at which the administration has been seeking to get ARRA and other funds disbursed highlights the importance of already "having a seat at the table' with an existing contract. Behind existing DOE contracts, CCBJ survey respondents rated existing EPA contracts and existing state contracts as the most valuable contract vehicles.

**Figure 41 Ranking of Contract Vehicles for ARRA Funds**

| |
|---|
| Existing DOE contracts |
| Existing EPA contracts |
| Existing contracts with other federal agency |
| Existing state contracts |
| Existing local/municipal contracts |
| Existing teaming arrangements with primes |
| Existing private client relationships |
| Non-profit entity/partnerships |
| University partnerships |
| Small biz/minority contractor status |
| New contract vehicles |

*Source: Climate Change Business Journal February & March 2009 survey of the Stimulus Package (ARRA); Survey question was: How do you rate the following contract vehicles or attributes in terms of their value in securing ARRA funds for projects?*

Another survey question asked what segments would benefit most from the ARRA (see table below), and the ratings fell into three tiers. At the top were renewable, energy efficiency and green building companies as expected, but joining them were construction firms and government research entities. These firms were expected to 'very strongly benefit' from the ARRA by 30-40% of respondents, with only 20-30% expecting modest or no benefit for them. (Worth noting is the survey respondent group included about a 20% core of 'naysayers' that said modest or no benefit for every segment of the climate change and environmental industries.) The second tier of firms is characterized by 15-25% rated to 'very strongly benefit' and 30-40% in 'modest or no benefit', and features expected core segments consultants, bioenergy, CCS and new generation transportation firms. The bottom tier not expected to benefit much from the ARRA includes many of the traditional environmental industry segments as would be expected.

**Figure 42 Ranking of Company Types Most Likely to Benefit from the ARRA**

| | Very strongly benefit | Will benefit | Modest or No Benefit |
|---|---|---|---|
| Renewable energy project developers | 37% | 44% | 19% |
| Energy Efficiency Contracting & Construction | 39% | 41% | 20% |
| Wind Turbine Sales | 34% | 49% | 17% |
| PV/Solar Power Systems | 36% | 44% | 20% |
| Energy Efficiency Analysis & Design | 35% | 46% | 20% |
| Energy Efficiency Equipment & Systems | 35% | 42% | 23% |
| Green Buildings Equipment & Materials | 32% | 43% | 25% |
| Construction firms | 31% | 44% | 25% |
| Government research entities | 27% | 49% | 24% |
| Green Buildings Construction | 31% | 40% | 29% |
| Green Buildings Design | 30% | 39% | 30% |
| Geothermal Systems Manufacturing | 29% | 42% | 29% |
| Bioenergy equipment & systems | 26% | 45% | 29% |
| Energy Storage development | 26% | 39% | 35% |
| Transportation C&E firms | 23% | 43% | 34% |
| Climate Change Consulting | 20% | 46% | 34% |
| Environmental consulting & engineering | 19% | 45% | 36% |
| Carbon Capture & Storage (CCS) | 18% | 48% | 34% |
| Climate Change Research | 19% | 45% | 36% |
| Hybrid cars | 21% | 40% | 39% |
| Fuel Cells | 20% | 42% | 38% |
| Transportation Batteries | 22% | 34% | 44% |
| Biofuels | 19% | 40% | 41% |
| Municipal water/wastewater systems | 12% | 47% | 40% |
| Carbon Trading | 16% | 43% | 41% |
| Air pollution control equipment manufacturers | 11% | 34% | 55% |
| Environmental information systems/software | 9% | 36% | 55% |
| Water equipment manufacturers | 8% | 32% | 60% |
| Non-profit entities | 7% | 33% | 60% |
| Instrument manufacturers | 8% | 29% | 63% |
| Environmental testing labs | 5% | 33% | 62% |
| Private water utilities | 4% | 33% | 63% |
| Remediation contractors | 1% | 30% | 69% |
| Hazardous water management | 3% | 26% | 71% |
| Solid waste management | 2% | 21% | 77% |

*Source: Climate Change Business Journal February & March 2009 survey of the Stimulus Package (ARRA); Survey question was: To what degree do you think the following segments of the environmental industry and the clean energy industry will benefit from ARRA in terms of prospects for business?*

When asked to rate specific ARRA programs for their company, there was a similar tiering of responses. Energy efficiency block grants, green water infrastructure and state energy programs rose fairly noticeably to the top. More than 20% rated these top three (see table below) as the 'best opportunity' or offering 'great potential', with less than half saying little or no potential. The second tier, and much larger group, is characterized by programs rated 10-15% as the 'best opportunity' or offering 'great potential', with 60-70% of respondents rating them as having little or no potential.

**Figure 43 Ratings of Stimulus Package Programs**

| | Best opportunity | Great potential | Good/Some potential | Little/No potential |
|---|---|---|---|---|
| Energy Efficiency & Conservation Block Grants ($3.2 billion) | 5% | 16% | 26% | 54% |
| Green and energy-efficient water infrastructure ($1.2 billion) | 7% | 6% | 36% | 50% |
| State Energy Programs ($3.1 billion) | 5% | 11% | 35% | 49% |
| Electricity Delivery & Energy Reliability, including smartgrid ($4.5 billion) | 6% | 9% | 27% | 58% |
| Green building modernization of public buildings & schools ($9.8 billion) | 6% | 6% | 26% | 61% |
| Expansion of PTC, ITC, grants in lieu of tax credits for RE projects ($22 billion) | 5% | 7% | 19% | 68% |
| Research and training for careers in EE and RE ($500 million) | 5% | 7% | 21% | 67% |
| Advanced Research Projects Agency-Energy ($400 million) | 4% | 6% | 26% | 64% |
| DOD and GSA energy efficiency building retrofits ($8.1 billion) | 4% | 7% | 21% | 68% |
| Innovative Technology Loan Guarantees ($6 billion) | 3% | 6% | 27% | 63% |
| Increase in Clean Renewable Energy Bond allocations ($1.6 billion) | 6% | 5% | 18% | 71% |
| Qualifying advanced energy project tax credit ($2.3 billion) | 4% | 7% | 18% | 71% |
| Energy conservation retrofits for public housing ($4 billion) | 4% | 8% | 17% | 72% |
| Energy and greenhouse gas reduction for public transit ($100 million) | 4% | 7% | 15% | 74% |
| Alternative fuel vehicles pilot program ($300 million) | 4% | 5% | 18% | 72% |
| Fossil Energy Research & Development ($3.4 billion) | 3% | 5% | 20% | 72% |
| Energy retrofits for Sec. 8 Housing ($250 million) | 3% | 6% | 15% | 76% |
| Removal of caps on 30% credit for homeowners installing RE devices | 4% | 4% | 13% | 78% |
| Energy Star program & matching grants for state rebates ($300 million) | 4% | 4% | 15% | 77% |
| BPA and WPA transmission upgrades ($6.5 billion) | 3% | 4% | 17% | 76% |
| Weatherization Assistance ($5 billion) | 3% | 4% | 13% | 80% |
| Advanced Batteries & Components Grants ($2 billion) | 1% | 6% | 13% | 80% |
| Plug-in Electric Drive Vehicle Program ($400 million) | 2% | 4% | 10% | 84% |
| Assistance for state/local gov'ts for alternative fuel vehicles ($300 million) | 1% | 3% | 11% | 84% |

*Source: Climate Change Business Journal February & March 2009 survey of the Stimulus Package (ARRA); Survey question was: Please rate the sections of the American Recovery and Reinvestment Act (ARRA) in terms of their potential for contracts and revenues for your company. Sections are ranked based on a factor of six possible responses: Best Opportunity; Great Potential; Good Potential; Some Potential; Little Potential; or No Potential.*

In the bottom tier, where less than 10% said 'best opportunity' or 'great potential' and 75-85% said little or no potential, were a couple of programs expected to offer more promise but perhaps somewhat less glamorous. The $5-billion weatherization program and the $6.5-billion electricity transmission programs each offer a significant scale of funding, as well as logical business tangents for consultants that made up 47% of the respondent pool and for specialty contractors (8%). Weatherization has been identified by a few asbestos contractors as a logical new opportunity. A final observation is that even in the bottom tier of preferred programs there is still a majority of programs that 3-4% rate as the best opportunity. These are not substantially larger than the upper tiers and are indicative of the level of specialization among clean energy firms and environmental firms or of fragmentation in the respective industries.

### 3.3.5. California Market Drivers

While this report was not intended to be a treatise on California's broad suite of policies relating to clean energy industry markets and companies, it would be remiss not to acknowledge the most influential programs as mentioned most frequently by industry participants and some of the agencies, members of non-profits and academia interviewed for this report.

First, with the implementation of AB 32 ahead as of the beginning of 2011, EBI summarizes the main elements of AB 32 and what types of client sectors and solution providers are most likely to be affected.

**Figure 44 AB 32: Sectors Impacted and Opportunities Created By Leading Measures**

| AB32 Program Element | Million mtCO2e reductions (2020) | Business sectors impacted | Solutions providers to benefit |
|---|---|---|---|
| Cap-and-Trade Program linked to WCI partners | 34.4 | Power, oil and gas, cement, food/beverage, industrial gases, glass, other menu., large institutions; after 2015, fuel suppliers. | Suppliers of combustion equipment, heat recovery systems, etc.; environmental consulting and engineering firms; allowance and offset sellers; offset project developers |
| Light-duty Vehicle GHG standards | 27.7 | Vehicle manufacturers and dealers | Vehicle manufacturers, automotive technology developers and component suppliers. |
| Energy Efficiency (incl. combined heat/power and solar water heating) | 26.3 | Utilities, energy users | Equipment suppliers; architects & engineers; energy efficiency consultants and contractors. |
| Renewable energy standard (33% by 2020) | 21.3 | Utilities | Equipment suppliers; project developers and independent power producers; consulting & engineering firms; construction contractors. |
| Low-carbon fuel standard | 15 | Fuel suppliers | Developers and suppliers of biofuels, natural gas and other low-carbon fuels. |
| Planning/transportation targets | 5 | Local governments | Planning, land-use and transportation consultants; developers of transit-oriented projects; suppliers of intelligent transportation systems. |
| Industrial emissions | 0.3 | Power, oil and gas, cement, industrial gases (facilities emitting >500,000 tCO2e) | Environmental consulting and engineering firms; Suppliers of combustion equipment, heat recovery systems, etc.. |
| Green building strategy | 26 | State and local governments and institutions; developers and builders; owners of commercial, industrial and residential property | Architects & engineers; consultants and contractors with expertise in energy, water and waste efficiency, Suppliers of green building materials and related systems. |
| High GWP gases | 20.2 | Suppliers of high-GWP gases; motor vehicle a/c manufacturers; users of large a/c and refrigeration's systems; refrigerated fleet operators; vehicle owners. | Manufacturers of large-capacity refrigerator and a/c systems; HVAC and refrigerator repair and service firms; Smog Check auto shops; |
| Recycling and waste | 10 | Landfill operators; commercial firms. | Consulting engineers to solid waste industry; commercial recycling operations. |
| Water | 4.8 | Water utilities; local governments; water users | Consulting engineering firms. |

*Source: EBI Inc. Not listed: Voluntary or redundant programs: Agriculture, Vehicle efficiency measures, Goods movement, Million solar roofs, Medium/heavy duty vehicles*

## Legislation and Programs Driving the Industry in California

The following legislative acts or agency programs were cited most frequently by industry participants as having a positive influence on their business.

- Executive Order #S-3-05 calls for a 30% reduction below business as usual by 2020
- Global Warming Solutions Act AB32: a comprehensive, multi-year program to reduce GHG emissions to 1990 levels by the year 2020
- CA Air Resources Board (ARB) Scoping Plan (Scoping Plan Measures Implementation Timeline of 10/2010 list 69 specific measures)
- SB 375: Requires ARB to develop regional greenhouse gas emission reduction targets. Applies to buildings, passenger vehicles, planning.
- Renewable Electricity Standard: Executive Order S-21-09 requires the state's load serving entities to meet a 33 percent renewable energy target by 2020
- CPUC Long Term Efficiency Plan
- Executive Order S-20-04 calls for reducing electricity consumption in existing and new state-owned buildings state buildings 20 percent by 2015
- Executive Order S-06-06 promoting the use of bioenergy
- 2010 California Green Building Standards Code (CalGREEN) set by the Building Standards Commission (BSC)
- HR 6 Energy Bill signed December 2008 by former President Bush appropriating $125 million for workforce training in renewable energy industries
- AB 2021 – created to overcome market barriers in energy efficiency
- SB 1760 (in-state green technology)
- SB 1672 ($3 billion bonds for new jobs)
- AB2477 CA Green Jobs Act 2008
- Diesel Risk Reduction Plan
- Toxic and criteria pollutant reductions to reduce near-source exposure and meet State Implementation Plan targets
- Assembly Bill (AB) 118's Alternative and Renewable Fuel and Vehicle Technology Program (ARFVTP).

More programs are highlighted on ARB's website: http://www.arb.ca.gov/cc/cc.htm

More details of selected programs are: (Note: The text in this brief review was adapted from state government websites.)

• AB 32: Assembly Bill 32 (AB32), the California Global Warming Solutions Act of 2006 mandates that California must reduce its greenhouse emissions to 1990 levels by 2020. The bill sets a goal of approximately an 11% reduction from current emissions levels and nearly a 30% reduction from projected business-as-usual levels in 2020. 25% of the state's greenhouse gas emissions are attributable to electricity generation while 38% are attributed to the transportation sector. Education and workforce development implications of AB32 are addressed in the Air Resources Board's proposed scoping plan, revised in 2008, under section IV: Implementation (pages 101-104).

• CA Executive Order S-14-08 (November 17, 2008). This order established a Renewable Portfolio Standard target for California mandating that all retail sellers of electricity shall serve 33% of their load with renewable energy by 2020. State government agencies are hereby directed to take all appropriate actions to implement this target in all regulatory proceedings, including siting, permitting, and procurement for renewable energy power plants and transmission lines. Section 16 states, "In order to facilitate the timely permitting of renewable energy projects, all state regulatory agencies shall give priority to renewable energy projects as set forth in this Executive Order."

• SB 1: The Million Solar Roofs Bill. This bill provides funding, incentives and mandates to increase solar panels throughout the state. Now known as the California Solar Initiative, the $3.3 billion incentive plan for homeowners and building owners who install solar electric systems will lead to one million solar roofs in California by 2017. The bill aims to achieve 3,000 megawatts of additional clean energy and to reduce the output of greenhouse gases by three million tons – the equivalent to taking one million cars off the road. Announced as a component of the California Solar Initiative in 2007, the New Solar Homes Partnership (NSHP) aims to create a self-sustaining market for solar homes and gain builder commitment to install solar energy systems. A new home that qualifies for the NSHP is at least 15% more efficient than the current building standards.

• AB 1451 will build on the state's solar power usage by continuing a property tax exclusion for projects that utilize solar panel energy and expanding the exclusion to builder-installed solar energy systems in new homes.

• AB 2466 will increase energy efficiency and help protect the environment by authorizing local governments to receive a utility bill credit for surplus renewable electricity generated at one site against the electricity consumption at other sites.

• AB 2267 builds on the state's green economy by requiring the CPUC to grant incentives to eligible California-technology manufacturers. This bill also requires the Energy Commission to give priority to California-based companies when granting awards and will not only create jobs for Californians but will attract more clean-tech and green-tech companies to the state.

• AB 35: Green Buildings – Requires state buildings to be built to environmental standards such as LEED. California has adopted the first statewide green building code which will promote green building practices and energy efficient technologies. The purpose of this code is to conserve natural resources, protect the economy, and reduce California's carbon footprint. The provisions of the California Building Code will apply to every building in California. The new standards become guidelines starting July 2009 and a grace period will render the new code optional until 2010 so that industry and enforcement agencies have time to prepare for the new building standards.

• AB 118 provides the funding for development and implementation of alternative fuel transportation. It is aimed at moving California forward toward a petroleum-free future by raising funds to invest in research and development of clean alternative fuel and vehicle technologies, deploy alternative fuel vehicles and fuels, and support development of alternative fuel infrastructure. The bill will raise $1.4 billion dollars over the next seven years to fund the program.

• As part of Los Angeles's plan to create the "Greenest Big City in America" all new city buildings will be built to LEED standards. The city presently has 59 LEED registered projects, placing it fifth in the nation for the highest number of registered projects. Additionally, Los Angeles plans to audit 500 city buildings and study the potential for green retrofitting job opportunities and training programs. The result could save the city $10 million in energy costs per year.

• The Green Jobs Act of 2007 (H.R. 2847), passed in June 2007, will create the energy efficiency and renewable energy worker training program within the Workforce Investment Act. Twenty percent of the program's $125 million appropriation will be dedicated to services that create pathways out of poverty for low-income adults.

• The Energy Efficiency and Renewable Energy Workforce Development Amendment sponsored by Senator Bernie Sanders of Vermont and former Senator Hillary Clinton of New York allots $100 million to train workers in "green collar jobs" – jobs that involve the design, manufacture, installation, operation, and maintenance of clean, efficient energy technologies.

• Clean Car Standards - Pavley, Assembly Bill 1493. On September 24, 2009, the ARB adopted amendments to the "Pavley" regulations that reduce greenhouse gas (GHG) emissions in new passenger vehicles from 2009 through 2016.

## 3.4. Economic Comparison with the Environmental Industry and the Green Economy

EBI has theorized that the emergence of the clean energy industry is analogous to the emergence of the environmental industry over the past four decades.

### 3.4.1. Definition of the Environmental Industry

To provide perspective and a comparison between the clean energy industry and the environmental industry, we include below EBI's definition of the environmental industry.

EBI defines the environmental industry as all revenue generation associated with environmental protection, assessment, compliance with environmental regulations, pollution control, waste management, remediation of contaminated property and the provision and delivery of environmental resources. The environmental industry represents total revenues of more than $300 billion, generated by about 30,000 private sector companies and more than 80,000 public sector entities in the United States, employing 1.7 million Americans. The U.S. environmental industry generated $305 billion in revenues in 2009 and the global environmental market was about  $776 billion in 2009.

EBI's basic methodology for market quantification has been annual surveys of revenues generated by companies, broken down three or four different ways such as by customer, by product or service, by media and by geographic region. Each year, EBJ compiles revenue information on more than 1,300 environmental companies and public sector entities generating environmental business revenues.

Although analysis of clean energy and other markets has been ongoing since 1987, EBI initiated detailed research on the clean energy industry in 2007. Our basic methodology has been similar to that used for the environmental industry led by the compilation of secondary data and databases of companies in each segment followed by primary research including surveys interviews.

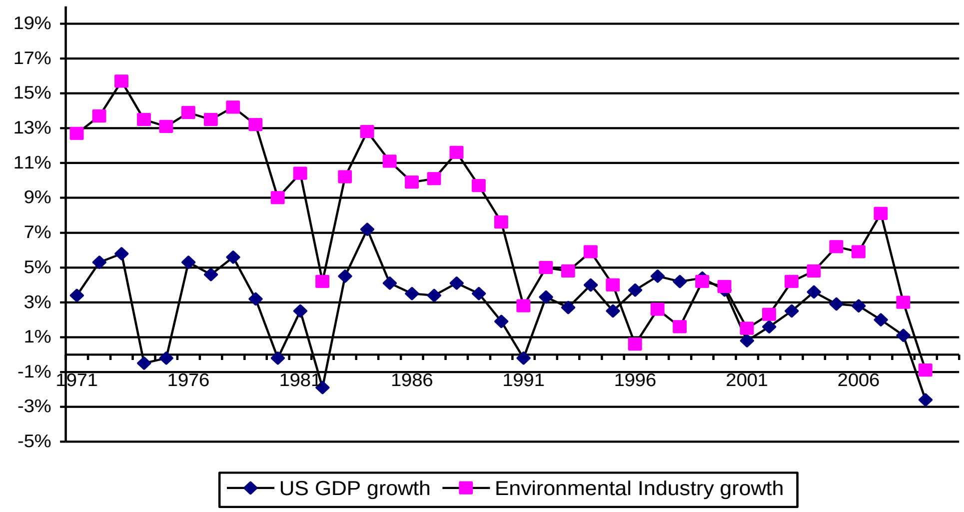
**Figure 45   Environmental Industry Segments**

| | | |
|---|---|---|
| **Environmental Services** | | |
| Environmental Testing & Analytical Services | Provide testing of "environmental samples" (soil, water, air and some biological tissues) | Regulated industries, Gov't, Environmental consultants Hazardous waste and remediation contractors |
| Wastewater Treatment Works | Collection and treatment of residential, commercial and industrial wastewaters. These facilities are commonly know as POTWs or publicly owned treatment works. | Municipalities, Commercial Establishments & All industries |
| Solid Waste Management | Collection, processing and disposal of solid waste | Municipalities & All industries |
| Hazardous Waste Management | Manage on-going hazardous waste streams, medical waste, nuclear waste handling | Chemical companies<br>Petroleum companies<br>Government agencies |
| Remediation/Industrial Services | Physical cleanup of contaminated sites, buildings and environmental cleaning of operating facilities | Government agencies<br>Property owners<br>Industry |
| Environmental Consulting & Engineering (C&E) | Engineering, consulting, design, assessment, permitting, project management, O&M, monitoring, etc. | Industry, Government<br>Municipalities<br>Waste Mgmt. companies, POTWs |
| **Environmental Equipment** | | |
| Water Equipment & Chemicals | Provide equipment, supplies and maintenance in the delivery and treatment of water and wastewater. | Municipalities & All industries |
| Instruments & Information Systems | Produce instrumentation for the analysis of environmental samples. Includes info systems and software. | Analytical services, Gov't<br>Regulated companies |
| Air Pollution Control Equipment | Produce equipment and tech. to control air pollution. Includes vehicle controls. | Utilities, Waste-to-energy<br>Industries, Auto industry |
| Waste Management Equipment | Equipment for handling, storing or transporting solid, liquid or haz. waste. Includes recycling and remediation eqmnt. | Municipalities<br>Generating industries<br>Solid waste companies |
| Process & Prevention Technology | Equipment and technology for in-process (rather than end-of-pipe) pollution prevention and waste treatment and recovery | All industries |
| **Environmental Resources** | | |
| Water Utilities | Selling water to end users | Consumers, Municipalities & All industries |
| Resource Recovery | Selling materials recovered and converted from industrial by-products or post-consumer waste | Municipalities<br>Generating industries<br>Solid waste companies |
| Clean Energy Systems & Power | Selling power and systems in solar, wind, geothermal, small scale hydro, energy efficiency and DSM | Utilities<br>All industries and consumers |

*Source: EBI Inc. (San Diego, Calif.)*

First, annual growth in the U.S. environmental industry compared to the economy shows a long stretch from 1970 to 1990 when growth was mostly 8-12 points higher in the environmental industry. The industry then slowed to 2-3 points higher than the economy until the mid-90s when it went through an adjustment and growth sank beneath the economy from 1996-1998 and was roughly equivalent from 1999-2004. Heightened energy, commodity and property prices fueled a growth spurt in the environmental industry in 2004-2008 until the economic crisis.

**Figure 46 U.S. Environmental Industry Growth vs. GDP 1970-2010**



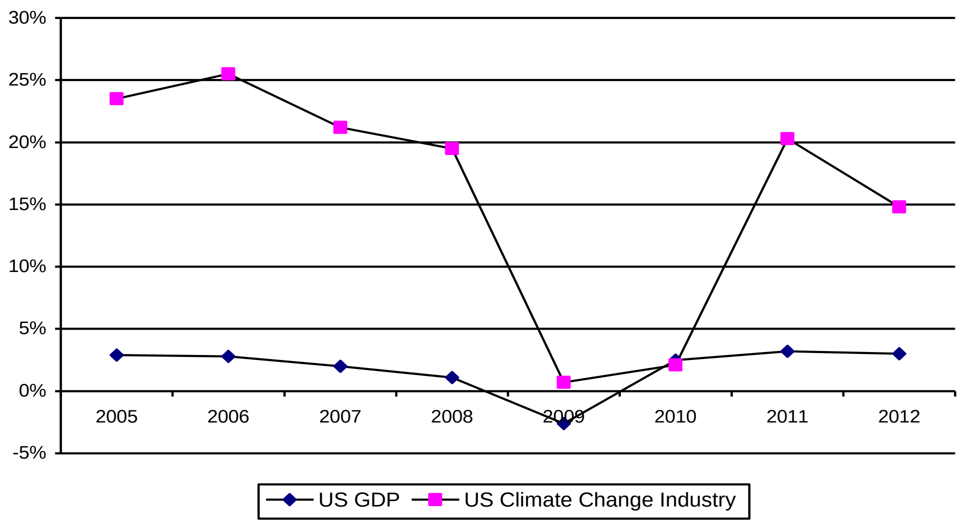

*Source: EBI Inc.*

This brief history lesson shows that the regulatory era lasted 20+ years in the environmental industry, but while it achieved healthy growth rates of 10-15% for a number of years it never reached the 30-40% growth rates that we have seen in the clean energy industry.

Another observation is that emerging industries eventually become more closely bound to the economy as the unique drivers that created them come to have less of an impact than basic economic issues, like customers' ability to pay and economic growth in relative terms. In addition the standard modes of operation and design and manufacturing of products eliminate the needs for tack-on equipment and services.

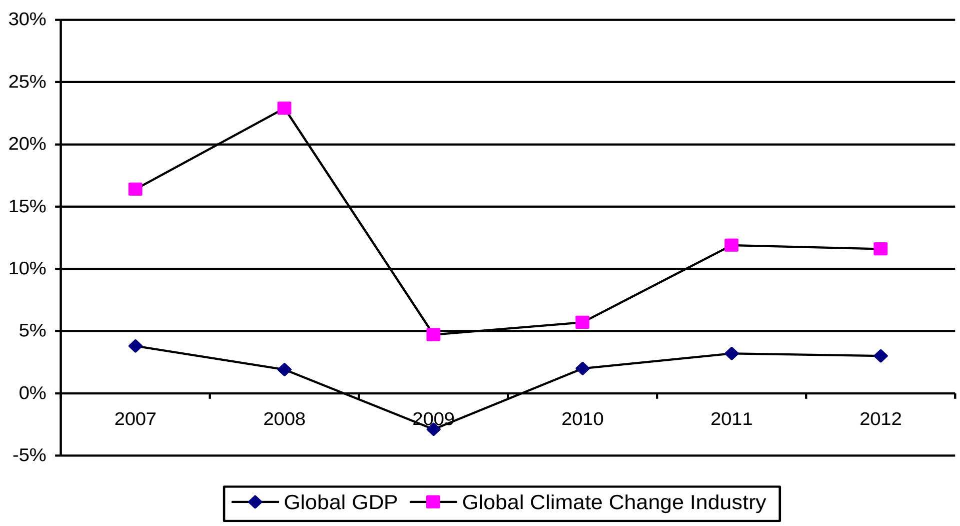
One reason for the high growth rates in the clean energy industry is that it is starting from a relatively small figure. (Environmental markets include solid waste and water/wastewater, two segments that were reasonably well developed by 1970.) Nevertheless, the gap between the growth rates illustrates the relative magnitude of the opportunity in clean energy markets compared to the overall economy.

**Figure 47 U.S. Clean Energy Industry Growth vs. U.S. GDP Growth 2005-2012**




*Source: EBI Inc.*

**Figure 48 Global Clean Energy Industry Growth vs. Global GDP Growth 2007-2012**

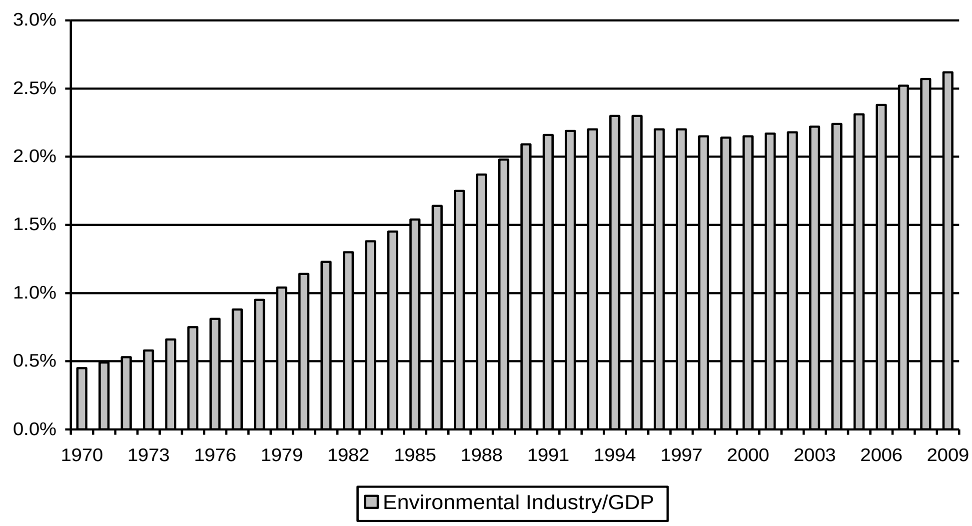



*Source: EBI Inc. Note the 2009-2010 drop was largely a function of falling carbon price in the carbon markets segment and lack of demand in energy and automotive markets*

Differences in 2009-2010 in the global clean energy industry compared with the U.S. clean energy industry were partly a function of carbon markets. Remember, carbon credits are 10-15% of the global market but don't even register on the U.S. pie chart. While volumes did not decline in 2009 European trading, the price did, mostly due to recession-reduced demand. This will lead to volatility in markets as credit and trading systems become more prevalent. Of course, there is a potential scenario absent widespread carbon trading and instead featuring an established, controlled price on carbon by means of a carbon tax or equivalent.

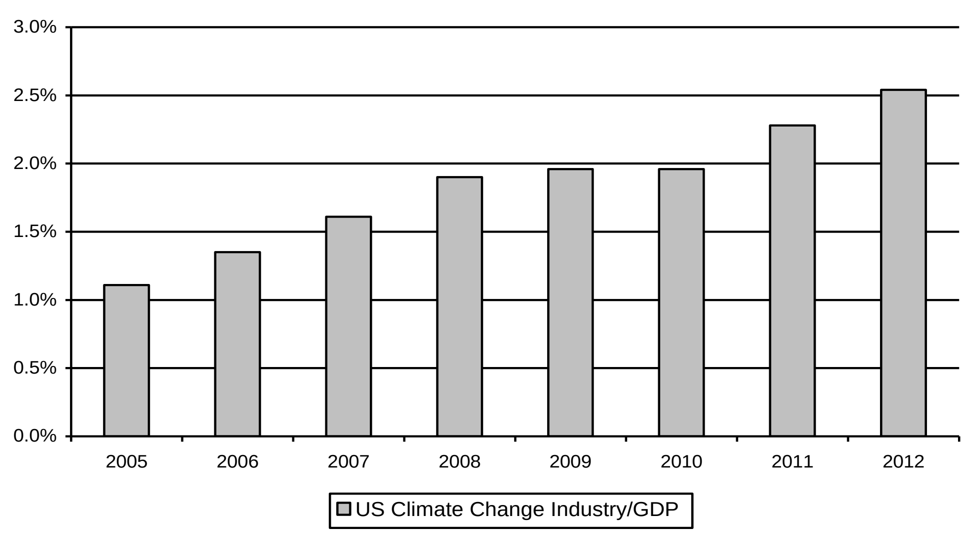
The final data comparison shows the relative stages of evolution of the two industries as a function of GDP. The environmental industry hit a plateau in the 1990s after a solid two decades of policy and regulatory drivers. The clean energy industry appears to be on a similarly rapid ascent in most segments.

**Figure 49 U.S. Environmental Industry as a Percentage of GDP 1970-2010 ($bil)**




*Source: EBI Inc.*

**Figure 50 U.S. Clean Energy Industry as a Percentage of GDP 2005-2012 ($bil)**




*Source: EBI Inc. Note: 2011-2012 total anticipate and US emissions trading program*

**Figure 51 U.S. and California Environmental Industry in 2009 ($bil, share and jobs)**

| Segment | 2009 US Revenues ($bil) | 2009 California Revenues ($mil) | California % of US | 2009 California Jobs |
|---|---|---|---|---|
| SERVICES | | | | |
| Analytical Services | 1.9 | 0.2 | 13% | 2,600 |
| Wastewater Treatment Works | 44.1 | 6.2 | 14% | 23,730 |
| Solid Waste Management | 51.1 | 5.9 | 12% | 30,870 |
| Hazardous Waste Management | 8.6 | 0.9 | 10% | 4,400 |
| Remediation/Industrial Services | 11.9 | 1.0 | 9% | 8,790 |
| Consulting & Engineering | 25.7 | 3.4 | 13% | 31,830 |
| EQUIPMENT | | | | |
| Water Equipment and Chemicals | 26.6 | 3.2 | 12% | 18,740 |
| Instruments & Information Systems | 5.2 | 0.7 | 14% | 5,010 |
| Air Pollution Control Equipment | 15.8 | 1.9 | 12% | 11,970 |
| Waste Management Equipment | 11.0 | 0.9 | 8% | 6,260 |
| Process & Prevention Technology | 1.8 | 0.2 | 10% | 2,830 |
| RESOURCES | | | | |
| Water Utilities | 40.6 | 6.5 | 16% | 25,930 |
| Resource Recovery | 24.5 | 2.4 | 10% | 8,590 |
| Clean Energy Systems & Power | 35.8 | 6.5 | 18% | 25,520 |
| **Environmental Industry** | **304.6** | **39.9** | **13%** | **207,070** |

*SOURCE: EBI Inc.*

### 3.4.2. The Clean Energy Industry and Green Jobs

Prevalent in today's debate on the subject of environmental policy, climate change, economic recovery, state and local economic development and host of other issues is the question of green jobs. During the process of developing and refining a definition and quantifiable segmentation model for the clean energy industry in the course of this research project, EBI encountered many allusions to green jobs and a number of different definitions and estimates.

A discussion and comparison of these efforts is outside the scope of this project (many of the documents reviewed are listed in the sources at the end of this report), but EBI does introduce its operating definition, market size and employment quantification of the green economy.

**Figure 52 U.S. and California Climate Change, Environmental and Green Industry**

| | USA Sales ($bil) | CA Sales ($bil) | CA % of USA |
|---|---|---|---|
| The Green Economy* | 525.90 | 64.91 | 12.3% |
| The Environmental Industry | 304.60 | 39.89 | 13.1% |
| The Clean Energy Industry | 223.57 | 27.00 | 12.1% |
| | **USA employment** | **CA employment** | **CA % of USA** |
| The Green Economy* | 2,842,831 | 336,485 | 11.8% |
| The Environmental Industry | 1,628,000 | 207,070 | 12.7% |
| The Clean Energy Industry | 1,126,610 | 122,917 | 10.9% |

*SOURCE: EBI Inc. Note: Some overlap exists in environmental and clean energy industry figures, notably renewable energy, and all environmental and clean energy industry figures are included in the green economy.*Green economy figures are for 2008.*

**Figure 53 U.S. and California Green Economy Market and Green Jobs: 2008**

| | USA 2008 Sales in $bil | USA Employment | Calif. 2008 Sales in $bil | CA Employment |
|---|---|---|---|---|
| Consumer Products | 63.40 | 321,547 | 9.03 | 47,117 |
| Consumer Services | 2.54 | 27,399 | 0.32 | 3,734 |
| Industrial Products | 200.47 | 951,709 | 22.27 | 102,427 |
| Industrial/Municipal Services | 225.72 | 1,317,751 | 30.26 | 170,954 |
| Recycled Materials & Products | 33.76 | 132,625 | 3.03 | 12,253 |
| **The Green Economy** | **525.90** | **2,751,031** | **64.91** | **336,485** |

*SOURCE: EBI Inc.*

**Figure 54 Green Economy vs. Climate Change and Environmental industry**

| | USA 2008 Sales in $bil |
|---|---|
| **The Green Economy** | **525.90** |
| The Environmental Industry minus Clean Energy | 268.76 |
| The Clean Energy Industry | 223.57 |
| Other Segments (mostly consumer products) | 33.58 |

*SOURCE: EBI Inc.*

## Figure 55 Definition of the Green Economy

### The Green Economy

**Consumer Products**

**Natural & Organic Food & Household Products**
Natural & Organic Foods
Natural & Organic Personal Care Products
Natural & Organic Cleaners
Natural & Organic Pet Foods & Supplements
Organic Clothing & Other Fiber Products
Organic Flowers

**Household Durable Goods**
Drinking water systems (point-of-use)
Air Quality filters & Home Air Purifiers
Energy Efficient Light bulbs
Super-Efficient Home Appliances
Home Solar Energy Collectors/Systems
Compost & Organic Gardening Supplies/Rainwater collectors
Hybrid Cars
Other Electric/Alternative Fuel Vehicles
Eco-House Building Kits
Home Energy Efficiency Products (weatherstripping, thermal curtains, audit devices)
Sustainable Timber Products & Supply
Consumer Educational Materials: Books, Tapes, CDs, Software

**Consumer Services**

Home Energy Efficiency Audits/Testing/Consulting
Green Power; Retail Renewable Energy
Demand Response; Curtailment Services
Consumer Education: Classes, Instructional Training
Eco-Tourism
Environmental/Climate Change Advocacy Groups

**Industrial Products**

Water Treatment Equipment and Chemicals
Air Pollution Control Equipment: Vehicular & Stationary Sources
Waste Management & Recycling Equipment (Vehicles, compactors, containers, shredders, etc.)
Environmental Instruments & Information Systems (lab eqpt., monitors, etc.)
Renewable Energy Systems (Solar, wind, biomass, fuel cells, geothermal, small scale hydro)
Renewable Energy Power Sales (Solar, wind, biomass, landfill gas, fuel cells, geothermal, small scale hydro)
Biofuels
Transportation Batteries
Industrial/Transport/Muni/Fleet Electric/Alternative Fuel Vehicles*
Energy Efficiency Appliances, Devices & Equipment
Green Building Materials (for Resource efficiency, Indoor air quality, Energy efficiency, Water conservation)

**Industrial/Municipal Services**

Environmental Consulting & Engineering
Site Remediation/Industrial Decontamination & Cleanup Services
Climate Change Consulting & Adaptation Services
Consulting & Engineering for Renewable Energy
Environmental Analytical Services: Lab Testing Services & Vehicle Smog Tests
Wastewater Treatment: Municipal & Private Infrastructure Operation & Maintenance
Water Utilities: Municipal & Private Infrastructure Operation & Maintenance
Solid Waste Management & Recycling: Residential, Commercial & Industrial: Collection, Transportation & Disposal
Hazardous Waste Management & Disposal: Industrial, Medical & Nuclear
Energy Efficiency

Energy Storage: Utility and Fuel Cells
Carbon Capture & Storage (CCS)
Carbon Trading; Credits & Offsets
Green Building Design and CM/PM; Green Building Construction
**Environmental/Climate Change Legal Services**

**Recycled Materials & Products**

Sales of Secondary/Recovered Materials (post-industrial & post-consumer)
Finished Consumer Goods Made Predominantly from Recycled Materials
(paper, tissue, plastic lumber, fiber-fill goods)

**Government Agencies & Other Services* (Not quantified in current model)**
Federal
State
Municipal/Local
NGOs/Non-Profits/Academia
Law Firms and Other Professional Services

*SOURCE: EBI Inc.*

The clean energy industry was a $27-billion industry in California in 2009, 12% of the U.S. total and 2.5% of the global total, employing 123,000 Californians.

# 4. Conclusions

The objective of this study was to define, characterize, quantify and forecast the growth of the clean energy industry in California, and to put its economic contribution into context. Research consisted primarily of obtaining consensus on the industry definition and list of segments, building databases of companies in each segment or subsegment, conducting interviews and surveys of industry participants and a compilation and study of reliable secondary market data. Data was then aggregated into segment models to estimate market size, growth, geographic breakdowns, leading companies and other qualitative aspects like business trends and market drivers.

The study concludes that the clean energy industry was a $27-billion industry in California in 2009, 12% of the U.S. clean energy industry of $223.6 billion and 2.5% of the global total of $1.1 trillion. In economic terms, the $27-billion clean energy industry in California represented 1.4% of the California economy in 2009, employing 123,000 Californians, or 1.1% of the state's total of 12.6 million jobs, according to the state's Employment Development Department.

Growth in the clean energy industry slowed from double-digit annual growth to 5% globally, 1% in the United States and -1% in California due to the recession in 2009. California's comparatively lower growth in 2009 is mostly attributable to more pronounced downturns in green buildings and hybrid automotive sales, higher growth in wind energy in developing economies, and growth of transportation options in Japan and Europe, and carbon credit market in Europe. Interim data indicates grwoth in 2010 was 8%. California's growth, or lack thereof, in the 48 sub-segments of the clean energy industry quantified in this report is often related to specific regulatory programs or financial incentives. California's Global Warming Solutions Act, AB 32, the Air Resources Board Scoping Plan and a number of other state programs are expected to increase both the growth prospects and the competitiveness of the California clean energy industry.

California plays a leading role in some segments and lags noticeably in others, partially due to the influence of government policy. The consensus of analysis of regulatory-driven industries like the environmental industry and the clean energy industry clearly indicates that the competitiveness of an industry in a nation or state is largely driven by domestic or state policy and the corresponding consistency of market demand usually driven by enforcement. In the emerging clean energy industry, California's pioneering policies have often created a framework for competitive advantage not always fully leveraged by consistent implementation or accompanying federal programs and initiatives, yet California still is home to some of the world's most innovative companies in the business of the many segments of the clean energy industry. As California enters the new era of AB 32 and emissions trading, this study serves as an important benchmark of a large and growing industry that is still in its infancy.

In a way, the California clean energy industry finds itself at a crossroads, if not perhaps on a launching pad, at the beginning of 2011. Decades of relatively progressive (although many argue not always consistent or broadly coordinated) policy in air, water, waste, energy efficiency and renewable energy have led to the evolution and emergence of a clean energy industry. With the implementation of AB 32, California promises a significantly more ambitious effort to coordinate programs and policy that will drive growth in all clean energy industry segments, in addition to creating a powerful market mechanism to find the most cost-effective solutions and stimulate innovation in energy use, storage, generation, transmission and efficiency and a host of supporting services and technology that will accelerate the transition to a more sustainable economy.

## 4.1. Recommendations

This study represents a first step in defining the clean energy industry, quantifying its market size and economic contribution, and an assessment of California's role in the global energy market.

The years 2011-2012 will see the implementation of AB 32, in addition to other clean energy, climate change and greenhouse gas initiatives in the State of California, which promise to stimulate more demand for clean energy industry products and services in all of the clean energy segments detailed in this report. This assessment of clean energy industry economic data in 2008-2010 will serve as a useful benchmark as ongoing research seeks to capture the growth and competitive trends in the emerging global clean energy industry.

While considerable effort has been undertaken to produce the market and industry analysis in this report and EBI is confident that it represents by far the best available compilation of data on these segments, the novelty and fragmentation of many of the industry sectors assures that this report's numerous estimates are far from perfect. EBI recommends that this study be viewed as a benchmark for the clean energy industry prior to the complete implementation of AB 32 and its cap-and-trade program, and that ongoing research is conducted on California's clean energy industry and global markets.

If properly and consistently implemented, California's clean energy and greenhouse gas reduction policies should enhance the competitiveness and economic contribution of California's clean energy industry. Future studies will be able to more accurately assess revenue generation, growth in local markets, employment and possibly evolve to the level of an accurate assessment of import-export models by segment and international rade balances.

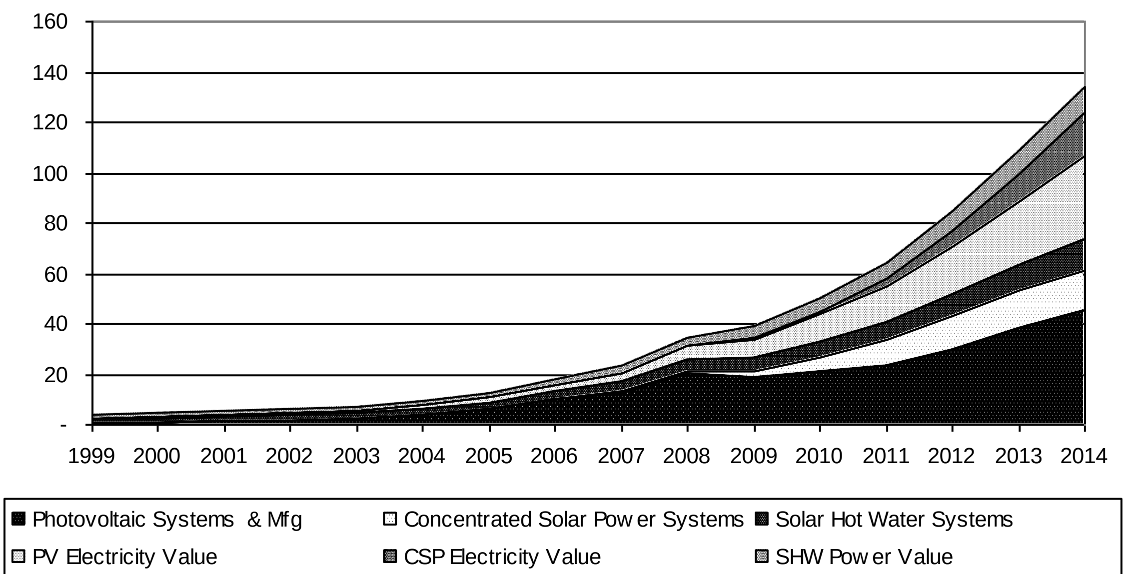
It is clear that most leading nations of the world are not standing still on clean energy and climate change, or on the policies that stimulate demand leading to the development of the businesses that speed energy security, emissions reduction and economic objectives. California cannot be accused of standing still on cleam energy or the clean energy industry, and the bold yet measured steps of 2011 and 2012 will play a significant role in California's economic future in clean energy and across the entire economy and population..

# 5. Solar Energy

The global solar energy industry grew 30-42% annually from 2004-2007, more than 50% in 2008, and represented $41 billion in global revenues in 2008, up from $5 billion in 2000. However, solar power still represented only 0.2% of global electricity generation at the end of 2008. The stock value of solar energy companies rose 210% in 2007 and venture investing in the sector grew 200% in 2007, yet solar power still represents only 0.2% of global electricity generation. Solar photovoltaics now represent 3.3% of electricity generation capacity in Germany thanks to a well-structured feed-in tariff, but solar power still represents only 0.2% of global electricity generation. And while solar energy of all types were expected to double again in capacity from 2007-2010, solar energy will still represent only 0.4% of global energy consumption in 2011.

For every argument in its favor, the relative insignificance of solar energy in the global energy equation waits to trump every card in the hand of solar advocates. Solar energy is indeed a mere drop in the bucket of mankind's 500 quadrillion BTUs of annual global energy usage. But just as surely as the sun comes up in the morning, that drop keeps getting bigger and less insignificant. But a drop it still is, and a number of factors are required for the drop to become even a trickle against the fire hose of global oil production of 90 million barrels a day.

**Figure 56 Global Solar Energy Industry 1999-2014 ($bil)**




*Source: EBI Inc. estimates derived from a variety of sources including International Energy Agency, Prometheus Institute, Solarbuzz, Emerging Energy Research, iSuppli, Young Market Research, Lawrence Berkeley National Lab, Photon Consulting, Morningstar and other sources.*

**Figure 57 Global Solar Energy Industry in 2008-2009**

| | 2008 in $Bil | 2009 in $Bil |
|---|---|---|
| Photovoltaic Systems & Manufacturing | 20.23 | 18.86 |
| Concentrated Solar Power Systems | 1.17 | 2.23 |
| Solar Hot Water Systems | 4.31 | 5.39 |
| **Systems & Equipment** | **25.71** | **26.49** |
| PV Electricity Value | 5.41 | 7.62 |
| CSP Electricity Value | 0.34 | 0.67 |
| SHW Power Value | 3.27 | 4.09 |
| **Power Value** | **9.01** | **12.37** |
| Planning, Design & Installation | 6.36 | 6.53 |
| **Total Solar Industry** | **41.08** | **45.38** |

*Source: EBI Inc. estimates derived from a variety of sources*

**Figure 58 U.S. Solar Energy Industry in 2008-2009**

| | 2008 in $Bil | 2009 in $Bil |
|---|---|---|
| Photovoltaic Systems & Manufacturing | 1.29 | 1.14 |
| Concentrated Solar Power Systems | 0.79 | 1.08 |
| Solar Hot Water Systems | 0.40 | 0.44 |
| **Systems & Equipment** | **2.48** | **2.66** |
| PV Electricity Value | 0.44 | 0.58 |
| CSP Electricity Value | 0.21 | 0.38 |
| SHW Power Value | 0.07 | 0.08 |
| **Power Value** | **0.71** | **1.05** |
| Planning, Design & Installation | 0.74 | 0.80 |
| **Total Solar Industry** | **3.94** | **4.52** |

*Source: EBI Inc. estimates derived from a variety of sources*

**Figure 59 California Solar Energy Industry in 2008-2009**

| | 2008 in $Bil | 2009 in $Bil |
|---|---|---|
| Photovoltaic Systems & Manufacturing | 0.21 | 0.15 |
| Concentrated Solar Power Systems | 0.39 | 0.57 |
| Solar Hot Water Systems | 0.12 | 0.14 |
| **Systems & Equipment** | **0.72** | **0.86** |
| PV Electricity Value | 0.29 | 0.39 |
| CSP Electricity Value | 0.18 | 0.33 |
| SHW Power Value | 0.02 | 0.02 |
| **Power Value** | **0.49** | **0.74** |
| Planning, Design & Installation | 0.31 | 0.35 |
| **Total Solar Industry** | **1.52** | **1.95** |

*Source: EBI Inc. estimates derived from a variety of sources*

Due to its intermittency and site dependency, advances in solar technology, as well as advances energy storage, efficient transmission and dispatchable applications like plug-in hybrid vehicles for PVs, must be made for solar energy to reach a level of anywhere near 10% of electricity generation in the next 20 years. Many solar companies do not believe that 10% is an unrealistic goal. CCBJ’s 2008 survey of 61 solar energy companies performed in March 2008 resulted in a median response that all types of solar will account for 5% of U.S. electricity generation in 2020, and 15% in 2050. Expectations for Europe were similar with a median response of 5-6% for 2020 and also 15% for 2020. For China and much of the developing world the expectation is 3-4% in 2020, and 8-10% in 2050.

Solar companies are understandably bullish on the prospects for their industry, and likewise are their market makers. Equity analyst Pavel Molchanov of Raymond James theorizes that PV’s share of 3.3% of power generation capacity in Germany is a realistic goal across the OECD by 2020 and equates this to an annualized growth rate of 20%. Feed-in tariffs and similar instruments are key for now for their economic incentive, but grid parity is only a matter of time, says Molchanov, and likely it will be attained by 2015, or even earlier with higher power prices.

For sustained near-term growth in the 30-40% range, however, consistent solar market drivers of energy security, financial incentives, minimum renewable requirements, lowered costs from technology development and manufacturing scale, high costs of oil & gas, and climate change policy all must be maintained or enhanced. A balance of short- and long-term policy instruments incorporating all these factors hardly seems far-fetched. At this point, most U.S. companies understandably view climate change drivers as having little impact on driving solar growth, with European solar firms more inclined to see themselves as part of a broader clean energy industry.

So how does the $40-billion solar industry fit in the context of the $1-trillion global clean energy industry? First it is neither the largest nor fastest growing segment, but clearly it intersects or even competes with a number of segments and subcategories like other renewables and low-carbon sources of power. Solar’s prospects will also be impacted by developments in carbon capture & storage, energy storage, energy efficiency, green buildings and carbon trading. The future for solar energy is indeed bright and EBI forecasts growth in each of our six subcategories. Overall growth was forecast in 2008 as 20-30% from 2008-2011 and 15-20% from 2012-2014. 2008 turned out to be over 50% growth, and 2009 at 10%, with interim data indicating a strong 2010 of 25-35% growth.

Forecasts for 2011-2014 aren’t largely different at the end of 2010 than they were before the credit crisis, market meltdown and solar pricing dynamics set off by oversupply. EBI is by no means the first to attempt to quantify and forecast the solar energy industry, but few before have approached the matter in dollars, incorporating the element of price, and taken on the value of the power generated. As PV and other solar data shows, the difference between nameplate capacity and kilowatt-hours in power generated is substantial and always will be.

Sales of all solar systems & equipment, including integration & installation equipment and services, accounts for about 60% of the $45-billion global solar energy industry. The value of power generated by solar energy worldwide increases in share with the installed base.

At $19 billion in 2009, PV represented the dominant share of systems & equipment sales. Power sales will grow from 23% in 2008 to 40% of the solar industry in 2014 although fluctuating economic conditions will impact this scenario. One thing is sure, however, Solar energy’s drop-in-the-bucket days are over and the persistent effort of companies, investors, policymakers and other advocates will be rewarded with a promising future.

# 5.1. Solar Industry Statistics & Review

**Figure 60 Global Solar Energy Industry**

| | 2007 | 2008 | 2009 | 2008 Growth | 2009 Growth |
|---|---|---|---|---|---|
| Photovoltaic Systems & Manufacturing | 12.71 | 20.23 | 18.86 | 59% | -7% |
| Concentrated Solar Power Systems | 0.64 | 1.17 | 2.23 | 84% | 91% |
| Solar Hot Water Systems | 3.64 | 4.31 | 5.39 | 18% | 25% |
| PV Electricity Value | 3.43 | 5.41 | 7.62 | 58% | 41% |
| CSP Electricity Value | 0.21 | 0.34 | 0.67 | 61% | 96% |
| SHW Power Value | 2.76 | 3.27 | 4.09 | 18% | 25% |
| Planning, Design & Installation | 3.37 | 6.36 | 6.53 | 89% | 3% |
| **Total Solar Industry** | **26.76** | **41.08** | **45.38** | **53%** | **10%** |

*Source: EBI Inc. estimates derived from a variety of sources*

**Figure 61 U.S. Solar Energy Industry**

| | 2007 | 2008 | 2009 | 2008 Growth | 2009 Growth |
|---|---|---|---|---|---|
| Photovoltaic Systems & Manufacturing | 0.85 | 1.29 | 1.14 | 51% | -11% |
| Concentrated Solar Power Systems | 0.64 | 0.79 | 1.08 | 24% | 37% |
| Solar Hot Water Systems | 0.34 | 0.40 | 0.44 | 18% | 10% |
| PV Electricity Value | 0.28 | 0.44 | 0.58 | 59% | 33% |
| CSP Electricity Value | 0.09 | 0.21 | 0.38 | 143% | 83% |
| SHW Power Value | 0.06 | 0.07 | 0.08 | 18% | 25% |
| Planning, Design & Installation | 0.54 | 0.74 | 0.80 | 39% | 8% |
| **Total Solar Industry** | **2.79** | **3.94** | **4.52** | **41%** | **15%** |

*Source: EBI Inc. estimates derived from a variety of sources*

**Figure 62 California Solar Energy Industry**

| | 2007 | 2008 | 2009 | 2008 Growth | 2009 Growth |
|---|---|---|---|---|---|
| Photovoltaic Systems & Manufacturing | 0.14 | 0.14 | 0.15 | 3% | 6% |
| Concentrated Solar Power Systems | 0.32 | 0.39 | 0.57 | 24% | 45% |
| Solar Hot Water Systems | 0.10 | 0.12 | 0.14 | 18% | 18% |
| PV Electricity Value | 0.19 | 0.29 | 0.39 | 56% | 32% |
| CSP Electricity Value | 0.07 | 0.18 | 0.33 | 142% | 83% |
| SHW Power Value | 0.02 | 0.02 | 0.02 | 16% | 15% |
| Planning, Design & Installation | 0.22 | 0.31 | 0.35 | 42% | 13% |
| **Total Solar Industry** | **1.05** | **1.46** | **1.95** | **38%** | **34%** |

*Source: EBI Inc. estimates derived from a variety of sources*

**Figure 63 U.S. Solar Energy Industry as a Percentage of Global Total**

| | 2007 | 2008 | 2009 |
|---|---|---|---|
| Photovoltaic Systems & Manufacturing | 7% | 6% | 6% |
| Concentrated Solar Power Systems | 100% | 67% | 48% |
| Solar Hot Water Systems | 9% | 9% | 8% |
| PV Electricity Value | 8% | 8% | 8% |
| CSP Electricity Value | 41% | 62% | 58% |
| SHW Power Value | 2% | 2% | 2% |
| Planning, Design & Installation | 16% | 12% | 12% |
| **Total Solar Industry** | 10% | 10% | 10% |

*Source: EBI Inc. estimates derived from a variety of sources*

**Figure 64 California Solar Energy Industry as a Percentage of U.S. Total**

| | 2007 | 2008 | 2009 |
|---|---|---|---|
| Photovoltaic Systems & Manufacturing | 16.2% | 11.0% | 13.1% |
| Concentrated Solar Power Systems | 50.0% | 50.0% | 53.0% |
| Solar Hot Water Systems | 29.1% | 29.1% | 31.1% |
| PV Electricity Value | 68.0% | 67.0% | 66.7% |
| CSP Electricity Value | 85.0% | 84.9% | 84.9% |
| SHW Power Value | 31.0% | 30.3% | 27.8% |
| Planning, Design & Installation | 41.0% | 42.0% | 44.0% |
| **Total Solar Industry** | 37.8% | 37.0% | 43.2% |

*Source: EBI Inc. estimates derived from a variety of sources*

**Figure 65 U.S. and California Solar Energy Industry: Employment**

| | USA $bil in 2009 | USA 2009 Jobs | Calif. $bil in 2009 | Calif. 2009 Jobs | % of USA Jobs in Calif. |
|---|---|---|---|---|---|
| Photovoltaic Systems & Manufacturing | 1.14 | 4,800 | 0.15 | 490 | 10% |
| Concentrated Solar Power Systems | 1.08 | 7,700 | 0.57 | 4,490 | 58% |
| Solar Hot Water Systems | 0.44 | 4,900 | 0.14 | 1,510 | 31% |
| PV Electricity Value | 0.58 | 2,100 | 0.39 | 1,390 | 67% |
| CSP Electricity Value | 0.38 | 1,000 | 0.33 | 820 | 85% |
| SHW Power Value | 0.08 | 400 | 0.02 | 110 | 28% |
| Planning, Design & Installation | 0.80 | 8,900 | 0.35 | 4,720 | 53% |
| **Total Solar Industry** | **4.52** | **29,800** | **1.95** | **13,530** | **45%** |

*Source: EBI Inc. estimates derived from a variety of sources*

According to Solarbuzz forecasts updated in early 2010, the global solar photovoltaic (PV) market will reach 6.37 GW in 2009. This represents growth of 5% on 2008 figures. (Note % is in GW growth not in dollars.)

* European demand will account for 71% of the global PV market, as Germany replaces Spain as the largest market. Germany's third quarter 2009 demand of 980 MW is

projected to rise to 1680 MW in fourth quarter, an increase of 71.4%. This corresponds to a total 2009 market size of 3.2 GW.

* Italy, Belgium, France and the Czech Republic together accounted for 277 MW in third quarter 2009. This helped deliver a total European demand of 1.3 GW in the third quarter of 2009, forecast to rise by 63% to 2.2 GW in the fourth quarter.

* Third quarter demand in North America was up 26% on second quarter. For the year 2009, the North American market increased 54% over 2008 accounting for 556 MW of installations in 2009, or 9% of the world market.

### 5.1.1. Solar PV Industry Weathers 2009

After enjoying extraordinary demand and growing at 30-50% annually from 2004-08, the solar industry's world turned upside down in the fourth quarter 2008. A seller's market became a buyer's market thanks to a large expansion of solar manufacturing capacity, increased competition, and an abrupt contraction of the Spanish market at the end of last year.

The global economic meltdown played a powerful part in bringing to an end an era of high growth and double digit profit margins for solar manufacturers: The mortgage debacle slowed residential solar sales, the recession created a risk-averse commercial sector, and the credit crisis all but put a stop to loans for solar project development.

However, once the short-term disruptions subside, most analysts believe a more rational solar market will emerge—one more favorably priced to the end-user and therefore better positioned to meet strong underlying demand and deliver on its promise as a substantial supplier of affordable electricity to the world.

Indeed, if 2009 was a step backwards for the solar energy industry, then the industry will be better prepared for the two steps or even the great leap forward long anticipated and supported by all the positive market drivers of regulations, renewable standards, subsidies, incentives, tax credits, declining costs of solar, increasing costs of conventional fuels, energy independence and ultimately climate change and carbon policy.

In the renewables business with its litany of market drivers, regulatory anomalies can never be discounted, and by far the severest impact on solar in 2009 was the collapse of the market for large solar projects in Spain, according to Ross Young, president and primary solar analyst for Young Market Research (YMR, Austin, Texas). In September 2008, Spain capped its generous feed-in tariff program that had spurred a gold rush of large-scale solar farm development. So whereas Spain represented a top-heavy 45% of the 5.5 GW installed capacity global solar PV market in 2008, in 2009 its portion declined by 80%.

Emerging markets in the U.S., Japan and China are expected to take up the running as global growth resumes in 2010 at the earliest, but government incentives take time to kick in. "This downturn has shown the dangers of being reliant on government subsidies," said Young.

Many publicly traded solar companies' reduced sales forecasts for 2009 and several have raised capital after spending heavily on constructing new capacity to meet previously robust demand. "They reinvested into building new capacity to such a degree that they didn't have enough cash to tide them over during the downturn," said Young. "Thus we have seen publicly traded solar companies offer additional rounds to raise capital at a time when stock offerings are less than favorable." The leading global solar cell manufacturer, Q-Cells of Germany, which increased its production by almost 50% in 2008, sold its 15% stake in Norwegian company REC for 530 million Euros to reduce debt—less than its value as previously listed on their books.

One analyst mentioned that many firms may now be investing in storage capacity with the yawning difference between the slowdown in installations and the dramatically increased production. Forecasts as of the middle of 2009 had PV production as high as 10,000 MW in 2009 with installations closer to 5,000 MW. The ratio in 2010 is expected to be much the same with production near 14,000 MW and installations around 7,000 MW, depending on the source of the forecast. The oversupply of PVs in dry dock represents a kind of energy storage that the clean energy industry and solar advocates would rather not see.

### Solar Panel Prices Decline

Behind dropping revenues and eroding profits in the solar hardware business are fundamental changes, including an overabundance of capacity, rapidly increasing competition and an ongoing price decline for solar panels and the materials used to make them. Starting in November and December 2008 and accelerating steeply in the first quarter of 2009, the price of solar panels went from the $4 per watt range towards $2.5 per watt, observed Henning Wicht, senior director and principal analyst of photovoltaics research for the market research company iSuppli (San Francisco). Prices still declined as of late summer 2009 and the rate of decline reportedly stabilized towards the end of 2009.

Although hardware prices appeared to decline quite suddenly, PV equipment had been accumulating for many months prior. But the industry was so focused on procuring supplies to meet demand driven by regulatory deadlines that it failed to notice supply creeping upwards—so much so that prices stayed high longer than they should have, Wicht observed. “More modules were produced in 2008 by far than were installed, but it went unnoticed because of such strong demand in Germany and Spain,” he said. Companies were “too busy and focusing on short-term deals like those that needed to be done before the end of the Spanish feed-in tariff.”

Supplies of silicon—the raw material for solar modules—had also crept up. In 2008, only eight companies were producing a large amount of silicon, and with demand outstripping supply spot prices rose from $30 per kilogram in 2004 to around $500 per kilogram prior to October 2008. However, when iSuppli surveyed 37 companies with 50 plants in September 2008, it saw a “huge amount” of polysilicon coming to market. Wicht warned clients to delay signing contracts until prices reflected this reality. But not everyone was so lucky. Post-October 2008, spot prices spiraled down to $70 per kilogram (the price was reportedly about $60 in the summer of 2009), and manufacturers with a backlog of expensively made solar panels found themselves competing with companies with access to cheaper feed stocks.

A DisplaySearch report named U.S.-based company First Solar Inc as the largest solar cell manufacturer with more than 1 GW of capacity. China’s Suntech Power Holdings Co Ltd., Japan’s Sharp and Germany’s Q-Cells AG, come next grouped second through fourth. By 2013, these companies and China’s JA Solar Holdings Co Ltd, Taiwan’s Motech Industries Inc, Norway’s Renewable Energy Corp, U.S.-based SunPower Corp, China’s Yingli Green Energy Holding Co Ltd, and Japan’s Showa Shell Sekiyu KK and Sharp Corp may be among the top 10 makers, with more than 16 GW, or 38 percent, of total capacity in 2013, the report said.

**Figure 66 Top-10 Suppliers of Solar Cells in 2008 and 2009 (production in MW)**

| Supplier | HQ | 2008 Production (MW) | Share (%) | 2009 Production (MW) | Share (%) |
|---|---|---|---|---|---|
| First Solar | USA:AZ | 503 | 7.5% | 1100 | 12.8% |
| Suntech | China | 494 | 7.3% | 595 | 6.9% |
| Sharp | Japan | 511 | 7.6% | 580 | 6.8% |
| Q-Cells | Germany | 574 | 8.5% | 540 | 6.3% |
| Yingly | China | 282 | 4.2% | 430 | 5.0% |
| JA Solar | China | 277 | 4.1% | 400 | 4.7% |
| **SunPower** | **USA:Calif.** | **236** | **3.5%** | **390** | **4.6%** |
| Kyocera | Japan | 300 | 4.5% | 390 | 4.6% |
| Motech | Taiwan | 272 | 4.0% | 360 | 4.2% |
| Gintech | Taiwan | 220 | 3.3% | 350 | 4.1% |
| Others | | 3065 | 45.5% | 3435 | 40.1% |
| **Total** | | **6,734** | | **8,570** | |

*Source: iSuppli Corp. September 2009; Note: Forecast is production not installations*

**Figure 67 Top Chinese Suppliers of Solar Cells**

| Name | Region | No.Staff | MWp Sold 2008 |
|---|---|---|---|
| Suntech Power | China | 9070 | 497.5 |
| Yingli Green Energy | China | 4500 | 281.5 |
| Trina Solar | China | 4500 | 201.0 |
| Solarfun Power | China | 1500 | 172.8 |
| Canadian Solar | China | 1200 | 167.5 |
| Eging Photovoltaic | China | 3000 | 106 |
| Jiawei Solarchina | China | 1150 | 90 |
| Ningbo Solar | China | 1000 | 80 |
| Guofei Green Energy | China | 230 | 65 |
| Chint Solar | China | 1000 | 65 |
| ET Solar Industry Ltd. | China | 1200 | 65 |

*Source:ENF, enf.cn*

Other notable companies in manufacturing or major installations include
* Ascent Solar, Tucson, Arizona, US
* Anwell Solar, Hong Kong, China
* **DayStar Technologies, Inc., Santa Clara, California, US**
* GH Solar Leuven, Belgium
* Global Solar, Tucson, Arizona, US
* GreenSun Energy, Jerusalem, Israel
* HelioVolt, Austin, Texas, US
* **International Solar Electric Technology, Chatsworth, California, US**
* Isofotón, Malaga, Spain

* Konarka Technologies, Inc., Lowell, Massachusetts, US
* LDK Solar, Xinyu, China
* Miasolé, California, US
* Mitsubishi Electric, Tokyo, Japan
* Moser Baer Photovoltaic, Delhi, India
* **Nanosolar, San José, California, US**
* PowerFilm, Inc., Ames, Iowa, US
* **Pyron Solar, San Diego, California, US**
* Renewable Energy Corporation, Norway
* Schott Solar, Germany
* **Signet Solar, California, US**
* SolarWorld, Bonn, Germany
* Solimpeks, Munich, Germany
* **Spectrolab, Inc., Sylmar, California, US**
* SunEdison, Beltsville, Md., US
* Sunetric, Hawaii, US
* Suniva, Norcross, Georgia, US
* Topray Solar, China

### More Solar Entrants Expected

Japanese giants like Sharp, Kyocera and Mitsubishi Electric pioneered the solar industry, and experts expect to see the entry of more global conglomerates. Moser Baer India Ltd., the world's second largest manufacturer of optical storage media, has entered the solar sector with both crystalline silicon cell technology and thin-film technology. Moser Baer also plans to build solar power plants to benefit from India's feed-in tariff program.

Last year, Robert Bosch GmbH of Germany, one of the world's largest automotive component part maker, acquired Ersol Solar Energy AG and more recently picked up Aleo Solar AG. One source of new and adjunct technology is likely to be the semiconductor industry, whose work in CDs and TVs is can be applied to the thin film solar business. According to a survey of semiconductor companies by Greentech Media and the PV Group, most of the 106 respondents said they are investing in solar or plan to do so soon.

In 2008 the $1.9 billion National Semiconductor Corp. acquired Act Solar's SolarMagic technology for getting maximum power from solar arrays, stating that the photovoltaic market is a natural extension of its focus on energy efficient systems.

Other semiconductor participants are Intel Corp., which last year spun off a solar thin film company called SpectraWatt, and Tokyo Electron, which announced a joint venture with Sharp to develop thin film manufacturing equipment.

Other conglomerates will carve out a support role: Dow Corning has positioned itself as a material house for the solar industry, developing and supplying materials from silicon feedstock to sealants. "Solar has been raised as one of our two major corporate priorities," said a company spokesperson. "And of course, we are investing accordingly. Between Dow Corning and our joint ventures at the Hemlock Semiconductor Group, we are spending billions of dollars to build a reliable supply chain and R&D facilities to support the solar industry."

### Vertical Integration a Logical Strategy

Over the last several years, manufacturers have vertically integrated in pursuit of production efficiencies and inventory control. Silicon ingot makers have gone into wafers, wafer-makers into cell production, cell producers into modules and panels, and vice versa. Most solar manufacturers have stopped short of actual silicon production—only REC and SolarWorld have large silicon operations—although others have taken equity stakes in silicon manufacturers.

While the first wave of upstream vertical integration is more or less complete, vertical integration continues to be the dominant strategy of the larger solar manufacturers, the difference now being they are looking down the value chain toward project development and installation. This strategy not only expands manufacturers into a new part of the solar business but perhaps more importantly creates a pipeline of do-it-yourself product sales in a fragmented U.S. developer segment unable to make use of the volume of solar equipment being produced.

California's SunPower was the first major U.S. manufacturer to branch into installation by acquiring PowerLight for $330 million in 2007. In January 2009, project developer Fotowatio of Spain purchased leading U.S. project developer MMA Renewable Ventures from MuniMae for $20 million with backing from GE Energy Financial Services. And leading Chinese manufacturer Suntech has entered project development in the U.S. through a joint venture with Fotowatio.

With financing drying up and projects in distress, more pipeline acquisitions are also on the cards. In March 2009, First Solar purchased the rights to OptiSolar's project pipeline—including a 50-MW development for Pacific Gas & Electric in California and another 1.3 GW of deals in the works—for $400 million, in addition to investing in the residential and commercial installer SolarCity. Also in March 2009, Recurrent Energy, a distributed power company, announced the purchase of a solar project pipeline of up to 350 MW from UPC Solar (Chicago), a renewable energy development company, having raised $75 million from Hudson Clean Energy Partners a few months earlier.

Manufacturers are also creating options by capitalizing projects. For example, SunPower and Wells Fargo in June 2009 announced a financing program in which Wells Fargo will finance the solar power systems, SunPower will design, build, operate, and maintain them, and customers will buy the electricity under a power purchase agreement without having to make a capital investment.

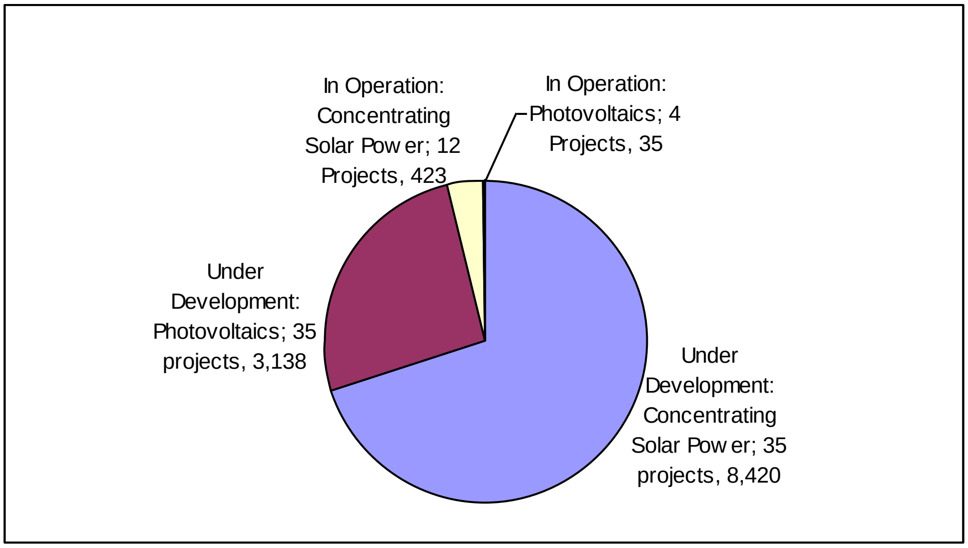
### 5.1.2. Project Developers & Utility Entrants

Solar development in the U.S. is still a basically a cottage industry with many small developers. Among the larger players present are Fotowatio Renewable Ventures, SunEdison, Chevron Energy Systems and SolarWorld, Conergy and Juwi Solar of Germany.

While declining panel prices is a bright spot for solar project developers, the credit crisis has been a millstone around their necks. "It's clearly very hard to get funding for large projects right now, more so than in a lot of industries since large solar projects are 70-90% financed through bank debt," said Hammerbacher. "If a project didn't have financing before October 2008, almost all were put on hold." However, he added that the lending situation was better in late summer of 2009 than three months prior, a view echoed by others.

Developers have also struggled to resell completed solar power plants. Wicht cited dilatory tactics by buyers who call repeated technical meetings and conduct multiple plant checks to postpone or derail a purchase.

**Figure 68 Solar Projects: Operational and Under Development in the U.S. in 2009**




*Source: Solar Energy Industries Association; Units in MW capacity in utility-scale projects*

With the emergence of the U.S. utility market we are likely to see more participation in the solar project development business by new entrants, including environmental consulting & engineering (C&E) and construction firms that have a strong history of working with utility customers. In addition, the planning and permitting aspects that C&E firms have a grip on from years of land development and infrastructure projects are highly applicable to utility-scale solar projects, as well as the transmission issues they inevitably include involving siting and geotechnical studies.

Aiming to take advantage of the C&E sector's diverse skill base and established relationships with electric utilities, in March 2009 Evergreen Solar Inc., a wafer, cell and panel maker, forged a partnership with environmental C&E firm RMT Inc. (Madison, Wis.) to co-market to electric utilities and independent project developers of utility scale solar power projects. RMT has designed and constructed more than 3.1 gigawatts of renewable energy projects across the U.S. with demonstrated strength in wind and will add solar power to its service offerings.

Who will design, build and operate utility-scale solar plants is still somewhat uncertain. A number of larger C&E firms in the billion-dollar range like Black & Veatch, Tetra Tech, URS Corp. and CH2M Hill are well equipped to tackle this market in an integrated service fashion with several other mid-size firms also taking aim. With today's active development project list at less that 100, however, the market still is small compared to the work these firms do in water, haz waste and transportation.

Other diversified contractors will also undoubtedly enter the solar engineering field like many did the environmental engineering field in the high-growth days of the late 1980s and early 1990s. In May, defense firm Lockheed Martin made a deal to design and build a 290-MW CSP plant for Arizona Public Service Company. An affiliate of Starwood Capital would own the project and APSC purchase the power.

In Spain, which saw a period of intense large solar development until the feed-in tariff market was capped in the fall of 2008, engineering firms have played a much larger role in building PV solar projects compared to the United States, but that could change with the market. "It's a process that takes some time. I'm pretty much convinced that they'll move pretty fast into it," said Hansjorg Lerchenmuller, CEO of CPV company Concentrix Solar. Solar will be a huge,

huge business [in the U.S.] and they want to get involved." The biggest difference is that European firms have a larger appetite for project ownership or equity in projects while few U.S. engineering firms even consider anything outside fee-for-service. It remains to be seen if those likely the best qualified to build utility-scale solar projects in the United States—and even the larger commercial or industrial site projects—will tolerate the risk profile of taking a business interest in the project.

### 5.1.3. Integrators and Installers

While manufacturers have enjoyed years of double-digit margins, solar installers that typically work at the industrial, commercial and residential level have not had that luxury, but perhaps finally market dynamics have tilted in their favor. "Installers are in a good position: Prices of modules are falling, they don't have to carry inventory, and stimulus programs are going… It's a good time to be an installer," said Ross Young of Young Market Research

However, competition is also increasing. "Installation companies have to work harder for their money now. They can buy cheaper, but the competition is getting stronger," said Wicht. In Germany, for example, to win a single contract installers now have to make five or six proposals not just one or two. "The end-user is probing the market and may ask for a new proposal in a few months. Buyers are playing a waiting game."

In Europe the installer segment is relatively consolidated compared to the mom-and-pop U.S. market. Established players include Phoenix Solar, Centrosolar and Conergy. Germany has the lowest cost of residential installation due to maturity of its installers. "They're very experienced, do faster installations, and the official procedures and paperwork to connect to the grid are relatively easy, and this helps bring the price down," said Wicht.

By contrast, the U.S. market is highly fragmented. "In North America it's still very much a free for all," said Hammerbacher. "It's a very local business and unless you have density of market it's not a good business… California has the best shot at fostering large installer."

In the United States, SunPower (through PowerLight) is a large manufacturer with a strong installation component. Independent installer leaders include SunEdison, SolarCity, Premier Power, REC Solar and Alteris. In Germany Q-Cell expects a €130 million 2009 turnover from its installation business. In July 2009, LDK Solar Co. Ltd., a leading manufacturer of multicrystalline solar wafers, announced the acquisition of a controlling interest of Solar Green Technology, an Italian installer.

### 5.1.4. Concentrating Photovoltaic Systems

By using lenses and mirrors to concentrate sunlight, concentrating photovoltaic (CPV) systems can deliver more power with much less solar cell material and in much less space than conventional PV modules. These capabilities have made CPV's high-efficiency multi-junction solar cells a favorite choice for generating power in space. CPV advocates promise that it will soon be price-competitive with PV here on earth—a promise that has been a long time coming. But in the last few years, the momentum behind CPV has accelerated. By March 2007, PV trade publication *Photon International* had tallied about $200 million worth of public and private investments in CPV development over the previous year. Since then, more investments have been announced, including SolFocus (Madrid, Spain; Mountain View, Calif.) raising $63.6 million, Solaria Corp. (Fremont, Calif.) raising $50 million and GreenVolts (San Francisco) raising $10 million. This money is nurturing "the outline of a concentrating PV supply chain" that includes makers of the high-efficiency multi-junction cells and tracking and optical specialists, according to PI. The number of system integrators aiming to draw on this supply chain to design and install CPV arrays had increased from 18 in 2005 to 32 in 2007.

### Solar as Service Model in California: Sun Run

While the “solar-as-a-service” model has been mostly focused on commercial customers, some new entrants are offering programs for residential customers. Sun Run (San Francisco) sharply discounts the upfront price for PV system in exchange for a contract from customers to buy electricity at 13.5 cents kWh. The company also offers a deal with a lower upfront cost and higher per-kWh rates, as well as leasing options. A typical PPA offering: a 3 kW system for $8,800 upfront and roughly $55 a month in electricity payments.

“We provide a performance guarantee,” said President Nat Kreamer. “If we don’t generate in a year what we say we will, we provide a money-back guarantee on the upfront payment.” Customers have options to prepay the contract balance or purchase the system. If they sell their home with a Sun Run system on it, the seller must purchase it, prepay the contract or assign it to the homebuyer, according to Kreamer.

In 2007, the company, which is privately financed by management and investors, installed its first system in late summer and completed “more than 10 but less than 100” jobs by year’s end. Initially focused on Pacific Gas & Electric customers in the San Francisco and Sacramento metro areas, the company aims to cover all of PG&E’s vast territory and expand its reach into that of California’s other two investor-owned utilities, Southern California Edison and San Diego Gas & Electric (owned by Sempra).

Sun Run has worked out deals with Borrego Solar (El Cajon, Calif.), Premier Power (El Dorado Hills, Calif.) and REC Solar (San Luis Obispo, Calif.) to supply and install equipment. “They have approved supply that they carry in their inventory [for Sun Run projects] and they do an excellent job of installing systems,” he said. But customers have some choice of modules. “If a customer wants black panels that are fairly flat to their roof they can select a Sharp system. If they want to have the panels that take the least amount of energy to manufacture, they can go with Evergreen.”

In January 2008, Sun Run and REC Solar won a bidding process to install PV for 50 homeowners in downtown San Jose, Calif. The bid was made in response to an RFP issued by a group of homeowners that had pooled their funds and rooftops to get the best deal on equipment and installation. According to the PV trade magazine *Photon International*, this kind of collective buying is increasingly common in California.

In the future, Sun Run hopes to sell RECs created by its owned systems to offset costs for its consumers and create an additional income stream for itself. “An Individual can’t monetize RECs because they lack adequate monitoring,” said Kreamer. “Because we have the monitoring, we can accomplish that. Right now we aren’t selling any RECs. It’s a market that’s evolving, and we want to wait and see how that goes.”

However, a vital current element in Sun Run’s business plan is the ability to qualify as a commercial owner of PV systems, and hence receive the 30% federal investment tax credit with no annual cap; an individual homeowner can only receive up to $2,000. Indeed, the federal ITC is pivotal to all U.S. commercial integrators and installers, and its extension is seen as absolutely vital to the U.S. PV business.

### 5.1.5. Thin-Film Technology

The real game-changer in the PV field may be the emergence of less expensive thin-film PV technologies, such as amorphous silicon, which uses vastly less silicon than crystalline deposition methods, and Cadmium Telluride (CdTe), Copper Indium (Gallium) di-Selenide (CIS/CIGS) and other emerging technologies that use materials other than silicon. Thin film technologies essentially trade off lower efficiency for much lower cost. Because they take up a lot more space but cost less per watt, thin-film modules can "satisfy requirements for large ground-mount arrays," according to Mark Culpepper, vice president of strategic marketing for commercial integrator SunEdison (Beltsville, Md.). "The volumes that thin-film manufacturers are looking to move into the market are substantial."

**Figure 69 2008 Global Leaders in Thin Film Production in MW**

| Company | 2008 production MW |
|---|---|
| First Solar | 504 |
| United Solar Ovonics | 112 |
| Kaneka | 53 |
| Mitsubishi | 40 |
| Sharp Electronics | 38 |
| Wurth Solar | 30 |
| Ersol | 20 |
| Honda | 18 |
| Schott Solar | 17 |
| Showa Shell Sekiyu | 15 |
| Others | 200 |
| **Total** | **1,047** |

*Source: iSuppli*

However, producing durable thin-film PV cells, scaling pilot plants up to commercial scale and improving efficiency have been stiff R&D challenges for the emerging thin-film PV sector. As Bradford noted in the introduction to his 2007 PV Technology, Performance and Cost report, "most amorphous silicon plants built in the last 10 years have exceeded design costs and failed to reach design goals for efficiency and yields." Similarly, many CdTe and CIS/CIGS pilot plants have been delayed. BP exited the thin-film game in 2003 after building a pilot CdTe plant. "We felt that thin-film wasn't stable enough to put the BP name brand and 25-year warranty behind," said Mary Shields, vice president of global sales and marketing. "It's a good technology for niche applications, but for us it was not a good fit with our commitment to long-term durability."

By all accounts, the break-out leader of the thin-film pack is CdTe technology-based manufacturer First Solar (Phoenix, Ariz.). Founded in 1999, the company went public in 2006 and soon became a star of the PV stock set, with its value rising 800% to over $270 per share by the end of 2007. First Solar's share price dropped 30% with the rest of the market in the first 12 weeks of 2008, but soon recovered with analysts rating the company highly. First Solar has achieved real market presence for thin-film PV by producing modules for about $1.25 per watt (silicon PV modules are produced for about $2.50 per watt), according to Bradford and Maycock who collaborated on a presentation at the September 2007 Solar Power Conference and Expo in Long Beach, Calif.

The pair predicted that the company would achieve $1 per watt costs in 2009. "First Solar changed everything," said Bradford. "Theirs is not the most efficient thin-film process by any stretch… and it may or not be cheaper than amorphous silicon on glass, but they've made the 30-year promise of thin film a reality." He noted that a key company victory was working through the European Community's ban on cadmium with a bonded recycling program.

Bradford and Maycock said that as of third quarter 2007, 86 companies were aiming to make a play with thin-film technologies. "A lot of these technologies have been fully vetted on pilot lines and are scaling up," Bradford said, estimating that about 10 well-funded companies are the closest to becoming commercially competitive. "The odds of every one getting there are less than even money… but the odds that some of them will get there are better than even. One should be skeptical about any claim from a particular company, but given the number of players, for the group the odds are high." He also noted that manufacturers using CIGS and amorphous silicon technology can use roll-to-roll production on flexible substrates, while CdTe is still glass-based deposition with semi-batch processing. Bradford and Maycock project that thin-film PV would command 23% of the world market by 2010 and could dominate beyond.

**Figure 70 PV System Ownership in U.S. Market 2008**

| | % of Watts Installed in 2008 |
|---|---|
| Home Owners | 26% |
| Building Owners | 30% |
| Energy Service Providers | 28% |
| Govt/Schools | 12% |
| Others | 4% |

*Source: iSuppli*

**Figure 71 Grid-Tied PV by State in 2008**

| | Installed in 2008 | (MW-dc) Cumulative |
|---|---|---|
| California | 178.6 | 530.1 |
| New Jersey | 22.5 | 70.2 |
| Colorado | 21.6 | 35.7 |
| Nevada | 14.9 | 34.2 |
| Hawaii | 11.3 | 15.8 |
| New York | 7 | 21.9 |
| Arizona | 6.4 | 25.3 |
| Connecticut | 5.3 | 8.8 |
| Oregon | 4.7 | 7.5 |
| North Carolina | 4 | 4.7 |
| Others | 15.3 | 36.4 |
| **TOTAL** | **292** | **791** |

*Source: SEIA*

### 5.1.6. Manufacturer Profile: SunPower

With only two out of three solar panels selling in 2009's oversupplied global market, photovoltaics (PV) equipment manufacturers are facing continuing downward price pressure. Deteriorating market conditions have forced companies to make layoffs, take write-downs, revise forecasts, renegotiate supply contracts, transition to demand-driven manufacturing models, delay factory expansions, and wring their hands over what was described by top executives as the worst first quarter in the history of the solar industry

Asked how SunPower (San Jose, Calif.), a billion-dollar manufacturer of high efficiency crystalline silicon cells, panels and systems, is weathering the current downturn in demand, Vice President of Public Policy and Corporate Communications Julie Blunden claimed that while they didn't see the economic meltdown coming, the company had already taken steps to manage raw material prices and increased competition between solar manufacturers.

When intense demand caused silicon prices to soar from 2006-08, the company facilitated the entry of new silicon makers in return for favorable long-term contracts. Thus SunPower never resorted to substantial purchase of spot priced silicon, which spiked as high as $500 per kilo in 2008 and left many competitors with painfully overpriced inventory when equipment prices started to decline at the end of 2009.

From a larger strategic perspective, the company also planned for the day when PV manufacturing became increasingly a volume- and price-based business: "In order for us to be in as strong a position as possible, we needed to be vertically integrated," Blunden said. In 2005 SunPower decided to expand both up and down the value chain from its nexus in silicon solar cell and panel manufacturing. In 2006, it formed a joint venture with Woongjin Holdings Co. Ltd. of Korea to manufacture monocrystalline silicon ingots. This was followed in 2007 by a joint venture with First Philippine Electric Corp. to make silicon wafers using SunPower's ingots and slicing technology. Solar cell manufacturing takes place at two facilities in the Philippines, where SunPower also does its panel assembly. A third solar cell facility is under construction in Malaysia. In June 2009, SunPower announced a multi-year solar panel manufacturing agreement with electronics manufacturer Jabil Circuit Inc. (St. Petersburg, Fla.) to build panels for SunPower's North American solar market in Mexico.

To further drive channel efficiency and extend into new parts of the value chain, SunPower became the first major U.S. PV manufacturer to integrate downstream into installation by acquiring its largest customer, PowerLight Corp. (Berkeley, Calif.), in a deal valued at $332.5 million in 2007. The systems integrator of large-scale rooftop and ground-mounted solar power plants opened up the large-scale installation market for SunPower. Today, SunPower has approximately half of its business in customer systems integration and half in sales to dealer partners and other resellers.

**Going Commercial in California**

Over the last three years, SunPower has beefed up its dealership network in order to grow its rooftop solar business for commercial and residential customers. "We went from a couple of hundred dealers in 2007 to adding hundreds" in 2008, said Blunden. In the second quarter of 2009, SunPower added another 100 dealers, bringing its network to approximately 600 globally.

"We were the first to develop a true dealer network," claimed Blunden. SunPower helps dealers to scale up by helping with warehousing, logistics and delivery, in addition to lead generation, training and financing services. "We don't just send them panels on a trailer."

In May 2009, in an industry not known for its brand building investments, SunPower, in conjunction with its dealers, launched a comprehensive solar ad campaign in the Bay Area with radio, digital and transit advertising exhorting the public to "Seize Today" and promising "a guaranteed return with every sunrise." According to the company's second quarter earnings call, the company got a 30% bump up in customer leads as a result.

By engaging in the project financing side of the solar business, manufacturers can help fill their product pipelines, in addition to building annuity revenue streams. In June 2009, SunPower announced a program with Wells Fargo for up to $100 million to finance commercial-scale solar power systems that SunPower will design, build, operate, and maintain. Customers sign a power purchase agreement for electricity at competitive rates with no initial capital investment. Two systems were financed in the second quarter: a 1.1 megawatt project to the University of California, Merced and a 1 megawatt system for the Western Riverside County Wastewater Authority. "The power of this structure is that SunPower is repaid nearly all of its cash costs when the construction of the project is completed," said Dennis Arriola, SunPower's CFO.

SunPower also offers five-year loans for residential customers through Addison Avenue Federal Credit Union of Palo Alto, Calif. Homeowners do not need equity in their homes to qualify for the loans and can transfer the SunPower systems to new owners on the sale of the house.

**Utility Contracts Kick Off**

SunPower has more than 550 large public and commercial solar power systems installed or under contract, representing more than 450 megawatts. "In the U.S. we're the largest manufacturer of residential systems and have the largest installed base of commercial systems," Blunden claimed.

In the next several years, solar developers and manufacturers will look to the U.S. utility sector to contribute a larger portion of revenues. Last summer, SunPower got to share in one of the transitional events in the U.S. solar industry—the awards by Pacific Gas and Electric Co. of 800 MW worth of contracts. SunPower won a 250-MW piece for high-efficiency PV solar power; OptiSolar Inc. (now owned by thin film rival First Solar) was awarded a 550-MW contract.

"2008 was the year when solar came into its own and became a dominant resource at utility scale in the world," said Blunden. "The PG&E agreement last August for 800 MW, that was tectonic, a fundamental disruption in how people thought about solar as a resource."

Today the number of signed U.S. utility contracts remains tiny, but "I'd say there are a good number of RFPs that are very active right now and more coming every month," said Blunden. As state deadlines for utilities' renewable energy targets approach, the modularity and velocity of solar installation has growing appeal, Blunden believes. "Utilities have woken up that solar is available today, and they can put it anywhere, at any scale, very fast to market. That's a very, very attractive value proposition for utilities who'd like to move their renewables portfolio forward by increments of 20 MW, not 100MW, at a time," said Blunden.

Solar panel prices generally have declined by as much as 40% since the fourth quarter of 2008 and are expected to keep pushing downward. But while price is king for most solar customers, for utilities "price is just one piece of the total picture," said Blunden. There may be little brand recognition among solar panels, but utilities will place high value on a manufacturing company's track record. "There's no way with a large scale power purchase that a utility is going to choose someone with no performance record. We opened up the large-scale market through PowerLight. We have a long record of performance data—more than others by a long shot."

SunPower's other utility agreements are with NextEra Energy (formerly FPL Group) to supply 300-600 MW from 2010 to 2012; Florida Power & Light Company for two solar PV power plants totaling 35 MW; Xcel Energy Inc. for a 17 MW solar power plant in Colorado; and with Exelon Corp. for a 8 MW solar power plant in Chicago in 2009. In Europe SunPower has more than 200 MW of solar power plants operating. "We're seeing a move from rooftop to central power generation," said Blunden. "Balance sheets are maturing and companies are maturing, so the entire industry is at a point where utilities are taking us seriously."

**Uptick in Second Quarter**

SunPower, founded in the 1980s in the Bay Area of California like its sister company PowerLight, recorded fiscal year 2008 revenue of $1.43 billion, up 85% from 2007. Total revenue in the first quarter 2009 declined 22% to $213.8 million over the year prior quarter, attributed to the harsh winter in Germany and deteriorating global economic conditions. However, revenue in the second quarter 2009 increased 39% from the first quarter to $298 million. The improvement came from the components side of the business, which focuses on the residential and light commercial customer segments and mainly from North American and German markets, with especially strong performance from California, where the company increased its market share. Based on analysis of California Solar Initiative data, SunPower's overall market share increased to more than 30% in California.

SunPower has an interesting investment history not unfamiliar to its Silicon Valley brethren. SunPower went public in November 2005, raising $145 million in its initial public offering. From 1990-1994 the company had raised a total of $4.3 million in four rounds of private capital. It raised $3 million in 1996 and $10 million in 2002 before the 2005 IPO. SunPower stock traded $25-$40/share during its first year, took off in 2007 and peaked around $130/share at the end of 2007, fell to $60-100 for most of 2008 before the crash took it back down to the $25-35 range it has traded at most of 2009, with a mid-2009 market cap of about $3 billion.

## Sharp Solar Energy Solutions Group

Germany's Q-Cells may have taken the top spot in cell manufacturing in 2007-2008, but Sharp is targeting a spread of markets for continued growth. The most reasonable way to deal with the downturn in the solar business is through "lots of contact with your customer and lots of information flow to really understand what their needs and problems are. It's really all up to them. They control the flow of goods." That's how Ron Kenedi, vice president of Sharp Solar Energy Solutions Group (Huntington Beach, Calif.), sees it. As the range of solar consumers and their circumstances proliferate, Sharp expects its focus on customer niches to stand it in good stead—whether it's a building integrated module for residential customers or ground-mounted thin film panels for the wholesale utility customer.

Sharp Solar has in-house teams that service contractors for the residential market and systems integrators for the commercial market, but the company's sales force deals directly with utility and off-grid customers. "The days of one size fits all are long gone in the solar industry," said Kenedi. "We specialize in making products for different customer sets and for different purposes."

In July 2009, for example, in response to customer feedback, Sharp released a black-on-black 235-watt panel with a low-profile rack for residential and commercial use. "That what our customers have asked us for, and we made it for them. So it looks really clean and sleek on the rooftops," said Kenedi.

With financing seizing up for commercial projects as a result of the credit crunch, Sharp Solar—the U.S. solar subsidiary of $30-billion diversified electronics firm Sharp Corp. of Japan—has found commercial projects slow going of late. Commercial rooftop projects used to make up 60% of Sharp Solar's business but while still substantial, that percentage is down in favor of residential. "That's been the biggest problem we've had, trying to limp along in that part of the market. Banks aren't loaning, financial agencies aren't loaning, and the incentive money is not on the street yet. So it's all a big waiting game."

However, once stimulus spending really kicks in, Sharp Solar expects a new segment to take up the running: institutional solar arrays. One of the main targets of the government's stimulus package is large solar systems for government buildings, Kenedi observed. Schools, VA hospitals, post offices and jails will all be part of the new commercial market: "Institutional solar is going to be huge."

Although farther out, Sharp Solar is also preparing for large projects in the utility sector, expected to gather steam in 2010—and that's where Kenedi believes the Sharp brand has leverage. Although banks aren't lending much these days, banks do favor Sharp, Kenedi explained. "The cost of money when you're using Sharp is a little less. The company has been in business longer than its warranties, which you really can't say about most solar providers today."

The same comfort level should apply to the utilities, he believes: "Utilities are very conservative. They'll buy from a company that will provide them with best product at the best price, but they don't want to take risks either… That's where the brand loyalty is—to the company that's going to make them successful."

Like other executives and analysts, Kenedi believes there is a rush to quality by the larger developers, systems integrators and utilities that will favor the larger, more established solar manufacturers because of the service and warranty commitments required for 20- to 25-year systems.

However, the lead times for utility contracts could be substantial, and despite its massive potential the utility market could still be modest in the next couple of years. "There's a lot of things that have to be done—big swaths of land have to be acquired, PPA arrangements have to be made. It's a long process, and as opposed to putting a system on a roof that might take a couple of weeks this [utility projects] might take up to two years."

Competing solar manufacturers like Sunpower, Suntech and First Solar have bolted on systems integration and project development capabilities to position themselves for the emerging utility opportunity. Does Sharp Solar have ambitions in installation or project development? "Sharp's core focus is manufacturing. We know how to make things and we really know how to make the machines that make things," said Kenedi. "And we are creating several new partnerships with large installers," said Kenedi.

### Sharp Thin Film

Sharp Solar Energy Solutions Group, (Huntington Beach, Calif.) has been in thin film technology for about 20 years, according to Sharp's Vice President Ron Kenedi, but commercial-scale production will kick off in 2009. In the first quarter of 2010, the company will throw the switch on its gigawatt-size factory to produce thin film solar panels for the utility market. Currently Sharp's thin film cells are being made in smaller factories in Japan. The new thin film factory will be located adjacent to Sharp's large LCD factory on a manmade spit of land outside Osaka. "We take advantage of economies of scale. The glass manufacturer is there, the gas manufacturer is there—raw materials common to both products. We make them side by side," said Kenedi.

Thin film technology offers a lower cost per installed watt and heat tolerance, making it well suited for large ground mounted solar arrays in desert environments. "Right now we're talking to a lot of potential customers for projects to get installed from now through 2014 (for the utility scale sector)," said Kenedi.

Sharp has adopted an amorphous/microcrystalline thin-film tandem cell design which uses layers of amorphous silicon and microcrystalline silicon yielding a conversion efficiency of nearly 9% and on track to reach 10% and higher from the gigawatt factory. This is 40% higher than conventional amorphous solar cells, the company claims. "Sharp's thin film efficiency is continually improving, and we are planning to increase that efficiency," added Kenedi. "Our market leadership is underscored by the experience that Sharp brings to the table – and the bank-ability that goes with manufacturing reliable, high quality modules."

Sharp's solar business accounts for $1.6 billion of its $30 billion in annual revenues, according to a July 2009 article on energycurrent.com. In 2007 German company Q-Cells edged past Sharp as the largest module and cell manufacturer globally, boosted by a feed-in tariff in the German market. In 2008, Q-Cells led the market by megawatts produced, while Sharp was roughly on par with Suntech and First Solar, according to research by iSuppli.

Will 2009—which has seen solar equipment prices decline steeply, turning a supplier's market into a buyer's market overnight—be viewed as a game-changing year for the solar manufacturing segment or just a bump in the road? Until backlogged inventory has cleared, it will be hard to tell, said Kenedi: "There are a lot of new entrants, new manufacturers coming into the solar field. They're striving to increase their market share, but they've got excess inventory. Frequently they're putting products on the market at below market pricing."

"I don't know if this is a bump in road. But I do know this: we have a President who wants to see solar succeed; we have energy prices that are increasing and utilities rates rising. I can't tell you who's going to win and who's not, but Sharp is in a very good position because we have a legacy in the industry," said Kenedi. "We have invested a lot in manufacturing. We own the technology, we have different technologies for different marketplaces, we have been around for a long time, and we're trusted."

## 5.2. Market Drivers

**Figure 72 Ranking of Market Drivers in Solar Energy**

| | Most important | Very important | Important | Not very important | Meaning-less |
|---|---|---|---|---|---|
| Government incentives/tax credits | 40% | 30% | 25% | 0% | 5% |
| Government requirements for renewable energy | 29% | 26% | 26% | 16% | 3% |
| Cost of oil | 13% | 43% | 25% | 20% | 0% |
| Energy self-sufficiency / energy independence | 16% | 32% | 34% | 18% | 0% |
| Corporate image | 0% | 27% | 54% | 14% | 5% |
| Environmental regulations on power sources | 3% | 26% | 43% | 23% | 6% |
| Carbon cap-and-trade | 8% | 25% | 25% | 33% | 8% |
| Carbon tax | 9% | 23% | 29% | 26% | 14% |
| Carbon offset buyers | 3% | 20% | 29% | 29% | 20% |
| Voluntary green power programs | 3% | 15% | 29% | 35% | 18% |

*Source: CCBJ Solar Energy Survey in 2008. Question was: Please rate the following solar market drivers in terms of their impact driving your sales in 2008*

Congress has set aside $5.5 billion so federal buildings and schools can increase energy efficiency and their use of renewable energy. The U.S. General Services Administration (GSA) estimates that 75% of the projects that receive this funding will use solar technology, according to Nick Hodge of Green Chip Stocks. For utilities, looming renewable portfolio standard (RPS) deadlines are a clear driver, and solar represents a fast, modular way to meet these targets. More than half of U.S. states now have renewable targets. Barclay's analyst Vishal Shah, cited by AP Energy Writer Chris Kahn, noted that demand for utility-scale solar projects could eventually make up half of the U.S. market and that major utilities could install about 5 gigawatts of solar photovoltaic projects during the next three years. Even 2008's 0.36 GW or 360 MW installed in the U.S. in 2008 was dominated by relatively small-scale commercial and residential installations with power developers accounting for just 28% of 2008 U.S. PV installations.

In a sign that incentives can trump an underlying bad economy, the California Public Utilities Commission in June 2009 reported that the California Solar Initiative, the country's largest solar incentive program, could install at least the same amount of megawatts in 2009 as in 2008, when added solar capacity in California nearly doubled to 156 MW. Through May 2009, 78 MW had already been installed. With recent rapid growth, California now has over 515 MW of cumulative installed solar PV capacity.

Solar appears to be gaining favor compared to other renewable sources as well. The July 2009 RPS Quarterly Report by the CPUC revealed solar bids had dramatically increased. In 2005 solar bids ranked behind wind bids; by 2006 the number of bids were about the same; 2007 saw solar start to pull away; but by 2008 solar bids were more than three times the number of wind bids.

Some other local initiatives include:

- The San Francisco Board of Supervisors passed solar incentives of up to $6,000 for homeowners and up to $10,000 for businesses. Applications for the program began on July 1, 2008.
- Berkeley initiated a revolutionary program where homeowners are able to add the cost of solar panels to their property tax assessment, and pay for them out of their electricity cost savings. In 2009, more than a dozen states passed legislation allowing property tax financing. In all, 27 states offer loans for solar projects.
- The California Solar Initiative has set a goal to create 3,000 megawatts of new, solar-produced electricity by 2016 (details below).
- New Hampshire has a $6,000 residential rebate program for up to 50% of system cost for systems less than 5 kWp installed on or after July 1, 2008.

### 5.2.1. Federal & State Drivers

In terms of regulatory drivers, at the federal level the extension of the investment tax credit to an eight-year timeframe on October 3, 2008, was critical, said Ron French, president of Alteris Renewables Inc.'s solar unit. "That as a backdrop for all of the states is incredibly important." At the state level, residential markets vary according to the incentive program. Asked which state residential markets are currently the liveliest, French noted that Massachusetts (Commonwealth Solar), New York (NYSERDIS) and New Jersey are all doing well. Connecticut is also a strong market on residential side but has no funding for commercial or municipal installations, he noted. The program most likely to be replicated nationally is New Jersey's Solar Renewable Energy Certificate, French predicted. SRECs are tradable certificates. Each time a system generates 1,000kWh (1MWh) of electricity, an SREC is issued which can then be sold or traded separately from the power.

"My guess is that this will be the direction in which most states are headed because it's a market mechanism that provides an incentive based on the amount of production." All that's missing is a floor price so customers can bank on a minimum return—something New Jersey is working through, said French.

Alteris Renewables' business has also benefited from Connecticut Clean Energy fund's solar leasing program under which CT Solar Leasing owns the solar system and householders pay a fixed monthly payment and no down payment. CT Solar Leasing aggregates the renewable energy certificates (RECs) to provide benefits through its Solar Dividends program, such as inverter replacement or out-of-warranty repairs. At the end of the 15-year CT Solar Lease the householder can either buy the system at its then current value, extend the lease, or have the system removed.

Does French foresee more third party ownership in residential market? "I absolutely do," he said. "If it weren't for the state of credit we would see more today… because in case of solar you're asking people for very high up front cost to save money over time. In essence to become your own utility, and many customers don't want to use their cash that way. If you offer an alternative you can save them money immediately."

Alteris Renewables' recent large-scale projects include a 217-kW solar power array for network cable company Siemon's corporate headquarters and manufacturing campus. The array, which went live in June 2009, was designed and installed by Alteris and benefited from a CT Clean Energy fund grant.

The company is also getting its feet wet in the utility business. In April 2009, Green Mountain Power of Vermont chose Alteris to build a 200-kW solar array, Vermont's largest solar project when finished this summer. "In the Northeast the [utility-scale] projects are not as large as in the Southwest, so there have not been many projects that exceed 1 MW in the Northeast, and we're very capable of handling that," said French.

The solar installation business is becoming crowded, French said. Solar installing is essentially specialized construction, so not surprisingly companies from the idling construction business, notably electrical engineers, are jumping into solar to keep their crews busy. However, he's also seeing many exits. "It's a very competitive and very difficult business to make money in… whether it's the difficulty of state funding that comes and goes, or of projects getting delayed, or of not having financial wherewithal to be able to inventory enough product, or on the training side to make sure projects work properly—it's a very difficult business."

Despite these challenges is this a good time to be in solar installation? Residential customers are more risk averse and cash limited; commercial customers have weakened underlying financials and are less able to take advantage of tax credits, but it's still a good time to be an installer, French believes. "Yes, the current economic situation has put a damper on the market, but otherwise the planets are aligned between pricing, legislation, awareness and increasing energy prices."

How fast solar proliferates will partly depend on bringing the public up to speed on the new solar equation. "It's changed because we have a federal investment tax credit of 30% which no longer has a cap for homeowners and we have generous depreciation allowances for businesses, plus state rebates and incentives that help buy down the price of the system. Plus the... carbon emissions. People need to rethink the equation," he concluded.

### 5.2.2. State Policy Drivers

U.S. states backing solar PV have historically used capital rebates that write down the upfront cost of a PV system. But these programs haven't always worked as well as the legislatures and governors hoped they would. In California, lack of performance standards led to rebates being paid out for PV installations on roofs that lacked good sun exposure. A New Jersey rebate program was "very successful for a couple years, then they spent their budget for five years and had to close the program down for six months," said Paul Maycock of PV Energy

Systems. "The legislatures are always impressed by how fast the industry responds with proposals and customers."

After several years of experience by the pioneering PV states, California and New Jersey in particular, many states, including those two, have "gone well beyond plain vanilla-flavor rebate programs to introduce a host of new program approaches that are paying off to foster development of new solar markets in the U.S.," said Mark Sinclair of the Clean Energy States Alliance (Montpelier, Vt.), a national non-profit group composed of 18 state clean-energy funding programs.

In many of the states with PV programs, renewable portfolio standards (RPS), also known as renewable energy standards, have been established with minimum requirements for PV capacity. Not so in California. PV installed under the ambitious California Solar Initiative that began last year does not count toward the investor-owned utilities' RPS requirement of 20% by 2010. "California's RPS focus is on large-scale generation," said Sinclair. "The state supports distributed generation through separate initiatives, such as the California Solar Initiative." As a result, under the RPS, California utilities are contracting with developers of concentrating solar power (CSP) plants, not to mention wind and other resources.

It's possible that California utilities will also contract with developers of large central generation PV arrays, but for now the California Solar Initiative is keeping integrators and installers busy. The CSI is putting more than $3 billion into PV incentives, with the goal of 3,000 MW installed by 2016. The largest part of the program, with a $2.2 billion budget funded with a surcharge on ratepayers' bills, is run by the California Public Utilities Commission. CPUC left behind the capacity-based rebate approach to use performance-based incentives (PBI) somewhat like Europe's feed-in tariffs – although at much lower rates. Owners of PV systems under 50 kW can also choose an upfront payment based on estimated production, known as an Expected Performance Based Buydown (EPBB). (The EPBB threshold started at 100 kW last year, dropped to 50 kW on Jan. 1, 2008 and 30 kW in 2010.)

The EPBB amount is based on an analysis of location, orientation and shading. "In the early days, there was no consideration given to where a system was installed or how it was installed," said Rob Erlichman, president of Sunlight Electric (San Francisco), a commercial integrator that builds systems up to 500 kW. "Rebates were paid on a per watt of capacity basis [with no penalties for poor performance]. This new program was designed to encourage people like us to design the most productive systems to generate as much power as possible."

Erlichman said his firm evaluates each project to recommend whether customers take the EPBB or PBI. "For most customers building a system over 50 kW, it is more advisable to do PBI." The PBI is paid for five years, while net metering – which credits customers at retail rates on their electric bills for the kWh of electricity their PV systems produce – also starts immediately and continues with no expiration date. "While the net metering transactions are going on, PG&E is also measuring with a stand-alone utility-grade meter how much power the system is generating independently of how much power the customer is using. It's upon that information that the PBI payment is based. PBI only lasts five years, while the customers get net metering from now until 50 or 60 years from now or whenever the system is no longer productive."

The California Solar Initiative, and similar programs run by the state energy commission and publicly owned utilities, has created a boom for residential installers and commercial integrators in California. "Without the CSI, we wouldn't be having this conversation," said Erlichman.

But the pace of the program had led to fears of a bust by the end of 2007, especially in the commercial segment. In 2007, the bulk of applications for PBI and EPBB came in for non-residential projects – 176.8 out of 208.6 MW, according to the CPUC. Even though the program devotes two-thirds of its incentives to non-residential PV, this robust response has caused the incentive levels for commercial projects to decline faster than expected. “What the CPUC couldn’t foresee as they crafted the program was that the first six months of activity was going to shoot through what they were planning to be three or four years of incentives,” said Stephen Torres, COO of DRI Energy, the PV installation and manufacturing side of West Coast roofing contractor DRI Companies.

“The CSI started in 2007 and immediately the industry effectively reserved the highest incentive levels with large commercial projects consuming the lion’s share,” said Sue Kately, executive director of the California Solar Energy Industries Assn. (CSLSEIA).

By April 2008, the PBI rate in PG&E territory had declined from the initial $.39 per kWh to $.22 per kWh for non-residential projects (the higher nonprofit/government rate declined from $.50 to $.32). EPBB payments had gone from $2.50 to $1.55 per watt of installed capacity. Incentive levels in the other two investor-owned utilities, Southern California Edison and San Diego Gas & Electric, were on similar tracks.

While such a decline was expected, and is indeed standard operating procedure for PV subsidies, it happened too fast to have the desired effect of stimulating increases in PV production volume – and thereby lowering costs, according to Torres and Kately. “The prices of modules and the balance of system costs have not really changed,” said Torres. “You have a cost structure in integration and delivery that has not changed, and a revenue structure that has been reduced by 33 percent.”

“The industry saw the incentives drop while costs for product, labor, insurance, and completing the paperwork increased,” echoed Kately. CALSEIA has urged the California Public Utilities Commission to reallocate and increase its budget.

### 5.2.3. Go Solar California

The Go Solar California! campaign is a joint effort of the California Energy Commission and the California Public Utilities Commission. The goal is to encourage Californians to install 3,000 megawatts of solar energy systems on homes and businesses by the end of 2016. The program also has a goal to install 585 million thermos of gas-displacing solar hot water systems by the end of 2017. The Go Solar California website provides California consumers a "one-stop shop" for information on solar programs, rebates, tax credits, and information on installing and interconnecting solar electric and solar thermal systems. The site has information on program rules, including eligible equipment and standards, as well as information on how to find an eligible, licensed solar contractor.

**Figure 73 Go Solar California Program Components**

| **Program Authority** | **California Public Utilities Commission** | **California Energy Commission** | **Publicly Owned Utilities (POUs)** | **Total** |
|---|---|---|---|---|
| **Program Name** | California Solar Initiative (CSI) (including CSI-Thermal) | New Solar Homes Partnership | Various Program Names | Go Solar California |
| **Budget** | $2,167 million (Electric) $250 million (Gas) | $400 million | $784 million | $3,351 million (Electric) $250 million (Gas) |
| **Solar Goals** | 1,940 MW (Electric) 585 million thermos (Gas) | 360 MW | 700 MW | 3,000 MW (Electric) 585 million thermos (Gas) |
| **Scope** | All solar systems in large IOU areas except new homes | Solar systems on new homes in large IOU areas | All solar systems in POU areas | All of California |

*Source: www.gosolarcalifornia.ca.gov; Note: The electric budgets are for 2007-2016, and the gas budgets are for 2010-2017.*

The 2007-2008 and 2009-2010 Sessions of the California State Assembly and California State Senate were busy for solar-related legislation in California with 11 and 6 key pieces passed A summary is available at http://www.gosolarcalifornia.ca.gov/about/gosolar/legislation.php.

The California Solar Initiative (CSI) is the solar rebate program for California consumers that are customers of the investor-owned utilities: Pacific Gas and Electric (PG&E), Southern California Edison (SCE), San Diego Gas & Electric (SDG&E). Elements include;

- A solar rebate program for customers in PG&E, SCE, and SDG&E territories. This program funds solar on existing homes, existing or new commercial, agricultural, government and non-profit buildings. This program funds both solar photovoltaics (PV), as well as other solar thermal generating technologies.
- A solar hot water rebate program for customers in PG&E, SCE, and SDG&E territories. This program funds solar hot water (solar thermal systems) on homes and businesses.
- A solar rebate program for low-income residents that own their own single-family home and meet a variety of income and housing eligibility criteria.
- A solar rebate program for multifamily affordable housing. This program is called the Multifamily Affordable Solar Housing (MASH) program.
- A solar grant program to fund grants for research, development, demonstration and deployment (RD&D) of solar technologies. This program is the CSI RD&D program.

## 5.3. Concentrating Solar Thermal Power

More than 40 concentrating solar thermal power (CSTP) projects have been proposed for sites owned by the federal government in southeast California, and tens of others have been announced for private and public lands elsewhere in California and in New Mexico, Arizona, Nevada and other Southwestern states where solar resources are considered adequate to generate power with the technology.

But many observers of the fledgling U.S. CSTP industry (also known as concentrating solar power or solar thermal power) are skeptical about whether even a small minority of those projects will move ahead. On top of the tight credit and loss of tax equity capacity that plague all U.S. renewable energy project developers, proponents of CSTP projects on federal lands have to go through a daunting National Environmental Policy Act (NEPA) review process to secure permits; they also have to solve vexing transmission riddles; and they need to maintain investors' and lenders' confidence amidst the perception that many project proponents that have announced utility power purchase deals will not be able to deliver power at a price that utilities will pay.

All this adds up to considerable costs for developers and owners, and a considerable project opportunities for consulting engineers developing specialty expertise along the permitting & planning to design engineering to construction management to plant operation continuum.

"Going back as far as 2005, a lot of the PPAs have been negotiated at prices that the project developers are probably not going to be able to achieve," said Reese Tisdale, senior analyst with the U.S. market research and business consulting firm Emerging Energy Research (EER). "Some PPAs are already under renegotiation."

## Spain the Clear Leader in Europe

In Spain, the leading CSTP market, the situation is quite different. Since 2007 when the government set a feed-in-tariff (FIT) of €0.278 per kwh (under the fixed scenario) for 25 years and €0.223 per kwh the following 25 years, the market has been inundated with projects.

"The original tariff was very attractive, so there was a great deal of interest from investors around the world to put money into solar thermal electricity projects, as well as photovoltaic, which enjoyed a similarly high tariff," said Carlos Segura, a partner at eclareon, an international strategy consulting firm with a sole focus in renewable energies. By September 2008, there were 13 CSTP plants under construction in Spain, according to Segura. As of July 2009, there were shovels in the ground at five more project sites, for a total of about 800 MW under construction, Segura told EBI. And a much larger set of projects (over 10 GW) is in some stage of development; Segura says very advanced projects representing about 4.3 GW have applied for the FIT under the set of rules established by the new law.

All this activity has dwarfed Spain's 500 MW national cap for the program. The government is now analyzing how many projects have met the new hurdles to qualify for the FIT, including having 50% of project costs financed, 50% of equipment ordered and €20 per kW of projected capacity on deposit. Segura says many of the projects have met these requirements, and that the government is now in discussions with the industry, represented by the Spanish CSTP Association or Protermsolar, about increasing the 500 MW cap and setting new, presumably lower, tariffs. Also under discussion is increasing the per-project cap of 50 MW.

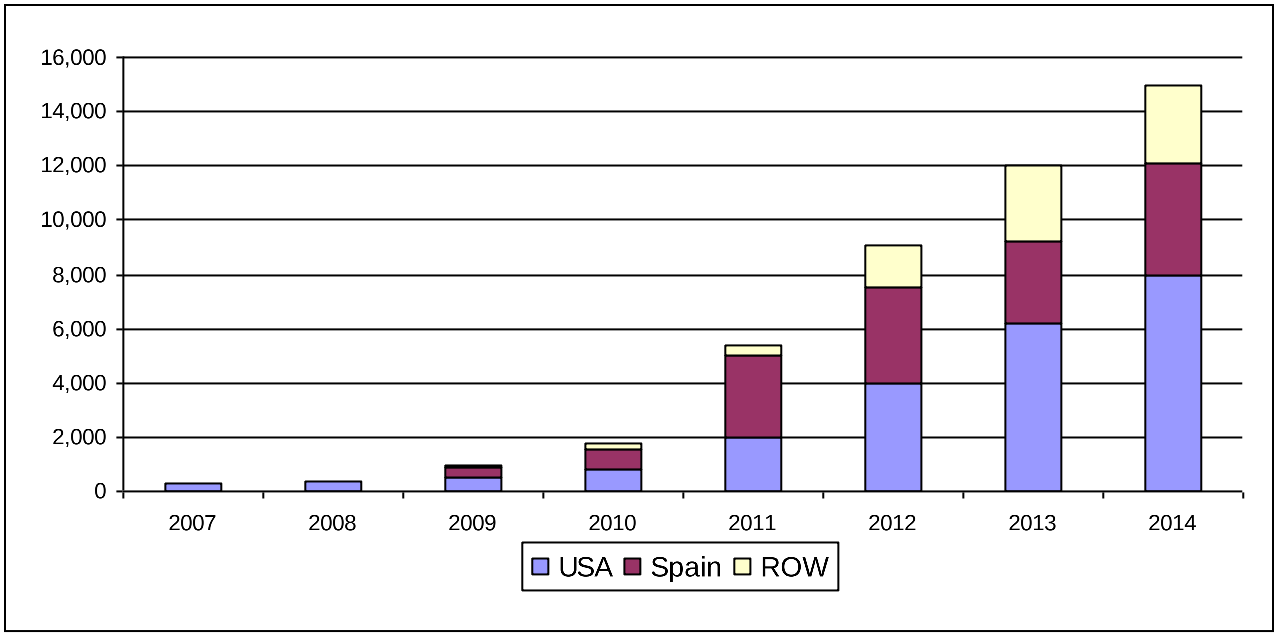
In the Spanish market, engineering, procurement and construction (EPC) firms such as ACS Cobra, Sener and Endesa Ingeniera are key players, often financing projects with equity. "In Spain EPC firms are taking 25 percent to 50 percent stakes in the plants, and sometimes 100 percent, as in the case of ACS Cobra. They're becoming an independent power producer," said Tisdale.

Tisdale says the high initial FIT in Spain has allowed Spanish EPC firms to enjoy high margins on CSTP projects and created an inflated marketplace. "The projects in Spain are incredibly expensive, and those costs actually have to come down," he said.

Segura agrees and predicts that the new Spanish CSTP tariff will be significantly lower. Preferential tariffs for PV projects in Spain were cut nearly 30% last year, causing many investors to back away from the market for a short period of time, he said.

**Figure 74   Concentrated Solar Power: Megawatts of Capacity in Pipeline 2007-2014**

| | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|
| USA | 300 | 400 | 500 | 800 | 2,000 | 4,000 | 6,200 | 8,000 |
| Spain | - | - | 400 | 750 | 3,000 | 3,500 | 3,000 | 4,100 |
| ROW | - | - | 50 | 200 | 400 | 1,600 | 2,800 | 2,900 |
| **Total** | **300** | **400** | **950** | **1,750** | **5,400** | **9,100** | **12,000** | **15,000** |




*Source: Adapted from Emerging Energy Research and SEIA.Note: SEIA's pipeline counts more than 8,400 MW of U.S. projects in development, however industry observers believe that only a fraction of that will get built in the timeframes presented by developers*

"One month later they were coming back," said Segura. "This was at end of last year. Why? Because installation costs had decreased even more than 30 percent so their returns on investment with the new FIT are almost as good as with the old FIT."

"I don't see that happening in such a dramatic way [with CSTP] but I think there is room for the manufacturers to reduce the costs of the equipment and also gain efficiency", said Segura.

## No Consensus in CSTP Technologies

In Spain, most projects under construction and proposed are using the most mature CSTP technology: parabolic trough, in which curved troughs of reflectors concentrate sunlight onto a hollow receiver tube where fluid is heated. The heat is then used to power steam generators in systems familiar to developers and engineers in conventional electricity generation.

In the United States, most project developers propose to use versions of the less mature technologies, including: power tower technologies, in which an array of movable mirrors (heliostats) concentrate sunlight onto a central tower where fluid is heated; dish sterling, in which dishes (resembling satellite dishes) concentrate sunlight onto a thermal collector coupled with a

Stirling engine; and Fresnel, which is similar to parabolic trough, with angled plane Fresnel mirrors used to concentrate sunlight more efficiently.

"This is an interesting difference between Spain and the U.S.," said Tisdale. "The large majority of projects in Spain are parabolic trough. It's a proven, bankable technology, and the companies have their own designs." One of the reasons for the technological innovation in the United States is the potential to reduce costs over what parabolic trough designs can deliver.

Although investor-owned utilities (IOUs) in California, Arizona, Nevada and New Mexico are under pressure to meet renewable energy standards, there's nothing forcing them to get it from CSTP projects (except in the case of New Mexico, where 4% of electricity sales must be generated with solar PV or CSTP by 2020). So, unlike in Spain where project developers can qualify for a rich FIT, CSTP project proponents in U.S. states must compete on price with wind power, biomass, PV, geothermal and other renewable technologies.

"In the U.S. there's more competitive pricing pressure because each project developer has to negotiate with a utility for a PPA," said Tisdale. "There's been a lot of pressure to deliver at the lowest cost possible."

Hence more projects are proposed with emerging technologies, usually proprietary versions, that may — or will in their proponents' view — deliver MWh less expensively than parabolic trough technology. Companies seeking to compete with proprietary versions of power tower and Stirling technologies include BrightSource Energy, eSolar, Stirling Energy Systems and others. "These companies are trying to cut capital costs and in some cases deliver higher efficiency as well as potentially higher capacity factors," said Tisdale.

Then there are larger established companies, particularly European firms with experience in the Spanish market, seeking to develop projects with the more mature and proven parabolic trough systems. These include Europeans Abengoa Solar and Solar Millennium and U.S. firm NextEra Energy (a subsidiary of FPL Energy). Which is not to say that these and other firms building parabolic trough projects are averse to newer technologies; Abengoa, for example, has built one 10-MW power tower and has another 20-MW project underway.

Some Spanish EPC firms have set up offices in California to pursue contracts with U.S. CSTP project developers, while U.S. EPC firms have been slower to focus on the market or are doing so in a low-profile manner, Tisdale said. "I think the big EPC firms are working behind the scenes. There's no sense in them making any big announcements until things get closer to construction."

One exception is Lauren Engineers & Constructors, according to Tisdale. "They worked on the Nevada Solar One plant and they're also working on the parabolic trough steam generation facility in Florida for Florida Power & Light," a 75-megawatt CSTP addition to an existing combined cycle gas turbine plant.

While PPA prices are confidential, at the July 14, 2009 CSTP roundtable hosted by InterSolar in San Francisco, representatives from Ausra, eSolar and Solar Millennium agreed that PPA prices for CSTP projects are typically in the range of \$0.15 to \$0.18 per kWh. Whether or not project developers using newer technologies can achieve those is an open question, since projects of the scales proposed have never been built with those technologies.

In Tisdale's estimation, projects with parabolic trough technology definitely have the edge in terms of financing at this time. "That's what the banks want and like because they're financeable.… There are questions as to whether some of these newer technologies are going to deliver."

As Tisdale noted, some PPAs signed by newcomers to the CSTP field may currently be at risk, and some are in renegotiation. In California, ratepayer advocacy group The Utility Reform Network has voiced concerns that PPAs for some renewable power projects have been signed at unrealistically low prices, setting consumers up for potential liabilities. According to the newsletter California Energy Markets, the California Public Utility Commission has “started a process to better gauge project viability, factoring in developers’ experience, project technology and permitting status.”

In a state where IOUs are required to reach 33% renewable energy standards by the 2020, non-viable CSTP projects may provide an opportunity for an established parabolic trough project developer and operator such as FPL Energy subsidiary NextEra Energy to step in, according to Tisdale. NextEra’s 150-MW SEGS III-IX facilities in California make it the “the largest owner of CSP in the world,” he said. “They have experience and they have access to capital.”

Yet Tisdale isn’t writing off non-parabolic trouble technologies. He notes that large players in the independent power producer (IPP) industry are backing CSTP project developers using power tower and other technologies. eSolar, for example, has partnered with NRG Energy, fossil-based IPP with 24 GW in the United States, Australia and Germany and 2008 revenues of $6.9 billion. NRG has invested $10 million in eSolar and agreed to partner with the firm on up to 500 MW of CSTP projects in the United States. “This is NRG’s first venture into solar power,” said Michael Liebelson, NRG’s chief development officer of low-carbon technology, in a news release.

The deep balance sheet of a company like NRG will help eSolar take its power tower technology from the demonstration phase—the firm operates a 5-MW demo plant in California—to broader deployment and sales, according to Tisdale. Along with its partnership with The ACME Group of India, “eSolar is in a better position than some firms to make it through what’s known as the valley of death, where you need a lot of money to demonstrate new technology so you’re able to go to public markets for equity and banks for project financing,” said Tisdale.

**Figure 75 Concentrating Photovoltaic Companies**

Amonix
Concentrix Solar GmbH
Cool Earth
Cyrium
Emcore
Energy Innovations
Entech
Green and Gold Energy
GreenVolts
Guascar Foton
JX Crystals
Menova
NuEdison
Prism Solar Technologies
Pyron Solar
Sharp
Sharp
Sol3G SL
Solar Systems

Solaria
SolarTec
SolFocus
Soliant
Soliant Energy
Solucar Energia (part of Abengoa)
Spectralab
Stellaris
Whitfield Solar
ZSW

*Source: EBI database of solar companies*

### 5.3.1. California CSP Profile: BrightSource

At Ivanpah back in California, BrightSource, which includes a number of the original Luz team members who developed SEGS, is forging ahead with its power-tower project. The firm's technology is based on DOE's Solar One and Solar Two demonstrations, and "what we've done is make commercial improvements," noted BrightSource's Ricker. "We've focused on getting the costs down."

Whereas Solar 1 and Solar 2 used giant parabolic mirrors—120 to 200 square meters each, requiring large amounts of structural steel and big foundations— "we use small mirrors that are simple to mount," said Ricker, adding that the Ivanpah mirrors will be on the order of seven square feet each. Moreover, the original technology faced challenges in controlling the movement of the mirrors "because the control mechanism and control strategies and economics in those days were very expensive," Ricker explained. "That's not the case today. We've taken advantage of lower-cost technology for controls."

Another factor that promises to make the BrightSource design economical "is that it's very simple," according to Ricker. "We use flat glass instead of curved glass, which is much less expensive, and there are dozens of large-scale, reliable high-quality suppliers, while there are only a couple that can supply curved white glass." In its first round of funding, BrightSource was supported by Vantage Point, Draper Fisher Jurvetson, JP Morgan and Chevron Technology Ventures. Morgan Stanley joined these backers in the second round.

The timeline for Ivanpah is not unlike that for any other proposed project. "That depends on the availability of transmission," noted Ricker, explaining that the company applied for access late in 2006. "It takes a long time to get these issues resolved. It looks like will go into construction in 2009 and be operating by the latter part of 2011. We can do it faster if transmission is available.

"A transmission line goes right through the property, but we won't know if available capacity can go to us or if an additional line will have to be strung," he went on to say. "It's not just the way you tie into the transmission system, it's the capacity out of the substation you're going to and where your customers are. It's a problem for all solar projects in the Mojave." Wind projects built in the region over the last several years, as well as planned wind projects, "have taken up a great deal of the capacity," added.

"At some point, the California Independent Systems Operator [CAISO] will tell us when we'll be able to get transmission access," Ricker said. "The transmission access allocation process doesn't show any favoritism to renewable energy. There's no mechanism for trading places in the queue or other factors that would help a project move the timeline up. A lot of people, including those at CAISO, the Public Utilities Commission [PUC] and the California Energy Commission [CEC] would like to see some of these things change."

### 5.3.2. California CSP Profile: Ausra

For its CFLR project in San Luis Obispo, Ausra, which is backed by venture capitalists Vinod Khosla and Kleiner Perkins Caufield & Byers, is going to flat glass to reduce capital costs. Like the parabolic trough systems, the CFLR system is line-focused and uses selective surface materials, albeit a new type of material that is more stable in air than preceding versions, according to O'Donnell. In addition, the parabolic reflectors are arranged in multiple flat strips on the ground rather than 35 feet in the air, thus saving costs on steel, which has undergone enormously high price increases of late.

Another advance in Ausra's approach—perhaps the most important one, O'Donnell claimed—is the adoption of assembly-line production techniques for key elements of the system. "One of the founders came out of the automobile manufacturing business and had a lot of experience with assembly-line production," O'Donnell said. He pointed to the typical parabolic trough system as requiring hundreds of technicians, standing on stepladders in the field, to implement the precision optical alignment. "One of the real simplifications in our CLFR system is that all the precision optical work is done on the production line in the factory and then transported to the site and dropped in place."

The Ausra CLFR system will operate at temperatures below 300ºC and thus be able to use water rather than oil or the increasingly popular molten salts as the heat storage fluid. At these lower temperatures, the heat turbines operate less efficiently, O'Donnell acknowledged, "but that really doesn't matter. What matters is the cost of building the collector versus the energy you get from it. It's paradoxical, because the rest of the industry is pushing to the highest possible temperatures while we're pushing for the cheapest materials, and it's working out. The question at the end of the day is how many hours of energy you can gather versus how much steel, etc., you are using...The fundamental difference is cheaper solar collectors. That's more fundamental than the cost differential between water-based storage and salt-based storage. We're competitive at the 9- to 10-cent/kWh level. Within five years we'll be directly competitive with coal-fired generation."

O'Donnell confidently asserted that Ausra's San Luis Obispo project was well ahead of other proposed CSP plants in California, for several reasons. "We will burn no fuel, so we don't need gas lines, and we're dry-cooled. That brings us down to land and transmission issues. Our spot in San Luis Obispo is land where 50 years ago they grew potatoes, and 10 years ago they grew wheat. Here was land that was lying idle, and didn't have any endangered species issues because of 100 years of farming." The fact that it was private land that the company pursued and not Bureau of Land Management (BLM) land presented another advantage in O'Donnell's view. "All the separate BLM offices are swamped. For some guys whose technology will be ready to start three years from now, that's great. For us, it's a non-starter. That's why we've gone to private land. BLM's process takes about two years from when you file."

O'Donnell was also upbeat about the availability of transmission capacity for the Ausra facility and other CSP plants. The California Public Utilities Commission has been enthusiastic about building out transmission corridors for renewable energy—for wind power in the Tehachapi area, for example. "Most of the wind doesn't produce when needed all the time, so if the solar plants can deliver over those lines, it reduces the cost per kilometer."

## 5.4. Electric Utilities in Solar

As electric utilities respond to state renewable portfolio standards (RPSs) and other climate change initiatives, they cast a broad net for those renewable energy sources that are best suited to their geographic coverage, their regulatory requirements, and their capital budgets. As expected, the viability of solar power generation is very geography-dependent, having the greatest popularity where the sun shines longest and strongest, in California and the Southwest.

In the decision to own and operate solar facilities versus purchasing the power from third parties, power purchase agreements (PPAs) currently appear to have the edge over internal ownership. Some utilities, however, are looking to "prime the pump" for the larger rooftop PV installations or other forms of utility-scale or near-utility-scale PV generation by pursuing a mix of internally and externally owned capacity development.

### 5.4.1. Southern California Edison

One such utility is Southern California Edison (SCE; Rosemead, Calif.). SCE claims to purchase more renewable power than any other utility in the nation, delivering 12.6 billion kilowatt-hours (kWh) per year, or 16% of all SCE power delivered. That renewables fraction does not include hydroelectric power, which cannot be counted as a renewable resource for RPS purposes in California.

SCE generates 30% of its total power delivery from internally owned and operated facilities, while for the remaining 70%, "we go into the marketplace to buy," SCE spokesperson Gil Alexander told EBI. "We don't anticipate changing that [ratio], and we prefer not to." Under California's deregulated power structure, "the preferred approach to power generation is for independents, not utilities, to do it... we support that philosophy."

In one major initiative involving solar power, however, the mix between internal development and third-party purchases is split evenly. In 2009, the California Public Utilities Commission (CPUC) approved an SCE proposal to develop 500 megawatts (MW) of solar rooftop capacity over the next five years, splitting the internal and external development right down the middle.

"What we'll do over the next five years is install the equivalent of four square miles of solar PV panels on top of about 300 buildings—large warehouses on the order of 500,000 to 600,000 square feet each, resulting in 500 MW of capacity," said Alexander. Comparing this capacity to a 1,000 MW gas-fired plant, Alexander stressed that the solar rooftop plan represents "a real order of magnitude in development. Half of that capacity we will own and operate, so picture 250 MW exactly like a utility. We will buy the panels and install them and own and operate the facilities. The other half we will solicit from generators through PPAs." That solicitation was expected to be released by the end of summer 2009.

In fact, SCE's original proposal was to invest $875 million over five years to develop 250 MW of SCE owned and operated solar PV capacity on 150 buildings. Following about a year of discussions with regulators, industry associations, solar system installers and other stakeholders, CPUC agreed to the proposal on the condition that SCE solicit another 250 MW of third-party-developed solar rooftop capacity.

SCE jumped into the rooftop PV arena because it saw a gap in the solar marketplace, according to Alexander. The build out of PV systems on small structures, such as residences and small commercial establishments, was proceeding apace, while several private firms have launched a resurgence of activity in utility-scale CSTP plants in the deserts of the Southwest. "What we noticed was very little activity in the middle—1 MW to 2 MW installations on large warehouses," noted Alexander. "We were hoping that, by doing 150 buildings, we'd prime the pump, and that others would catch onto it and bring down prices."

Confident in the merits of its proposal, SCE actually completed its first rooftop installation in 2008, well in advance of CPUC's approval. In December 2008, the utility started up operations of a solar PV system on 600,000 square feet of rooftop on a distribution warehouse in Fontana, California. The system consists of 33,000 solar panels generated 2 MW, enough to power about 1,300 homes.

Key among the drivers for renewables development at this scale is California's RPS, which mandates that the state's electric utilities derive 20% of their power from renewable energy by 2010—"the most aggressive RPS in the nation," according to Alexander. A secondary driver is California's Assembly Bill 32, the Global Warming Solutions Act of 2006, which sets stringent standards for greenhouse gas (GHG) emissions reductions. Finally, SCE's proposal "supports the nation's most aggressive initiative in solar power, the Million Solar Roofs program," noted Alexander.

"All of the other reasons for [undertaking the solar rooftop project] are common to all solar generation—the benefits of renewables, and the abundance of solar energy in California, etc." he continued. "You don't do it because it delivers to customers the least-expensive power available. It is not the least expensive."

Solar adds to the diversity of the generation resource, which is also critical, Alexander added. "We felt it was appropriate to tell our customers one year ago that, if current natural gas cost trends continued—and they had doubled in six months—our customers could see by January 2009 a 25% increase in customer rates. That's because 54% of our generation in California is from natural gas. Anything you can do to diversify your portfolio so you don't face spikes in one source is beneficial."

That said, the development of new generating capacity constitutes a very small percentage of SCE's overall capital budget. "There's no major, long-term investment plan in new renewables generation," Alexander stressed. The solar rooftop program "should be seen as a one-off project to prime the pump in an area where we had seen a gap.... We have five-year, $20.4 billion capital investment program underway that does have a piece of it for investment in generation, so I'm not saying we're doing no investment in generation," he continued. "But we don't have a major strategic solar investment program that would be affected by trends in today's marketplace. Of the $20.4 billion plan to invest over the next five years, $2.7 billion will go to generation, and $875 million will go to that solar project. Another major piece is focused component replacement at our nuclear plant for components, like steam generators, which are nearing the end of their lifetime."

SCE is also adding solar generation through PPAs, including a series of deals struck in February 2009 with BrightSource Energy (Oakland, CA). The contracts call for BrightSource to eventually deliver 1,300 MW from its Luz Power Tower 550 facility, which is currently under development near Ivanpah, California. That facility is expected to begin delivering power in 2013, according to Kathleen Sloan, an SCE project manager with responsibilities in regulatory and legislative policy involving renewables and alternative energy.

SCE has issued one competitive solicitation per year for renewables since the state's RPS was established in 2002. Solar has an obvious attraction in California, and SCE purchased about 60% of all solar power purchased in the nation last year, according to Sloan, but solar power gets no preferential treatment going in. "We don't have a specific carve-out or preference for one technology or another. We evaluate them all. We take into account when the power is going to be delivered, when it will come on line."

Nor is PV preferred over CSTP, or vice versa, she added. “We evaluate all technologies equally and match it with our output and need. We have parabolic troughs, power tower, and Sterling dishes—a gamut of technologies within our portfolio.”

Sloan noted, however, that solar does offer some advantages over other renewable alternatives. “One of the benefits of solar is that it more closely meets peak demand than some other technologies. It delivers when the sun is shining, when it is hotter, and when people are using more power.”

The renewal of the tax credits for wind, solar, and other renewables was welcome, but financing hasn’t been the biggest challenge for the facilities from which SCE is seeking power deliveries. “The larger concern is transmission—bringing the energy from the desert to the load centers,” said Sloan. “That process can take seven to ten years. That’s a major hurdle.”

SCE is in the process of building the Tehachapi transmission line, primarily to connect wind resources to the load centers. “We own that line and are building it, and we’re the ones who brought it through the regulatory process,” said Sloan. “We’re now looking to identify a state-wide collaborative process to focus on where new transmission should be built. Most of those lines will go through our territory [50,000 square miles in southern California], because it is rich in wind and solar.”

### 5.4.2. Pacific Gas & Electric

In northern California, Pacific Gas & Electric (PG&E; San Francisco, CA) is delivering electricity supplied by solar power, most of which is being contracted through PPAs. Like SCE, PG&E has a 1,310 MW with BrightSource, expanded in May 2009 from an original 900 MW deal. On July 27, 2009, PG&E entered into a PPA with El Dorado Energy LLC, a subsidiary of Sempra Generation, to purchase 48 MW of the electricity to be generated at El Dorado’s proposed Copper Mountain Solar PV facility near Boulder City, Las Vegas.

Other solar PPAs include deals with AV Solar Ranch 1 LLC for 230 MW and Alpine SunTower LLC for 92 MW. AV Solar Ranch 1, a subsidiary of San Francisco-based NextLight Renewable Power LLC, is developing a utility-scale PV plant near California’s Antelope Valley. Alpine SunTower, which is a subsidiary of NRG Energy Inc. (Princeton, NJ), will use solar thermal technology developed by eSolar (Pasadena, CA) at the Lancaster facility, which is scheduled for completion in 2012.

Pursuing the frontiers of innovation, PG&E has also applied for CPUC’s approval of a PPA with Solaren Corp. (Manhattan Beach, CA), which is developing a space-based solar power project. The space-based facility would collect solar energy while traveling in a geosynchronous orbit, covert the energy into radio frequency (RF) power, and transmit it to a receiving station in Fresno County. If everything goes according to plan, Solaren would begin delivering power from the facility in 2016.

The PG&E contract with Solaren is for 200 MW, “but the power is available 24-7, so 200 MW based from space delivers more energy than a 200 MW installation on earth,” PG&E spokesman Jonathan Marshall said. “It would serve almost a quarter of a million homes.”

PG&E recognizes that there is a risk that some of the developers with whom it has contracts may not be able to perform. “For that reason, we’re aggressively trying to contract for new power sources above and beyond our state requirements,” Marshall noted. “We know that not all the energy we’re contracting for will be developed, so we need to have backup plans in effect.”

Like SCE, PG&E has made a foray into rooftop solar through a mix of internally owned and operated facilities and projects to be developed by third parties. This initiative “marks our first foray into development and ownership,” said Marshall. “It would involve a lot of projects in the 1 to 20 MW range—bigger than the kind of residential and commercial installations you see, and smaller than some of the utility-scale projects. They would be easier to site and quicker to market."

PG&E's proposal to develop 250 MW of its own internally operated solar rooftop capacity is currently before the CPUC. In parallel, PG&E has developed a companion program to attract third-party projects of similar size, amounting again to a total of 250 MW of capacity, "to bring this type of power to market quicker," noted Marshall. The utility has also embarked upon the installation of a pilot project under which it will install 2 MW of PV panels on one of its substations.

"Until the end of last year, the way federal tax law was written, there was really no way utilities could cost-effectively build their own projects," Marshall said in explaining PG&E's new venture into internal ownership of solar facilities. "They weren't eligible for the same tax credits. That changed last year, so we're taking a long look at supplementing third-party development with our own. That way we can leverage our balance sheet with our expertise to bring solar energy to our customers at an accelerated pace."

Fears persist that utilities could monopolize solar generation to an extent, but bringing solar to market has trumped the objection. "There's so much need for renewable energy that there's no way we will be crowding private developers out of the market," Marshall said. "Given the difficulty that small developers are having in getting financing, it's important that utilities get involved at this time. But all of us, whether utilities or third-party developers, are facing the same challenges in terms of siting projects, getting permits, getting access to transmission, and so forth, particularly for the larger-scale projects."

In states like California, "solar is a very attractive form of renewable energy," Marshall said. "It's not the lowest cost form of energy, but we're seeing substantial improvement in cost effectiveness, both in solar thermal and PV. That's one reason we're supporting it—to help industry drive costs down and make it more competitive. We're certainly interested in wind, geothermal, and biomass, and we have an R&D program in wave energy, because California has some of the best wave energy resources in the country, but that technology is some years away from commercial viability."

## 5.5. Installation Market

### 5.5.1. Commercial and Residential Installers

Consolidation only beginning in a business that is tough to scale. Compared to Europe, where solar installation is relatively mature, in the United States it's a fragmented business populated by hundreds of small, independent and regional outfits. California, which accounted for 60% of installed megawatts in 2008, has close to 800 firms tied to the solar industry of which 90-95% are installers and dealers and 82% are small (24 or fewer employees), according to California Community Colleges Centers of Excellence solar workforce report.

Since the solar installation business only exists in those states with adequate incentives, it is also essentially a bi-coastal business concentrated in the Northeast and the Southwest. In these two regions, there is a revolving door of new entrants and exits. However, a dozen or so dedicated multi-state installers have come to the fore, plus a handful of large, vertically integrated players based in manufacturing and independent power production.

In the solar installation market, a variety of business models are being pursued: Most involve selling or leasing panels; others involve paying for and owning the installation and selling the electricity. For example, SunEdison, a provider of solar energy services, assumes the costs of installation for large corporate and institutional clients, leveraging capital from investors like

Goldman Sachs. It owns and operates solar installations on the roofs of its customers' sites; customers buy the electricity at locked-in prices and the excess is sold to utilities.

SolarCity (Culver City, Calif.), founded in 2006, offers a SolarLease, where the customer pays a combination of a low monthly lease payment and smaller electricity bill that is typically less than a regular utility bill. SolarCity retains ownership of the PV panels.

Leadership in solar installation is fairly mercurial and shifts from state to state. The largest installers tend to be vertically integrated and full service, i.e., involved in not just installation but also design, engineering, financing, operations, maintenance and even ownership. These companies include ESPs (electric service providers) like SunEdison and large solar module manufacturers like SunPower that have acquired installation capabilities and work up to utility-scale projects.

The smaller multi-state installers like REC Solar and Alteris Renewables tend to have the majority of their business in the commercial and residential sectors, although they likely won't be left out of the smaller projects in the emerging utility market.

According to iSuppli's PV Perspectives in June 2009, nationally (including utility type projects), SunEdison was the largest installer in 2008 with 25.5 MW or almost 10% of all grid-connected capacity added last year; SunPower was second with an estimated 20 MW of installations, mostly in California, and thin film manufacturer First Solar, was third with two utility projects representing 12 MW combined.

In California, which represented close to two thirds of PV megawatts installed in 2008, SunPower became the largest installer with almost 17% marketshare through January-May 13, 2009, according to iSuppli's analysis of California Solar Initiative data. (The calculation excluded large utility-scale awards.) Chevron Energy Sources ranked second with almost 10%, partnering with manufacturer SolarWorld on many projects, while SPG Solar had 8% share. REC Solar, SolarCity and Akeena followed in the ranking, and overall the top nine players accounted for a little over 55% of the California market.

The fragmentation and lack of saturation in U.S. solar installation represents a huge opportunity, but not necessarily one that will be easy to exploit. The three main components of a full service installer are sales and project development, engineering and design, and strong project management. All are people and skills intensive, in addition to which warehousing and delivery logistics become increasingly challenging over large geographic areas, making organic growth a big challenge.

"The characteristic of the residential market is it's self-performed, and because of that it's very unscalable," said Executive Vice President Stephen Clevett of Premier Power Renewable Energy Inc., an installer active in California and Europe that recently made an acquisition in Italy. In the residential market "you grow out of reach very, very quickly… You have to replicate by bringing in a lot of people, it becomes very unwieldy, and when you get a lot of competition and saturation you have to relocate."

However, recognizing that there may be benefits to scale, larger installers have been making their first cautious acquisitions. Recent M&A activity has included:

- Mercury Solar Systems acquired K-Star Solar
- Alteris Renewables acquired Renewable Power Systems
- GroSolar acquired Borrego Solar Systems;
- Real Goods Solar acquired Regrid Power Inc.
- SunEdison acquired Business Institute Solar Strategy of Germany
- Premier Power Renewable Energy acquired Arco Energy in Italy.

In related M&A news Itochu Corp., which acquired California-based wholesale distributor and systems integrator Solar Depot in 2007, acquired 85% of SolarNet LLC in 2009. SolarNet is a solar power systems provider that includes DC Power Systems and Stellar Energy Solutions. The combined market share of Solar Depot and DC Power will give Itochu the largest solar distribution network in the U.S. and positions Itochu as a leading integrator of commercial-scale solar power systems with a project pipeline of over 80 MW across the U.S., claimed a SolarNet press release. Itochu is a Japanese trading company with an announced strategy of rolling up wholesale distribution companies that include installation components. Also pursuing a roll-up strategy is Lonestar Capital Corp., dba Acro Energy Technologies, beginning with Acro Electric, Inc., which it characterized as the eighth largest residential solar integrator in California.

While scaling up to form any kind of clear-cut leadership will be challenging, what does appear to be certain is a growing momentum in solar installation that is undeterred by the current economic turmoil. In the country's largest solar state the California Public Utilities Commission reported in June 2009 that May was the highest month on record for new solar applications (over 22,000) and that the California Solar Initiative could install at least the same amount of megawatts in 2009 as 2008, in spite of the state's financial woes.

California now has over 515 MW of cumulative installed solar PV capacity at nearly 50,000 sites; 226 MW of this was installed in 2008 and 2009 under the California Solar Initiative. New Jersey is second with 70 MW installed, followed by Colorado and Nevada with 35 MW each.

Of the almost 300 MW of PV capacity installed in the U.S. market in 2008, 30% was owned by building owners, 28% by energy service providers like SunEdison, 26% by homeowners, and 12% by government/schools iSuppli estimated. Analysts and executives foresee more third party ownership ahead in both commercial and residential segments.

### 5.5.2. Installer Profile: Premier Power Renewable Energy

In a down market there are always a few companies that seem to find a way—through strategic positioning and good timing—to buck the trend. Premier Power Renewable Energy Inc. (El Dorado Hills, Calif.), a designer and integrator of solar energy solutions that went public in September 2008, appears to be one such player.

Premier Power is one of a few U.S. solar installers with an international presence. The company operates in Spain and in June 2009 it entered the Italian market by acquisition. But while the Spanish market for large scale solar farm projects has shrunk dramatically since the government capped the country's feed-in tariff in September 2008, the "Spanish market has been going gangbusters," for Premier Power, reported Executive Vice President Stephen Clevett.

"We didn't at that time have the wherewithal to compete in the solar farm market," said Clevett. Instead, Premier Power chose to focus on Spain's commercial rooftop market, leveraging its engineering experience in California's residential and agricultural rooftop installations, including exacting projects for the winery business in Napa.

While the Spanish solar farm market will shrink dramatically in 2009, the commercial rooftop market is estimated by ASIF, a Spanish solar PV industry association, to become the leading market segment in Spain, growing to more than 4.4 gigawatts over the next 10 years. Premier Power received signed contracts for more than 1 MW of commercial solar rooftop installations in Spain during the month of June 2009 alone and anticipated almost doubling its revenues in Spain for the year.

**Raw Economics of Solar Spurs Italian Acquisition**

Leveraging its experience in Spain, in June 2009 Premier Power announced it had chosen Arco Energy of Italy for its first major acquisition because of the country's favorable feed-in tariff model and high electricity prices. While public policy is still driving solar in the U.S., Italy is tagged by the European Photovoltaic Industry Assn. to be the first country in Europe likely to reach pricing parity with mainstream electricity—as early as next year in the south. Arco Energy is a solar project developer, EPC and distributor with more than 20 MW watts of permitted projects worth approximately $114 million in potential revenue, according to Premier Power. The acquisition doubled Premier's size overnight. Premier Power's Italian operations will initially focus on large-scale solar greenfield farming opportunities and expand to rooftop opportunities as the market matures.

Premier Power has installed over 1,000 systems. Net sales in 2008 were $44.2 million, up 165% from the year prior driven by strong growth in Spain (up 585%) and increased commercial sales in the U.S. (up 125%). For the first quarter 2009, sales were more or less flat compared to the prior year's comparable quarter, with expanding Spanish operations offsetting the slowdown in U.S. sales—not a bad result in a solar industry that saw revenues decline sharply for many firms.

Although the European portion of sales will be significantly higher this year, in 2008 Europe represented 33% of Premier Power's business, while 49% was in the U.S. commercial market, where the company is fielding inquiries from schools, universities, health care, and wastewater distributors, Clevett reported. "We're seeing a lot of interest from those types of entities in energy conservation within the building, as well as supply choices that involve renewable energy," said Clevett, who described the company's commercial business as bi-coastal—concentrated in California and the East.

Premier Power was founded in 2001 to serve increasing demand for solar power from its then parent company, Premier Homes. Eighteen percent of 2008 sales were in the California residential market, where Premier Power will continue to focus its residential resources. Acquisitions to expand its residential turf could be in the cards, however. "We'll definitely look at acquiring and expanding, but not in terms of organic growth," said Clevett.

In the nascent U.S. utility market, Clevett identified two segments: The large-scale market and the middle market municipalities and cooperatives. "We'll be very active in that middle market," said Clevett. Meanwhile the company is keeping a close eye on large-scale utility proposals. "That market can be highly competitive, and it may not be attractive for us or for companies like us to participate. I would much rather deal with a number of smaller projects in a higher profitability sector than go after a big project with a very low margin."

Competing in the utility market are the large solar module manufacturers like First Solar, Suntech and SunPower. "They're taking advantage of the immaturity of the market, and rightfully so, and basically creating a market for their own products," said Clevett. However, he added, while they are competitors at this time, "both businesses are completely different and have completely different risk profiles. So I see it as transitory and a reflection of the immaturity of the market."

**Moving into Solar Development**

Premier Power was preparing to move into the project development end of the solar business, including asset ownership, management and financing. The company has developed proprietary financing structures that follow a leasing rather than a partnership model. "One of the good things also about being active in Europe is we talk a lot to European lenders. They understand the project finance market much better," said Clevett, who like other executives has observed a growing "flight to quality" as more institutional lenders get involved in the solar business. These lenders will be looking hard at fundamentals, and many smaller players in solar development will find they can't compete, Clevett predicted. By contrast, as a public company with a "very well positioned balance sheet," he expects Premier Power to be a bankable prospect.

The declining price of solar panels is good news for developers and installers like Premier Power, but it represents more than just a supply and demand pile-up, Clevett said. "What you're seeing is the maturation and commercialization of the business worldwide, and so you've got manufacturers bringing huge amounts of capacity on line. That's going to continue. It's not going to abate, and the price of solar panels will continue to dip to a level that is sustainable for a long-term solar business model."

### 5.5.3. Installer Profile: DRI Companies

For West Coast roofing contractor DRI Companies (Irvine, CA), the opportunity to participate in the rooftop PV integration and installation market became increasingly obvious starting about five years ago. "At first we happened to serve a lot of the early adopters, especially some retail chains," said Stephen Torres, COO. "Then about two years ago, other types of commercial customers started asking us if we could put solar on their new buildings."

What wasn't so obvious was the way in which DRI would integrate PV product design into its business model. At first, the company owners, Tim Davey and Brian Flaherty, figured that DRI's value proposition would be offering a one-stop-shop for residential and commercial builders. With a sizeable existing business—the company reached $98 million in annual revenues in 2006, with sales divided 60% commercial and 40% residential—DRI leveraged its sales, marketing and management infrastructure and built up its in-house PV and electrical expertise. It formed a subsidiary, DRI Energy, which began integrating and installing rooftop PV systems on new buildings and homes.

However, in sourcing PV modules and racking systems, managers in the DRI Energy division were disappointed at the range of options. "As soon as we started looking at the technology available, we didn't find a lot of solutions out there that resulted in good roofing practices on the commercial side," said Torres. "We found that traditional rack systems have on average 1.5 penetrations per module installed. On a 50-75 kw commercial system, you could have 250 penetrations. That raised concerns about the long-term life of the roofing structure under the PV system."

On the residential side, the issue was aesthetics. For developers of new subdivisions, like those that were being constructed rapidly in Southern California before the fall in housing starts in 2007, traditional rack-mounted glass-covered PV systems were viewed as unsightly and likely to turn off potential buyers, according to Torres.

So the company decided to design a proprietary line of building-integrated PV modules for both the commercial and residential new-build markets. "We used our roofing and construction management background to design products that really are easy to install and represent sound roofing practices," said Torres. DRI partnered with fast-growing Chinese PV manufacturer Suntech to produce the product line, dubbed Lumeta. It began showing them off at a West Coast builders conference in May 2007, and the products are currently going through UL certification, with DRI expecting to have them on the market by June 2008.

For commercial applications, the Lumeta Power-Ply 380 Roof Integrated Photovoltaic (RIPV) module adheres to flat roofs (typical for commercial buildings) without racking systems that require extensive penetrations. The module design reduces the weight of PV arrays, a factor that is critical on many warehouse and manufacturing buildings, according to Torres. DRI has a patent pending on the product, which Torres said is unique in its form but not its technology. "Our manufacturing partner Suntech makes standard modules using the standard EVA crystalline cell encapsulation process. The intellectual property for us is really moving away from glass and using this teflon film that has some transparency correctors."

"We use a rigid back sheet because we lost rigidity once we took the glass out of the module," said Torres. Taking out the glass also eliminated the need for metal frames, which in turn cut out the need to ground each module. "Our system can be ungrounded because there's no exposed metal."

DRI wasn't the first to design RIPV products. "The other roof-integrated solution that addresses weight issues is the thin film solution being manufactured by Unisolar," said Torres. "They have a product and technology that has been proven and is successful… We have installed Unisolar products" on commercial buildings, he said.

While Unisolar uses thin-film technology that offers lower costs, Torres said that DRI's Lumeta product has the advantage of higher efficiency. "We chose to stay with crystalline technology because we felt that in many applications, the energy density, the number of watts generated per square foot of area, is a key element in technology choice for many customers," he said. "If you have a distribution center that has a lot of square footage that is not air conditioned, and a small amount of office space that is, that's a perfect application for a thin-film technology because you have a lot of roof area and a relatively small amount of consumption. But if you look at a supermarket, with all the refrigeration, or a retail outlet with a large air conditioning load, what those customers want to do is maximize the electrical output from their available roofing space."

DRI is projecting the final installed cost of a system using the Power-Ply PV products to be 5% to 6% lower per watt of capacity than a conventional rack-and-panel PV system. But power output will be reduced by the flat angle. "[Our products will not be] tilted [toward the sun] resulting in a loss of output of about 4% as compared to tilted modules. So our overall installed costs need to be lower," said Torres.

**Rolling Out Solar Mission Tiles**

DRI/Lumeta's RIPV residential product is a PV module integrated into two types of concrete roofing tiles—one for flat tiles and one for the mission or "S" tiles—that are common in the Southwest. They're designed to "match exactly" the tiles of leading roofing manufacturers, according to Torres. "One of our solar tiles takes the place of three regular tiles," he said. "They're literally installed as the roof is installed. Roofers layout the tiles, and the electrician does the electrical work after."

Wired from underneath, the tiles integrate with the roof profiles with little visual impact. Photos on DRI's website show installations where the PV tiles are visible because of a difference in color or reflectivity, but far less obtrusive than a typical PV array. "The unique technology is not in the solar piece per se," said Torres. "The IP is all around how it integrates into the roof system."

Torres acknowledged that when his company rolls out the tiles in mid 2008, it will likely be before the residential real estate market recovers in California and Nevada, where DRI's new-home roofing business is concentrated. "It's going to be a challenge for us," he said. "There's not going to be a lot of new construction in [those markets in] 2008."

Like other installers in the U.S. PV segment, DRI will likely suffer a decline in business due to the December 31, 2008 scheduled lapse of the federal investment tax credit for PV, a deadline that looks increasingly likely to not be extended as of the middle of 2008. "Certainly the '09 business environment and market prospects are greatly hampered by the decision" of the U.S. Congress to delete a proposed extension of the credits from energy legislation.... We are seeing some awareness by sophisticated customers that the Federal ITC may not be available beyond 2008, and their desire to complete projects by 2008."

Boosting the company's prospects in the longer term, according to Torres, is its plan to sell the solar tiles to wholesalers and other installers. "As the residential solar market evolves, we see ourselves selling the product to installers in other areas of the country for the retrofit market, which is not a market we intend to participate in… We don't put solar on existing homes. We sell residential systems to builders. That's the only residential business model we have, so we don't compete with a lot of the retrofit installers."

On the commercial side, DRI is sourcing PV equipment from vendors to compete against large-scale integrators such as Sun Edison and PowerLight. It anticipates ramping up the competition by offering to install Power-Ply on existing commercial buildings; although the installation must be coordinated with re-roofing. "We have a saying, 'We don't put good solar on bad roofs. If your roof only has three years of life left, we recommend you do your roof at the same time you do your solar."

Like PowerLight and Sun Edison, offering financing models to customers is a vital selling point for DRI. Depending on the customer's financial structure and cash flow, systems can be customer owned or owned by a third-party with the customer signing a power-purchase agreement (PPA). An option the company has proposed to some customers but has yet to execute is a lease. "You're basically renting the equipment and getting the benefits, then there's a fair-market value [purchase option] at the end of the lease term, say 10 or 15 years," said Torres.

PPA and lease agreements are always handled by third parties, according to Torres. "We have a couple of good partners for the PPA and municipal and commercial lease deals," he said. He declined to name the partners, noting that the ability to structure financing was a key competitive asset. "Some of the intellectual property of our energy business is the ability to find good partners."

## 5.6. Solar Hot Water Heating

### 5.6.1. Solar Water in U.S., Europe and Canada

Installed for lower capital costs and delivering faster payback on energy savings than solar photovoltaic (PV), solar water heating (SWH) has long been considered by experts to be the most cost-effective technology to deploy in most regions of the world. But to the ongoing frustration of SWH's advocates, these humble collectors of solar thermal energy haven't generated the kind of investment and buzz that their electron-exciting PV relatives have. "Solar thermal is the most efficient, least expensive… form of renewable energy, [but] since it is low-tech with no big glitz, it's the 'poor country cousin,'" wrote blogger Ken Schwantje on *RenewableEnergyAccess.com*.

SWH "is not highly valued in financial markets," echoed Richard MacKellar, managing director of Chrysalix Energy Venture Capital (Vancouver, B.C.), which has invested in PV, SWH and other energy technologies. "Yet its performance on a kilowatt-hour equivalent basis, the cost of installation and the ongoing avoidance of greenhouse gases by replacing electricity, gas or oil are very favorable, much more so than PV," said MacKellar. "You can get a financial payback with a solar thermal system, without subsidies, in two to 12 years depending on where you are. Even in Vancouver, a relatively poor area in terms of sunlight with no subsidies, you get a 10 to 12 year payback."

In the United States, growth has been driven by the 30% federal tax credit instituted in January 2006. "In the last two years we've grown 300% in sales and we've gone from nine employees to 45," said Billy Byrom, president of Alternate Energy Technologies (Jacksonville, Fla.), which built out its plant space from 25,000 to 50,000 square feet to meet demand. Rebates and tax credits are also offered by many U.S. states, and utility districts across the country offer additional incentives. California's legislature approved a substantial rebate program last year, and the state public utilities commission will roll it out statewide after a pilot program in San Diego is evaluated. As an indication of just how much the SWH industry has grown recently, Byrom notes that a little more than a year ago, the SWH system rating agency Solar Rating and Certification Corp. had only 24 participating manufacturers; by January 2008, the number had grown to 60.

Byrom has been in the solar water heating business since the 1970s, and for him the boom times are reminiscent of SWH's last golden age during the administration of former President Jimmy Carter. "The last year has taken us back to 1980," he said. Back then, with demand driven by a 40% federal tax credit, the industry had "hundreds of manufacturers [and] thousands of dealers," said Byrom. "They were not selling solar water heaters, they were selling tax credits. When the tax credit went away on Dec. 31, 1985, so did the industry.... In the U.S. it went from 300 manufacturers down to five."

The frenzied boom and bust in the United States left a mixed legacy for SWH: some systems weren't designed to operate well in northern winters; maintenance and parts weren't available for systems whose makers went out of business; and power ratings weren't trustworthy. "In the late 1970s and early '80s, many claims were made by solar heating collector manufacturers that were difficult to substantiate," said the February/March 2008 edition of *Home Power* magazine. But standard testing protocol and transparent data from SRCC has made ratings much more reliable,

**Figure 76 Global Solar Hot Water/Heating Capacity in 2006 (Total = 104 GWth)**

| Nation/Region | % |
|---|---|
| China | 65.4% |
| EU | 13.0% |
| Turkey | 6.2% |
| Japan | 4.4% |
| Israel | 3.1% |
| Brazil | 2.1% |
| USA | 1.7% |
| Other | 1.4% |
| Australia | 1.3% |
| India | 1.2% |
| South Africa | 0.2% |

**Figure 77 Concentrating Solar Power Projects In Development in the United States**

| Developer | Project Name | Electricity Purchaser | Location | Technology | Capacity (MW) |
|---|---|---|---|---|---|
| Abengoa Solar | Solana plant | Arizona Public Service | Gila Bend, AZ | Trough | 280 |
| Acciona | Ft. Irwin plant | U.S. Army/Utilities | Ft. Irwin, CA | Trough | 500 |
| Albiasa | Kingman project | | Kingman, AZ | Trough | 200 |
| Ausra | Carrizo Energy Solar Farm | Pacific Gas & Electric | Carrizo Plain, CA | Linear Fresnel | 177 |
| Boulevard Associates | Sonoran Solar Energy Project | | Maricopa County, AZ | Trough | 375 |
| BrightSource Energy | Ivanpah | Pacific Gas & Electric | Barstow, CA | Tower | 300 |
| BrightSource Energy | Ivanpah | Southern California Edison | Barstow, CA | Tower | 100 |
| BrightSource Energy | | Southern California Edison | California | Tower | 1,200 |
| Emcore/SunPeak Power | | | Southwest US | Lens CPV | 200 |
| eSolar | Gaskell Sun Tower (Phase I) | Southern California Edison | Kern County, CA | Tower | 105 |
| eSolar | Gaskell Sun Tower (Phase II) | Southern California Edison | Kern County, CA | Tower | 140 |
| eSolar | Santa Teresa NM SunTower | El Paso Electric | Santa Teresa, NM | Tower | 92 |
| eSolar | Alpine SunTower | Pacific Gas & Electric | Lancaster, CA | Tower | 92 |
| Florida Power & Light | Martin Next Generation | Florida Power & Light Co. | Martin County, FL | Trough1 | 75 |
| GreenVolts, Inc. | GV1 | Pacific Gas & Electric | Byron, CA | CPV | 2 |
| Harper Lake, LLC | Harper Lake Solar Plant | | California | Trough | 250 |
| Inland Energy, Inc. | Palmdale Hybrid Gas/Solar | | Palmdale, CA | Trough | 50 |
| Inland Energy, Inc. | Victorville Hybrid Gas/Solar | | Victorville, CA | Trough | 50 |
| NextEra Energy Resources | Beacon Solar Energy Project | | Kern County, CA | Trough | 250 |
| San Joaquin Solar | San Joaquin Solar 1 | Pacific Gas & Electric | Coalinga, CA | Trough1 | 53 |
| San Joaquin Solar | San Joaquin Solar 2 | Pacific Gas & Electric | Coalinga, CA | Trough1 | 53 |
| SkyFuel | SkyTrough demonstration | Southern California Edison | Daggett, CA | Trough | 43 |
| Solar Millennium | Amargosa Farm Road 1 | NV Energy | Nye County, NV | Trough | 242 |
| Solar Millennium | Amargosa Farm Road 2 | NV Energy | Nye County, NV | Trough | 242 |
| Solar Millennium | SoCal Edison | Southern California Edison | Blythe, CA | Trough | 242 |
| Solar Millennium | SoCal Edison | Southern California Edison | Ridgecrest, CA | Trough | 242 |
| Solar Millennium | SoCal Edison | Southern California Edison | Ridgecrest, CA | Trough | 242 |
| Solel | Mojave Solar Park | Pacific Gas & Electric | Mojave Desert, CA | Trough | 553 |
| Sopogy | Demonstration plant | | Kailua- Kona, HI | MicroCSP | 1 |
| Starwood Energy Group | Starwood Solar I | Arizona Public Service | Harquahala Valley, AZ | Trough | 290 |
| Tessera Solar | AZ Reference Plant | | Phoenix, AZ | Dish-engine | 2 |
| Tessera Solar | SES Solar One | Southern California Edison | Victorville, CA | Dish-engine | 850 |
| Tessera Solar | SES Solar Two | San Diego Gas & Electric | Imperial County, CA | Dish-engine | 750 |

| | | | | | |
|---|---|---|---|---|---|
| Tessera Solar | SES Solar Two Expansion | San Diego Gas & Electric | Imperial County, CA | Dish-engine | 150 |
| Tessera Solar | Western Ranch | CPS Energy | San Antonio, TX | Dish-engine | 27 |

*Source: Solar Energy Industries Association*

**Figure 78 Solar Projects: Operational and Under Development in the U.S. in 2009**

| | MW |
|---|---|
| Under Development: Concentrating Solar Power; 35 projects | 8,420 |
| Under Development: Photovoltaics; 35 projects | 3,138 |
| In Operation: Concentrating Solar Power; 12 Projects | 423 |
| In Operation: Photovoltaics; 4 Projects | 35 |

| Projects Under Development | |
|---|---|
| Concentrating Solar Power (including Concentrating Photovoltaic) Total | 8,420 |
| Photovoltaics (excluding Concentrating Photovoltaic) Total | 3,138 |
| **Total Under Development** | **11,558** |

| Projects in Operation and Under Development | |
|---|---|
| Concentrating Solar Power Total | 8,843 |
| Photovoltaics Total | 3,173 |
| **Total Projects in Operation and Under Development** | **12,016** |

*Source: Solar Energy Industries Association*

**Figure 79 California Projects Under Development: Photovoltaics (excluding Concentrating PV)**

| Developer | Project Name | Electricity Purchaser | Location | Technology | Capacity (MW) |
|---|---|---|---|---|---|
| Chevron Energy Solutions | Lucerne Valley Solar Project | Southern California Edison | San Bernardino County, CA | Thinfilm PV | 45 |
| Clean Tech America, Inc. | CalRENEW-1 | Pacific Gas & Electric | Mendota, CA | PV | 5 |
| Clear Skies Solar Inc. | | | Mojave Desert, CA | PV | 6 |
| First Solar | Commercial Rooftop Installations | Southern California Edison | Southern California | PV | 250 |
| First Solar | Topaz Solar Farm | Pacific Gas & Electric | Carrisa Plains, CA | Thin-film PV | 550 |
| First Solar | Desert Sunlight | Southern California Edison | Desert Center, CA | Thin-film PV | 250 |
| First Solar | FSE Blythe | Southern California Edison | Blythe, CA | Thin-film PV | 8 |
| First Solar | Stateline | Southern California Edison | San Bernardino County, CA | Thin-film PV | 300 |
| SunEdison | | California State Universities | California | Thin-film PV | 8 |

| | | | | | |
|---|---|---|---|---|---|
| SunPower | California Valley Solar Ranch | Pacific Gas & Electric | San Luis Obispo, CA | PV | 250 |
| | Commercial Rooftop Installations | Southern California Edison | Southern California | PV | 250 |

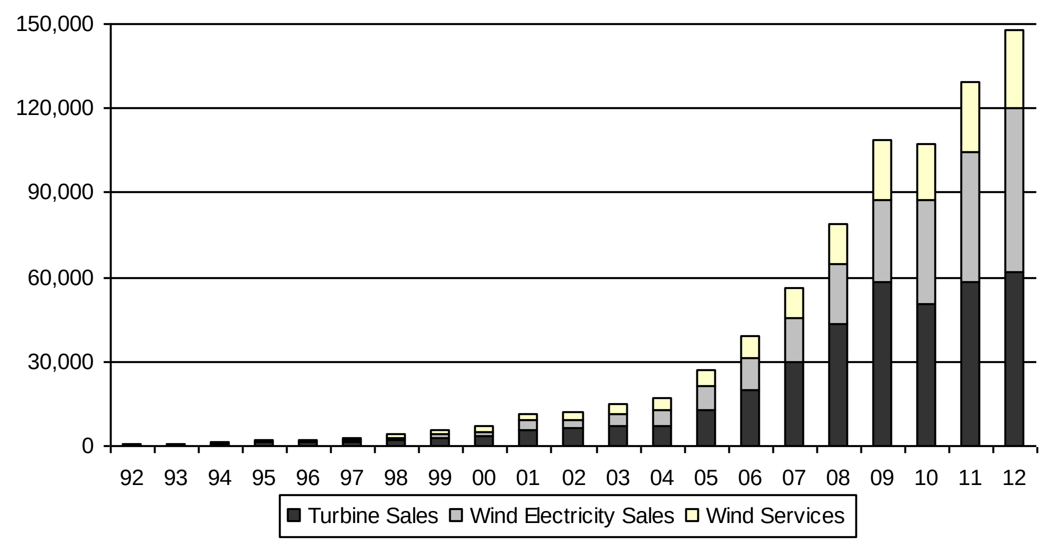
*Source: Solar Energy Industries Association*

# 6. Wind Energy

Wind energy serves as probably the most pronounced cautionary tale for California and the United States in the renewable energy and climate change industries regarding policy and competitiveness. The global pioneer in electricity generation from wind power, California had the majority of global wind power generating capacity and manufacturing production through the 1980s. By 1991 the United States still held a 79% share of global wind generating capacity, a figure that declined to 14% by 2000 due to wavering U.S. domestic policy combined with ambitious policies—and emerging companies—in Germany, Denmark, Spain and other countries.

In the 2000s, the global wind industry really took off and by the end of the decade annual growth of 40-70% of a then sizeable industry even started to overtax the wind energy supply chain. The industry has responded to the challenge and, despite a recession-induced hitch in growth in 2010, is well prepared for the expansion anticipated ahead. From West to East, the establishment has embraced wind energy. Tomorrow might belong to solar or biomass or some other renewable energy technology not yet invented, but today wind sits atop the global energy agenda.

**Figure 80 Global Wind Energy Industry 1992-2015 ($mil)**




*Source: EBI Inc. derived from a variety of sources including EER, AWEA, EWEA, BTM Consult, U.S. DOE, EIA, CCBJ interviews and surveys and others. Electricity sales derived from a product of national capacity, capacity factor and average annual wholesale price/kWh of electricity.*

By the end of 2010 China's installed capacity was nearly 90 GW with 42 GW reported installed that year. By comparison, California in 2009 installed 0.26 GW of the USA 9.5 GW total, and the global installed total was 158 GW in 2009.

EBI sizes the global wind energy industry at $108 billion in 2009, with turbine sales the majority and electricity sales representing a growing 27%. Growth was 43%, 41% and 37% in 2007-2009 after 45% growth in 2006 and 61% growth in 2005.

Wind energy has come of age on several fronts. In the EU it was the leading source of new electricity generation in 2007. Denmark remains the clear leader at 20%, but wind jumped from 10% to 12% of electricity generated in Spain in 2007, Portugal went over 9%, Ireland passed 8% and Germany 7%. The United States stood at 1.2% in 2007, the same as the global total, but in 2007 wind accounted for 35% of all new U.S. power-producing capacity after barely registering on the radar screen until 2005. In terms of direct costs, larger wind farms in windier areas are now considered competitive with many fossil fuel power plants and even superior economically when externalities such as air pollution, land degradation and carbon emissions are factored in.

"Wind power offers today what is arguably the world's greatest potential for future growth of renewables," said Felix Losada, spokesman for the European turbine manufacturer Nordex AG. "Alongside hydroelectricity it is also the most economical to produce. What's more, in good locations electricity can already be produced competitively from wind compared with conventional power stations, especially after the recent increases in the prices of fuels such as oil, coal and gas."

According to Marty Crotty, president of AES Wind Generation and vice president of AES Corp., "To the extent that the EPC [engineering, procurement and construction] costs are on the low end of the expected range [for conventional power] or the carbon costs are on the low end of the expected range, wind becomes less competitive. But... both the EPC and the carbon costs have been going up, and to the extent they're in the middle or high end of their expected range, wind is very competitive."

## 6.1. Wind Industry Statistics & Review

**Figure 81 Global Wind Energy Industry ($bil)**

| | 2007 | 2008 | 2009 | 2008 Growth | 2009 Growth |
|---|---|---|---|---|---|
| Wind Turbines | 29.64 | 43.12 | 58.10 | 45% | 35% |
| Windpower Electricity Sales | 15.84 | 21.76 | 29.54 | 37% | 36% |
| Wind Consulting & Engineering | 1.49 | 1.91 | 2.00 | 28% | 5% |
| Wind Construction | 6.52 | 9.15 | 14.90 | 40% | 63% |
| Wind Operation & Maintenance | 2.44 | 3.05 | 3.89 | 25% | 28% |
| **Toal Wind Energy Industry** | **55.93** | **78.99** | **108.44** | **41%** | **37%** |

*Source: EBI Inc. derived from a variety of sources including AWEA, EWEA, EER, BTM Consult, U.S. DOE, EIA and others; Wind electricity sales is wholesale sales or value*

**Figure 82 U.S. Wind Energy Industry ($bil)**

| . | 2007 | 2008 | 2009 | 2008 Growth | 2009 Growth |
|---|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| Wind Turbines | 7.74 | 13.45 | 15.20 | 74% | 13% |
| Windpower Electricity Sales | 2.23 | 3.58 | 5.18 | 60% | 45% |
| Wind Consulting & Engineering | 0.61 | 0.65 | 0.51 | 7% | -22% |
| Wind Construction | 1.70 | 2.85 | 3.90 | 68% | 37% |
| Wind Operation & Maintenance | 0.30 | 0.43 | 0.64 | 44% | 49% |
| **Toal Wind Energy Industry** | 12.58 | 20.97 | 25.43 | 67% | 21% |

*Source: EBI Inc. derived from a variety of sources including AWEA, EWEA, EER, BTM Consult, U.S. DOE, EIA and others; Wind electricity sales is wholesale sales or value*

**Figure 83 California Wind Energy Industry ($bil)**

| | 2007 | 2008 | 2009 | 2008 Growth | 2009 Growth |
|---|---|---|---|---|---|
| Wind Turbines | 0.09 | 0.15 | 0.42 | 69% | 172% |
| Windpower Electricity Sales | 0.32 | 0.36 | 0.42 | 11% | 16% |
| Wind Consulting & Engineering | 0.01 | 0.02 | 0.02 | 51% | 6% |
| Wind Construction | 0.03 | 0.08 | 0.15 | 137% | 86% |
| Wind Operation & Maintenance | 0.04 | 0.05 | 0.06 | 22% | 10% |
| **Toal Wind Energy Industry** | 0.50 | 0.66 | 1.06 | 32% | 60% |

*Source: EBI Inc. derived from a variety of sources including AWEA, EWEA, EER, BTM Consult, U.S. DOE, EIA and others; Wind electricity sales is wholesale sales or value*

**Figure 84 U.S. Wind Energy Industry as a Percentage of Global Total**

| | 2007 | 2008 | 2009 |
|---|---|---|---|
| Wind Turbines | 26% | 31% | 26% |
| Windpower Electricity Sales | 14% | 16% | 18% |
| Wind Consulting & Engineering | 41% | 34% | 25% |
| Wind Construction | 26% | 31% | 26% |
| Wind Operation & Maintenance | 12% | 14% | 16% |
| **Total Wind Energy Industry** | 23% | 27% | 23% |

*Source: EBI Inc. derived from a variety of sources including AWEA, EWEA, EER, BTM Consult, U.S. DOE, EIA and others; Wind electricity sales is wholesale sales or value*

**Figure 85 California Wind Energy Industry as a Percentage of U.S. Total**

| | 2007 | 2008 | 2009 |
|---|---|---|---|
| Wind Turbines | 1.2% | 1.1% | 2.8% |
| Windpower Electricity Sales | 14.4% | 10.0% | 8.0% |
| Wind Consulting & Engineering | 2.0% | 2.8% | 3.8% |
| Wind Construction | 2.0% | 2.8% | 3.8% |
| Wind Operation & Maintenance | 14.4% | 12.2% | 9.0% |
| **Total Wind Energy Industry** | 4.0% | 3.2% | 4.2% |

*Source: EBI Inc. derived from a variety of sources including AWEA, EWEA, EER, BTM Consult, U.S. DOE, EIA and others; Wind electricity sales is wholesale sales or value*

**Figure 86 U.S. and California Wind Energy Industry: Employment**

| | USA $bil in 2009 | USA 2009 Jobs | Calif. $bil in 2009 | Calif. 2009 Jobs | % of USA Jobs in Calif. |
|---|---|---|---|---|---|
| Wind Turbines | 15.20 | 58,300 | 0.42 | 320 | 0.6% |
| Windpower Electricity Sales | 5.18 | 4,700 | 0.42 | 380 | 8.0% |
| Wind Consulting & Engineering | 0.51 | 4,200 | 0.02 | 190 | 4.5% |
| Wind Construction | 3.90 | 36,400 | 0.15 | 1,370 | 3.8% |
| Wind Operation & Maintenance | 0.64 | 3,200 | 0.06 | 290 | 9.0% |
| **Total Wind Energy Industry** | **25.43** | **106,800** | **1.06** | **2,550** | **2.4%** |

*Source: EBI Inc. derived from a variety of sources including AWEA, EWEA, EER, BTM Consult, U.S. DOE, EIA and others; Wind electricity sales is wholesale sales or value*

**Figure 87 Recent Wind Installations in California**

| Project | Power Capacity (MW) | Units | Turbine Mfr. | Year Online |
|---|---|---|---|---|
| Pine Tree Extension | 15 | 10 | GE Energy | 2010 |
| Teichert Aggregates | 1.5 | 1 | GE Energy | 2010 |
| Garnet Wind Project | 6.5 | 13 | n/a | 2009 |
| Pine Tree Wind Farm | 120 | 80 | GE Energy | 2009 |
| Shiloh II | 150 | 75 | REPower | 2009 |
| Edom Hills repower | 20 | 8 | Clipper | 2008 |
| Alite Wind Farm | 24 | 8 | Vestas | 2008 |
| Dillon | 45 | 45 | Mitsubishi | 2008 |
| Solano Wind Project | 63 | 21 | Vestas | 2007 |
| Buena Vista | 38 | 38 | Mitsubishi | 2006 |
| Shiloh Wind Power Project | 150 | 100 | GE Energy | 2006 |
| Solano IIA | 24 | 8 | Vestas | 2006 |
| Coram Energy (Aeroman repower) | 10.5 | 7 | GE Energy | 2005 |
| Kumeyaay Wind Power Project | 50 | 25 | Gamesa | 2005 |
| Victorville Wind Project | 0.8 | 1 | Vestas | 2005 |
| Victory Garden | 0.7 | 1 | Vestas | 2005 |
| Victory Garden | 6 | 8 | Zond | 2005 |
| Coram Energy (Aeroman repower) | 4.5 | 3 | GE Energy | 2004 |
| Diablo winds | 20.5 | 31 | Vestas | 2004 |
| Lake Palmdale | 1.0 | 1 | Vestas | 2004 |
| Total | 750.8 | | | |
| USA-Manfactured Share | 327.5 | 44% | | |
| Other Share | 416.8 | 56% | | |

*Source: AWEA project database; GE, Clipper and Zond are USA manufacturers: Clipper's HQ is in California but its manufacturing is in Iowa*

### 6.1.1. 2010 Wind Industry Update

Wind energy is not only here to stay but appears to many to still be at the early stages of its growth cycle. 2009 was a record year for new installations in the United States and worldwide. While 2010 almost certainly will be an adjustment year given the financing cycle of wind projects, it will likely be a blip on the screen when reviewing the wind industry's history decades from now. Wind accounted for 1.8% of U.S. electricity generated in 2009 (and represented 39% of all new electric capacity added in 2009) and the state of Iowa got 14% of its electricity from wind in 2009. According to American Wind Energy Association and Global Wind Energy Council, wind energy employed 85,000 people in the U.S. and almost 500,000 worldwide in 2008. EBI estimates wind energy jobs in the USA at 107,000 in 2009.

Respondents to CCBJ's annual wind energy survey forecast a median response of 5-6% of U.S. electricity from wind in 2020 and 10-12% in 2050, although 46% of respondents believe the 2050 figure will be over 20%. Wind energy was also tabbed as the second leading contributor to greenhouse gas emission reduction for the future among 16 other clean energy industry segments.

**2009 Figures Shock the Experts**

By most accounts, 2009 should have been a terrible year for wind power development in North America. The worst recession in decades eviscerated the tax credit appetite of the financial institutions that invest in wind projects, and the loans needed for project finance all but disappeared. Yet the U.S. wind energy capacity grew by 40%, installing a record-breaking 10 GW to end 2009 at 38 GW or 22% of the global total of 158 GW. California installed just 261 MW in 2009. Canada's wind capacity also grew by 40% and Mexico's fledgling wind power market grew by more than 130%. In spite of this growth, North America still trailed Asia which expanded capacity 64% in 2009 to total 40 GW. Asia was paced by China that more than doubled capacity to 26 GW and in the process set the national mark for annual installations at 13,800 MW in 2009. Europe remained the global leader with 76 GW of total capacity at the end of 2009, but only grew capacity by 16%. In turbines, US-based GE almost caught perennial leader Vestas of Denmark and three Chinese companies are now in the top 10.

**U.S. Market Trends**

In the United States, credit for the good year goes to the Obama Administration and Congress which enacted, in the ARRA stimulus bill, a grant-in-lieu-of- tax-credit program that wind and other renewable power developers could tap for 30% of their project costs. "Congress and the administration creating such a flexible investment tax credit really lit the 2009 market on fire," said Roby Roberts, vice president, government relations, for developer Horizon Wind Energy.

Most of the U.S. wind farms that went into commercial operation in the record 2009 were well along in planning and even construction, a legacy of the boom period leading up to the third-quarter of 2008. Analysts see slower growth in 2010. "Most of the megawatts put in the ground in 2009 were projects that had financial commitments in place in 2008," said Martin Pasqualini, managing director of CP Energy Group (Boston). In 2010 "we're seeing what I'd call a recovering market."

American Wind Energy Association (AWEA) reported only 540 MW installed in the first quarter of 2010, the lowest first quarter figure since 2007, and used the occasion to call for a "strong national renewable electricity standard (RES) as part of comprehensive climate and energy legislation to provide hard targets to stabilize the industry.... While the industry worked diligently to accelerate shovel-ready projects in 2009 and installed over 10,000 MW, continued lack of long-term market signals, combined with low power demand and price, has allowed the pipeline for advanced projects to slow over the past 18 months," said AWEA.

The flattening of growth in electricity loads as well as lower natural gas prices in 2010 is indeed making wind power purchase agreements less attractive to many utilities. “We’re seeing utilities balk at signing new PPAs when they might not need the power,” said Matthew DaPrato, an EER analyst. “For 2011, we’re looking for the market to pick back up and get to near 2009 build levels, with power demand coming back and state RPS policies continuing to come due,” said DaPrato. “We’ll see a lot more willingness by utilities to sign PPAs as well as some lower prices from OEMs. Before, wind power was very much a supplier’s market where everyone was looking for turbines. With the crisis, the OEMs had a lot of inventory to push through and that has brought prices down.”

EBI forecasts a dip in U.S. capacity added in 2010, but 2011 activity nearly level with 2009. Higher activity is expected globally due to continuing growth in Asia. GWEC expects Asia will surpass Europe as the world’s leading wind energy region by 2014. By then offshore will account for 18-20% of Europe’s capacity lending momentum to further offshore developments worldwide says GWEC (5% of new 2009 capacity in Europe was offshore).

Achieving the kind of continued growth that most anticipate, however, will require major increases in transmission capacity, especially from wind-rich areas with little demand to major load centers. Project managers indicate transmission costs can exceed non-turbine wind farm development costs by a factor of two or three depending on proximity of the grid.

In terms of GWh, wind power reached 1.8% of total U.S. generation in 2009. Iowa became the first state to break the 10 percent mark in 2009, with 14.2% of their generation in-state coming from wind. Six additional states had over 5% of energy coming from wind.

The list of the top five owner-operators changed, although the top two rankings didn’t change: NextEra (formerly FPL) is the largest by far with 7,460 MW, followed by Iberdrola Renewables with 3,230. Horizon Wind Energy nudged MidAmerican from third to fourth place, and E.ON Climate & Renewables moved Invenergy from fifth to sixth.

AWEA counted 50 active wind project developers in the market, up from 20 in 2004. “More players are doing a lot of wind projects, diversifying this field and making it active and robust,” said Salerno. AWEA’s database shows 3,300 MW under construction in the U.S. at the end of Q1 2010 with 18 of the 36 projects in the 100-240 MW range. The largest wind farm in the world is the 780-MW Roscoe Wind Farm in West Texas, one of five in the region of more than 500 MW.

Among turbine manufacturers, the top three in the U.S. remained the same in 2009 as in 2008: GE Energy (40%), Vestas (15%) and Siemens. “GE still has a firm grip on the [U.S.] market and probably won’t go anywhere because of its success with its existing turbines and the new rollout of its 2.5 megawatt turbine which should happen at the end of this year,” said DaPrato. “But after GE, it’s becoming a very close competition that really presents a lot of options to developers.”

Turbine manufacturers continue to invest in North America. AWEA tallied a lower rate of projects announced, expanded or opened in 2009—39 as opposed to 58 in 2008. But the trend is still strong. “We’re seeing a lot of turbine manufacturers, foreign and domestic, boost their U.S. supply capacity,” said DaPrato. “The U.S. has had year-over-year record growth since 2005, and that has sparked investment from companies like Mitsubishi, Suzlon and Siemens.”

New Energy Finance reported that as of mid-March 2010, $1.6 billion of $2.7 billion in Treasury grants for renewable energy projects had gone to foreign-owned companies. Prominent Democratic members of Congress have said they’ll put “buy American” requirements in any extensions of the grant or tax credits—something the Ontario legislature did to ensure its lucrative feed-in tariffs led to a high proportion of Ontario jobs. The Obama administration doesn't like this "protectionist" idea, and NEF underscored how many domestic jobs are being created with the grant funds. It should also be pointed out that the firms are U.S. based subsidiaries of foreign companies and that job counts will be the ultimate trump card.

Large U.S. investments by Siemens and others certainly will help the political equation. German-owned E.ON (which received $324 million in Treasury grants) makes the case in these pages and elsewhere that it matches each dollar of Treasury funds with $3 to $4 of its own capital.

But there's no question that the controversy complicates what the wind power industry hopes to get from Congress this year: an extension to the Treasury grant program. "There's been discussion that the grant money is putting people to work in foreign countries to build the equipment," said one wind power market participant who asked to remain anonymous. "That makes the whole issue a bit messy. I am optimistic that we'll see [an extension] before the end of the year but to be honest, it wouldn't surprise me if we did not."

The industry wants to make the case that a national RES is also the key to stimulating domestic investment and job creation, and that message may get muddled by the controversy. "Thirty years ago, the wind industry was essentially invented in the U.S. Today most of the manufacturing is offshore," Don Furman, president of the AWEA board and Iberdrola Renewables' SVP for development, transmission and policy, said at AWEA's news conference.

"We're making strides in bringing manufacturing onshore with demand from state policies [but] we're the only major developed country that doesn't have a renewable energy standard or a functional equivalent," said Furman. "China is way out ahead of us. All the countries in Europe are way out ahead of us. We're in a race to get factories built and jobs created in the U.S., and unless we have a firm policy at the federal level... the investments will be made overseas and the jobs will be there for 20 years."

"To remain competitive, we're going to have these policies," added Furman. "This is a big logistically intensive business. Transportation is a huge part of our costs. Not only for the jobs but for the lower costs, we need to have manufacturing onshore."

The wind industry has indeed become global, but the majority of its issues are still intensely local; from siting, permitting, power prices, views and birds & bats to today's hot-button green jobs issue. For a sector that arguably will be driven largely by the global issue of climate change and its manifest national energy policies, it should be an interesting ride.

**Figure 88 Total U.S. Installed Capacity of Wind Energy by State in MW: End of 2009**

| | | |
|---|---|---|
| Texas | 9,403 | 27.0% |
| Iowa | 3,604 | 10.3% |
| **California** | **2,798** | **8.0%** |
| Washington | 1,849 | 5.3% |
| Minnesota | 1,810 | 5.2% |
| Oregon | 1,758 | 5.0% |
| Illinois | 1,547 | 4.4% |
| New York | 1,274 | 3.7% |
| Colorado | 1,244 | 3.6% |
| North Dakota | 1,203 | 3.4% |
| Wyoming | 1,099 | 3.2% |
| Indiana | 1,036 | 3.0% |
| Oklahoma | 1,031 | 3.0% |
| Kansas | 1,021 | 2.9% |
| Pennsylvania | 748 | 2.1% |
| New Mexico | 597 | 1.7% |
| Wisconsin | 449 | 1.3% |
| Montana | 375 | 1.1% |
| West Virginia | 330 | 0.9% |
| South Dakota | 313 | 0.9% |
| Missouri | 309 | 0.9% |
| Utah | 223 | 0.6% |
| Maine | 175 | 0.5% |
| Nebraska | 153 | 0.4% |
| Idaho | 147 | 0.4% |
| Michigan | 138 | 0.4% |
| Hawaii | 63 | 0.2% |
| Arizona | 63 | 0.2% |
| Tennessee | 29 | 0.1% |
| New Hampshire | 25 | 0.1% |
| Massachusetts | 15 | 0.04% |
| Alaska | 9 | 0.02% |
| New Jersey | 8 | 0.02% |
| Ohio | 7 | 0.02% |
| Vermont | 6 | 0.02% |
| Rhode Island | 2 | 0.01% |
| | 34,863 | 100.0% |

*Source: U.S. DOE*

**Figure 89 U.S. Wind Energy Turbines: 2009 Installations by Manufacturer**

| | MW installed 2009 | USA Share |
|---|---|---|
| **GE Energy: US** | **3,978** | **39.8%** |
| Vestas: EU | 1,509 | 15.1% |
| Siemens: EU | 1,220 | 12.2% |
| Mitsubishi: Japan | 800 | 8.0% |
| Suzlon: India | 700 | 7.0% |
| **Clipper: US** | **610** | **6.1%** |
| Gamesa: EU | 570 | 5.7% |
| Repower: EU | 280 | 2.8% |
| Acciona: EU | 170 | 1.7% |
| Nordex: EU | 60 | 0.6% |
| AAER | 40 | 0.4% |
| DeWInd | 20 | 0.2% |
| Goldwind: China | 20 | 0.2% |
| Fuhrlander: EU | 20 | 0.2% |
| | 9,996 | |

*Source: AWEA*

**Figure 90 Top 10 Countries: Total Installed Capacity in Wind, 2008**

| Country | MW | % of total |
|---|---|---|
| US | 25,170 | 20.8 |
| Germany | 23,903 | 19.8 |
| Spain | 16,754 | 13.9 |
| China | 12,210 | 10.1 |
| India | 9,645 | 8 |
| Italy | 3,736 | 3.1 |
| France | 3,404 | 2.8 |
| UK | 3,241 | 2.7 |
| Denmark | 3,180 | 2.6 |
| Portugal | 2,862 | 2.4 |
| Rest of the world | 16,686 | 13.8 |
| **Total top 10** | **104,104** | **86.2** |
| **World total** | **120,791** | **100** |

*Source: GWEC. http://www.ewea.org/fileadmin/ewea_documents/documents/press_releases/2009/GWEC_Press_Release_-_tables_and_statistics_2008.pdf*

**Figure 91 Top 10 Countries: New Capacity, 2008**

| Country | MW | % of total |
|---|---|---|
| US | 8,358 | 31 |
| China | 6,300 | 23 |

| | | |
|---|---|---|
| India | 1,800 | 7 |
| Germany | 1,665 | 6 |
| Spain | 1,609 | 6 |
| Italy | 1,010 | 4 |
| France | 950 | 4 |
| UK | 836 | 3 |
| Portugal | 712 | 3 |
| Canada | 523 | 2 |
| Rest of the world | 3,293 | 12 |
| **Total top 10** | **23,763** | **88** |
| **World total** | **27,056** | **100** |

*Source: GWEC.*

### 6.1.2. Drivers: Wind Spurred by Government Targets

Helping create today's intense demand for wind energy is growing awareness of the economic dangers of fossil fuel dependency and the threat of global warming, which have led to a range of economic incentives and renewable energy mandates set by governments worldwide. Now viewed as the most mature and proven of all renewable technologies, governments are backing wind as the engine for their ambitious renewable energy goals. For example, the EU aims to get 20% of its energy from renewable sources by 2020, with wind contributing 12-14%. China is seeking 15% of its electricity from renewables by 2020. Hydroelectric power will contribute the biggest share, but wind energy is exceeding expectations and has already blown past its goal of 5 GW by 2010.

The feasibility of ambitious wind energy goals set by governments and states worldwide appears to be supported by research such as the U.S. Department of Energy's (DOE) May 2008 report, which concluded that wind power is capable of accounting for 20% of U.S. electricity by 2030. In June 2008 the International Energy Agency (IEA) released *Energy Technology Perspective*, which acknowledged that wind power would play the major role in reducing emissions in the power sector in the next 10-20 years. In one scenario, IEA forecast that wind energy could account for up to 17% of global power production by 2050.

All this adds up to unprecedented opportunity for wind turbine manufacturers, subcomponents suppliers, wind farm developers, and providers of adjunct products and services. Executives interviewed for this issue generally agreed that lofty goals are attainable for wind, but only with greater and more consistent government support, in addition to massive infrastructure investment in national grids worldwide: two very big 'ifs'. In the short term, some urgent but more manageable challenges, notably supply chain shortages and rising commodity and component prices, threaten to inhibit growth in an industry promoted as one of the cheapest and fastest energy sources to bring on line.

To reap the most from this period of high demand for wind energy, which looks set to continue for the next several years, global players up and down the manufacturing supply chain are engaged in record levels of capacity expansion, reaping the fruits but also the challenges of excess demand. Meanwhile, large wind farm developers, including utilities, are acquiring and investing globally in project pipelines, consolidating the wind generation sector at an unprecedented rate.

**Figure 92 Annual U.S. Turbine Installation Capacity, by Manufacturer**

| Manufacturer | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|
| GE Wind | 1,433 | 1,146 | 2,342 | 3,657 |
| Vestas | 700 | 439 | 948 | 1,120 |
| Siemens | 0 | 573 | 863 | 791 |
| Suzlon | 25 | 92 | 197 | 738 |
| Gamesa | 50 | 74 | 494 | 616 |
| Clipper | 2.5 | 0 | 47.5 | 595 |
| Mitsubishi | 190 | 128 | 356 | 516 |
| Acciona | 0 | 0 | 0 | 410 |
| REpower | 0 | 0 | 0 | 102 |
| Other | 2 | 2 | 3 | 13 |
| **TOTAL** | **2,402** | **2,454** | **5,329** | **8,558** |

*Source: Wind Technology Market Report 2008 by EERE. July 2009. Original source: AWEA project database.*

**Figure 93 Top 10 wind turbine manufacturers by MW installed worldwide in 2009**

| | |
|---|---|
| 1. Vestas (Denmark) | 35,000 MW |
| 2. Enercon (Germany) | 19,000 MW |
| 3. Gamesa (Spain) | 16,000 MW |
| 4. GE Energy (Germany / United States) | 15,000 MW |
| 5. Siemens (Denmark / Germany) | 8,800 MW |
| 6. Suzlon (India) | 6,000MW |
| 7. Nordex (Germany) | 5,400 MW |
| 8. Acciona (Spain) | 4,300 MW |
| 9. REpower (Germany) | 3,000 MW |
| 10. Goldwind (China) | 2,889 MW |

*Source: Company data posted on websites*

**Figure 94 Prominent Mergers & Acquisitions in Wind Energy 2002-2007**

| Acquiror | Target | Business | Date |
|---|---|---|---|
| GE | Enron Wind | Turbines | 2002 |
| Suzlon (India) | Hansen Transmissions (Belgium) | Gearboxes | 2005 |
| Siemens | Bonus (Denmark) | Turbines | 2005 |
| Composite Technology (US) | DeWind (Lubeck, Germany) | Turbines | 2006 |
| Iberdrola | Scottish Power (PPM Energy in US) | Developer | 2006 |
| Areva | Multibrid (Germany) | Turbines | 2007 |
| Alstom | EcoTecnica (Spain) | Turbines | 2007 |
| EDP Energias de Portugal | Horizon Wind Energy LLC (us) | Developer | 2007 |
| E.ON | Airtiricity's N.A. assets | Utility | 2007 |
| Acciona & ENEL | Endesa (Spain) | Utility | 2007 |
| Suzlon (India) | RE Power (Germnay) | Turbines | 2007 |

| | | | |
|---|---|---|---|
| Wind Energy America | Boreal Energy Inc. (assets, US) | Developer | 2007 |
| E.ON (Germany) | DONG Energy (wind farm operator in Iberia (Denmark) | Developer | 2007 |
| American Superconductor | Windtec (Austria) | Turbines | 2007 |

*Source: Company documents and published reports*

# 6.2. Global Wind Industry

## 6.2.1. Global Leadership in Wind Turbines

The biggest news in wind in 2009 was China which accounted for 37% of the world's total new wind energy capacity of 38 GW. The 13,800 MW installed in China in 2009 was the largest volume of installation ever by one country in a single year.

On the manufacturer side, the most significant change was the strong growth of Chinese wind turbine manufacturers, three of which are now in the Top 10. Sinovel took the No. 3 spot, Goldwind ranked No. 5, and Dongfang was No. 7, according to BTM Consult rankings. BTM said that Sinovel and Goldwind only joined the Top 10 in 2008, and Dongfang was in the Top 15 that year. While wind power will deliver 1.6% of the world's electricity in 2010, BTM forecasts that in 2019 wind could be 8.4% of the world's consumption of electricity with unpredictable dynamics in marketshare.

Vestas retained its position as the world's leading wind turbine manufacturer in 2009 with GE Energy virtually tied in 2009 installed capacity. GE made news in August 2009 with the €18.2 million acquisition of Norwegian direct drive wind turbine technology developer ScanWind. The acquisition "will give GE the ability to provide a direct drive, offshore wind turbine offering as an option to our customers," said Victor Abate, GE's vice president of renewables. GE's offshore wind power involvement dates back to 2000 but it has reportedly kept a low profile in offshore until now as GE affirmed the "strategic fit" of ScanWind.

**Figure 95 Total Installed Wind Capacity 2009 in MW**

| | | |
|---|---|---|
| USA | 35,064 | 22% |
| China | 25,805 | 16% |
| Germany | 25,777 | 16% |
| Spain | 19,149 | 12% |
| India | 10,926 | 7% |
| RoW | 41,784 | 26% |
| | 158,505 | 100% |
| | | 158 GW |

*Source: EBI Inc. derived from a variety of sources including AWEA, EWEA, EER, BTM Consult, U.S. DOE, EIA and others; Wind electricity sales is wholesale sales or value*

**Figure 96 Total Added Capacity 2009 in MW**

| | | |
|---|---|---|
| China | 13,803 | 36% |
| US | 9,996 | 26% |
| Spain | 2,459 | 6% |
| Germany | 1,917 | 5% |
| India | 1,271 | 3% |
| RoW | 8,896 | 23% |
| | 38,342 | 100% |
| | | 38 GW |

*Source: GWEC*

**Figure 97 Global Wind Energy Turbines: 2009 Installations**

| | MW installed | MW Share | Est. Wind Revenues ($mil) |
|---|---|---|---|
| Vestas | 4,780 | 12.5% | 7,700 |
| GE Energy: USA | 4,740 | 12.4% | 7,600 |
| Sinovel | 3,520 | 9.2% | 4,900 |
| Enercon | 3,250 | 8.5% | 5,200 |
| Goldwind | 2,750 | 7.2% | 3,900 |
| Gamesa | 2,560 | 6.7% | 4,000 |
| Dongfang | 2,480 | 6.5% | 3,500 |
| Suzlon | 2,450 | 6.4% | 3,500 |
| Siemens | 2,250 | 5.9% | 3,600 |
| REpower | 1,300 | 3.4% | 2,000 |
| Others | 8,140 | 21.3% | 12,200 |
| Total | 38,210 | | 58,100 |

*Source: EBI model of the global wind industry derived from GWEC, AWEA, EER, BTM and individual company reports*

## 6.3. Trends in Wind Energy Supply Chain

### 6.3.1. Service Providers to the Wind Industry

From environmental consultants to wind resource specialists, from law firms and financial advisors to engineering, procurement and construction (EPC) contractors, the wind power industry is heavily dependent on consulting firms and contractors.

Transmission developers hoping to link remote wind power sites with load centers also rely on engineering, environmental, legal and financial service providers. “To develop one of these [long-haul transmission] projects costs tens of millions of dollars before you break ground,” said Clean Line Energy CEO Michael Skelly. “That money is going to go to lawyers and engineers and permitting specialists.”

EBI estimates U.S. wind power services generated $5.3 billion in revenues in 2009, with $3.9 billion from construction, $520 million from consulting & engineering (C&E) and $900 million from operation & maintenance.

The three construction leaders Mortenson Construction, Blattner Energy and RES Americas build about half of U.S. wind farms and most of the O&M is done by the OEMs

(Vestas reports 8% of its 2009 revenues of $8.3 billion was in services, principally O&M), but the C&E market is much more fragmented and specialized.

C&E service providers include firms that specialize in environmental analysis and permitting and those with a broader reach. Environmental firms such as ICF International and Ecology & Environment do projects ranging from up-front “critical issue analyses” to sketch a permitting roadmap for a developer to full environmental analyses and permitting. But they don’t do wind resource assessment or windfarm design and engineering

More diverse offerings from firms like CH2M Hill include wind resource assessment, design, engineering and construction management. Garrad Hassan and AWS Truepower (formerly AWS Truewind) do much of this work also, with more emphasis on helping clients plan and run wind farms and representing third-parties in due diligence evaluations.

### 6.3.2. Typical Projects in Wind Consulting & Engineering

According to the professionals contacted by EBI, the timeline for completing a wind farm typically runs from two to three years from concept to operation, but variables can extend the timeline out much further. One developer recently told TRC’s Fleischauer that “from concept, to cutting trees, to operation—that can be a good five years.” As wind power development moves eastward, where the land use regulations are more stringent and the sites available for utility-scale development are more limited, the average development timeline could lengthen before it shrinks, she suggested.

Actual construction typically takes four to six months; it’s the site assessments, wind modeling, environmental impacts, and adjustments arising from the interplay of each of these factors, plus the subsequent permitting, that consumes the time. “We typically come in once a client determines that it has a specific site to consider,” said ICF Jones & Stokes’ Miller. “They’ve done some desktop analysis, determining the wind regime at the site, and they bring us that information—‘here’s the site and our expectation of the wind resource.’ The first thing we do is look at the site and prepare a constraints or fatal-flaw analysis, looking at the regulations, land use issues—anything you can find without more than a cursory physical site review. It’s not in depth, so we can give them a thumbnail sketch of the issues they are dealing with, the permits they need to obtain. That’s a few-weeks project, with the cost varying according to the size of the project and amount of area affected. It may be a five-figure exercise, but [the costs] can vary.”

TRC’s Fleischauer painted a similar picture of the initial process, but hastened to point out that the requirements for the service provider will vary according to the developer’s approach. “Not every client does everything the same way. Some will ask you to do a permit review and permit feasibility study, without giving too much away. At the same time, they will require a site access study, because so many sites are on ridgetops, and you need to find out how to get there. And then there’s the issue of access to transmission—how to get there, how to get the product out.”

The site access study can cost $15,000 to $20,000, Fleischauer said, and the electrical access related to that could be equivalent, while a detailed critical-flaw review cost be $25,000 to $30,000. “These are ballpark figures,” she was quick to point out. “If everything at those stages comes together, and they decide to pursue the project,” she continued, “we’d go into the field studies related to the environmental permits.”

The field studies include the assessment of wetlands and cultural resources impacts, as well as the impacts on bird and bat mortality. Bird mortality is a big issue, and perhaps the biggest environmental impact issue that wind developers face, according to Dail Miller. Indeed, his firm has just embarked upon the third and final year of a major avian and bat mortality study at the Altamont Pass Wind Farm in California, one of the first wind farms built in the United

States. "That study will be interesting to a lot of people in the industry, because one of the issues in the study is the adaptive management plan, which essentially entails a seasonal shutdown of the facility," Miller said. "It's a unique location, so not every lesson learned there will be translatable to the rest of the industry, but many people will be interested in the outcome."

The EIS requirements can vary by state, and a federal EIS is not always required. "If you have to do a comprehensive EIS or a local land use application, you have to address a number of issues not related to federal or state regulations but more to local concerns, entailing studies with regard to visual impacts, noise, and, if you will, economic impacts to the local community," said Fleischauer. By all accounts, depending upon the complexity of the site and the size of the development, and adding in the need to conduct local meetings to maximize stakeholder participation, the assessment and permitting services can range in cost from a few hundred thousand dollars to in excess of $1 million.

**Figure 98 Categories of Services**

| |
|---|
| **Site Identification and Feasibility Studies** |
| Assessing wind resources and modeling energy production |
| Environmental assessments, planning and permitting |
| Community relations |
| Design, turbine layout |
| Engineering grid connections |
| Asset optimization |
| Due diligence for lenders/investors |
| Engineering and construction: turbines, towers and roads/infrastructure |
| Operations and maintenance |
| **Assessments, Planning & Permitting: Tasks and Subcontracts** |
| Field studies (avian, bat) |
| Communications/ radar interference |
| Agency consultation |
| Wetland delineation |
| Noise studies |
| Visual impact studies |
| Cultural/archaeological resource assessment |

*Source: EBI Inc.*

### 6.3.3. Manufacturers Enjoy Economies of Scale and Higher Prices

Besides the good fortunes of turbine leaders, components suppliers are also reporting record growth. For example, Hansen Transmissions International (Antwerp, Belgium), which makes gearboxes for several turbine manufacturers, grew 26% to €421 million in FY08 and set a growth target of 50% for FY09. Trinity Industries Inc., one of the largest tower manufacturers for the U.S. wind industry, grew tower revenue from $11 million in 2004 to $230 million in 2007, ending the year with a $750 million in backlog.

Danish company LM Glasfiber, a leading global supplier of rotor blades, increased sales by 22% to $850 million in 2007 and reported its largest ever backlog of orders totaling $3.5 billion. Aided by a double-digit carbon fiber price increase with its major customers, Zoltek (St. Louis, Mo.) grew sales 63% to $151 million in FY07, up from $92 million in 2006 and from $55 million in 2005. Zoltek is a carbon fiber manufacturer that does the majority of its business with four big wind turbine customers.

Profitability is also creeping up as manufacturers reach critical mass, customer demand exerts pressure to increase productivity, and turbine prices push upward. “I see an economies of scale situation,” said Bob Carey, chief investment officer of First Trust Portfolios LLC (Lisle, Ill.), which launched the First Trust ISE Global Wind Energy Index Fund in June 2008. “I also see improving levels of asset turnover… These plants are getting more efficient. In some cases operating margin is improving; in others, asset turnover is improving…. The asset side of the balance is growing very rapidly.” In terms of competing with other energy sources, “scale is the great equalizer,” Carey concluded. First Trust’s dedicated wind index fund, which was aiming for $100 million under management within a couple of years, as of August 1, 2008 had already reached $75 million, according to Carey.

Nordex attributed its recent 142% rise in EBIT to economies of scale and the greater profitability of projects completed, with scale predicted to be the biggest gauge of profitability in the future. Higher turbine prices have helped. At Vestas in FY07 EBIT improved by €242 million to €443 million (EBIT margin of 9.1% up from 5.2% in 2006), attributed to better prices, improved in-house processes and product flows. Clipper plc reported that it expected “significantly improved margins and earnings in 2009,” with a key contribution from improved turbine pricing. Turbine manufacturers are all reporting a growing backlog of orders. GE’s backlog grew to $12 billion, up from $11 billion in the fourth quarter of 2007. Vestas’s order backlog increased by 20% to end 2007 at €4.8 billion, with the Americas representing around 40%.

Excessive demand, while a good problem to have, creates intense pressures, and the average lead-time for delivery reportedly increased from six months in the middle of 2007 to between 24 and 36 months in the middle of 2008. To meet record requirements for wind turbines, manufacturers have been investing heavily in factories worldwide, particularly where markets are moving fastest, notably in the U.S. and China. Spanish turbine manufacturer Gamesa has established nine production centers in the last couple of years, four of them in the U.S. and four in China. In January 2008, Acciona, both a wind farm developer and a turbine manufacturer, opened its first production facility in the United States. In March 2008, the Danish turbine leader Vestas opened its first U.S. manufacturing facility, a blade factory, in Boulder, Colo., with additional plans to build the world’s largest tower factory there “in spite of the uncertainty surrounding the extension of the PTC.” The 2.5-MW turbines to supply Nordex’s U.S. contracts in 2008 and 2009 are largely being assembled in Germany. However, over the next few years, Nordex will be spending around $100 million to establish its own U.S. production facilities, and over the next four years aims to generate around 20% of sales in North America.

In this “sold out” industry, turbine makers are themselves suffering shortages of subcomponents, from gearboxes to blades, bearings, bolts, cast iron, towers, and electrical parts. Vestas reported up to a 15-month lead-time on some parts, and stated that in 2007 it again experienced that one of the greatest impediments to growth, development, and improved profitability was, “a much too unstable supply situation” and quality failures.

Shortages have spurred manufacturers to lock in supply through longer-term relationships with fewer subcomponent suppliers and to set up quality control programs to maintain parts integrity. In 2007, GE announced commercial agreements with two leading component suppliers, Molded Fiber Glass Companies and TPI Composites, to build new wind turbine blade manufacturing plants. The MFG plant represents a $40-million investment.

“Most manufacturers are trying to help the subcomponent suppliers gear up,” said Peter Duprey, CEO of Acciona Energy North America Corp. (Chicago), a developer and sister company to the turbine manufacturer, Acciona Windpower. "For blade manufacturers we'll tend to put supplier quality engineers on site to help build quality into our components."

In 2007, Spanish manufacturer Gamesa continued to develop local providers in the U.S. and China. And in parts of the supply chain not core to its business, Gamesa has set up strategic alliances to supply towers and improve logistics and shipping. These alliances have helped improve return on capital by reducing inventory levels in the case of towers and by optimizing logistics and warehousing costs, the company said.

"All the big companies in the world have become logistics plays more than anything else," said Carey of First Trust. And wind clearly is no exception.

Some turbine manufacturers have pursued vertical integration from the start, notably Suzlon Energy and Gamesa. Suzlon purchased Hansen Transmissions in 2006 for €465 million. In earlier deals, Siemens acquired Flender and Winergy (gearboxes) and Vestas purchased Weier Electric. By contrast, Nordex's approach to components supply has been to let market forces reign rather than acquire or invest in the supply chain. "The market has proved us right," claimed Losada, who noted that many new component suppliers have appeared on the market, and established suppliers have invested in expanding their capacity.

Duprey of Acciona Energy confirmed that suppliers are reappearing in the United States. "The U.S. is expanding its supply chain, so you can get most of the components. Some manufacturing jobs had left the U.S.—large castings, gears, castings that support blades…. We're starting to see them coming back. There aren't many tower manufacturers, but we're seeing existing manufacturers expand," he said.

Seizing the opportunity to rationalize the supply chain, the aforementioned Broadwind Energy is rolling up companies in gears, towers, O&M and hauling to serve as a broad-based supplier.

### 6.3.4. Utilities Race to Consolidate Development Business

Meanwhile, on the electricity generation side of the wind energy business, wind farm developers have been pursuing acquisition strategies culminating in huge deals, sucking up project pipelines and multi-megawatts of operational wind farms. According to Emerging Energy Research (Cambridge, Mass.), mergers and acquisitions accounted for approximately one-third of total wind ownership growth among Europe's top 20 wind owners in 2007.

Major consolidation moves in 2006-2008 included:

• Spanish utility Iberdrola SA's U.S. expansion through the acquisition of Scottish Energy in a deal worth $23 billion. The deal included its subsidiary PPM Energy's holdings in the U.S., possibly positioning Iberdrola ahead of FPL Energy, the long-time leader in U.S. wind development.

• Power company EDP Energia de Portugal's acquisition of leading U.S. developer Horizon Wind Energy from Goldman Sachs in 2007 for $2.15 billion

• German utility E.ON's 2007 purchase of Energi E2 Renovables Ibericas, a wind farm operator in Spain and Portugal, from the Danish utility Dong Energy for $994 million, followed by the purchase of the North American division of Irish wind farm development company Airtricity for approximately $1.4 billion.

Also in 2007, Naturener SA (Spain) entered the North American market by acquiring Energy Logics Inc. and Great Plains Wind & Energy LLC.

"Clearly right now the players are bigger and bigger. It's not any longer a small companies' business. It's a huge companies' business," said Martin Mugica, president of Iberdrola Renewable Energies USA.

"The market is, overall, maturing with rising barriers to entry," noted AES's Crotty. But, he added, "There's still opportunity to consolidate. In various markets are developers who have pipelines; larger companies could come in and consolidate those smaller developers and piece together a pretty big portfolio."

Global expansion characterizes the strategy of all the leading wind energy players both in development and in manufacturing. While the emerging markets are in everyone's sights, the more mature markets still offer good potential. In a reversal of the "head west" direction of European developers, AES Corp. (Arlington, Va.), one of the largest global power companies with $13.6 billion in annual revenues, has entered the European market by acquisition of wind farm pipelines in Scotland, France and Bulgaria. Indeed, while Germany and Denmark show signs of maturing, other parts of Europe where wind power is less advanced still offer opportunity. France, for example, showed growth of 57% in wind energy and Italy 28% in 2007.

Today, AES operates more than 1,000 MW of wind facilities in the U.S. and has another 6,000 MW of wind projects in various stages of development. AES's wind business will take advantage of the parent company's global infrastructure, explained Crotty. For example, it is pursuing wind projects in Brazil, where AES already has a very significant presence, in addition to Chile and China.

To help fund expansion, some developers have gone to public markets. Iberdrola raised $6.5 billion in a public offering of 18% of its renewable energy company in December 2007. In the same year, EDP Energia de Portugal raised $2.8 billion from an IPO of 25% its renewable energy arm. In the summer of 2008, Noble Environmental Power filed to raise up to $375 million in an IPO. Founded in 2004, Noble began operating its first wind parks in March 2008; it reported $72 million in net losses as of the end of 2007. And in July 2008, First Wind Holdings filed preliminary papers with SEC for an IPO of up to $450 million. First Wind's portfolio of projects included approximately 5,560 MW of capacity, of which just 92 MW were operating and 182 MW were under construction.

### 6.3.5. Developers Face Rising Costs

High demand for wind energy and shortages up and down the supply chain means developers are now paying more for turbines, although there are so many factors in the economic mix—currency fluctuations and rising commodity and transportation costs being the most obvious—that executives claimed it was hard to say what the real increase has been. When installed in larger quantities, turbines of 2 MW will typically cost $5 million, said one developer. "The price of developing a wind farm has gone from $2.1 million a MW to $2.4 million a MW in about 18 months."

Asked by what percentage wind turbine manufacturing costs have risen in the last 12 months, 52% of respondents to the CCBJ wind energy survey said by 10-20% and 32% said by 20-30%. Asked what was behind the run-up in price, 29% rated the decline of the dollar as 'most important,' 25% said steel costs, and 24% said transportation costs.

Comprehensive research by the U.S. DOE at the Berkeley Lab charts the trajectory of both U.S. wind turbine costs and installed wind project costs over time. Modern equivalent turbine costs started at $1,600/kW in 1997, were roughly $1,200/kW in 1998-1999, bottomed out at about $700/kW in 2000-2002 and have steadily climbed to an average of $1,240 in 2007, with the average increasing 10% from 2006 to 2007. Installed project costs started at $3-4,000/kW in 1985, lowered consistently to $2,500/kW in 1990 and under $2,000/kW in 1994-1995, before bottoming out around at annual averages of close to $1,500/kW from 2001-2005. Turbine price increases have driven 2006 and 2007 averages to $1,570/kW and $1,710/kW with costs of projects in the pipeline averaging about $1,900/kW as even higher turbine costs work their way into the system.

Two factors can ease the turbine shortage: 1. When developments fail or are delayed, leaking turbines onto the secondary market; and, more critically, 2. The appearance of turbines from Asia, notably China. "We are expecting the price of turbines not to continue growing at this pace, and eventually to reduce in price," mainly because of competition from Asian companies, said Mugica. The first Chinese manufacturers expected to enter the international market are Goldwind and Sinovel in 2009 and 2010. Testing organization Germanischer Lloyd said it is certifying the design of Sinovel's 3-MW turbine.

A few Chinese companies have entered the wind energy business through licensing agreements. A-Power Energy Generation in January 2008 announced that its subsidiary Liaoning GaoKe Energy Group had licensed technology from Norwin of Denmark and Fuhrlander of Germany. It said its 750 kW Norwin wind turbine was expected to sell for $0.46 to $0.51 million, and its 2.5-MW Fuhrlander wind turbine for $2.7 to $3.2 million, with 8% to 12% gross margins.

According to a report from The Climate Group, a non-profit organization, China will become the world's leading manufacturer of wind turbines by 2009, which is perhaps only a year or two early. Vestas's decline in global market share from 28% in 2006 to 23% in 2007 was attributed to competition from China's domestic manufacturers.

Developers are eager for turbine competition, but new entrants will face scrutiny. The pitfalls of transferring technology from the grid and weather conditions of one country to another were perhaps illustrated when dozens of blades on turbines made by Indian manufacturer Suzlon Energy cracked in fierce winds at wind farms in the U.S. Midwest earlier this year. Now, Suzlon turbines installed at projects managed by Deere & Co. aren't producing enough power to meet sales contracts because of lower than contracted availability rate, according to a June 2008 article in *The Wall Street Journal*, which said some turbines have failed to produce enough power because of incompatibility with the U.S. electricity grid. At about $3 million each, Suzlon's turbines sold in the U.S. are priced about 25% cheaper than those of major competitors, WSJ reported.

While today's turbine prices are making developers wince, a degree of brand loyalty is likely to persist. According to Duprey of Acciona Energy, "Once you've learned the ins and outs [of a turbine] you're apt to buy it again. This is complicated equipment." Another developer confirmed that some investors have strong opinions about which turbines they will or won't use.

But there's no mistaking the global nature of this business. Suzlon of India, for example, has established dedicated centers for gearbox technology in Belgium, technology innovation in Denmark, process engineering in India, aerodynamic development in the Netherlands, and composite wind turbine technology in Germany.

### Transmission and Other Challenges

Apart from rising prices and material shortages, what are the biggest challenges facing wind energy development? Mugica of the development company Iberdrola Renewables identified location as one of the biggest challenges. "Although wind is infinite, land is not. We have to look for good places with good capacity. Other challenges are the different permitting regimes from state to state." However, whereas permitting was once the biggest development headache, "I'd say transmission is becoming a bigger issue than permitting at this point," said Duprey. Many in the industry would agree. "It will take leadership in Washington. We need to look at our transmission system as a national effort similar to the way we looked at our highway system 40 to

50 years ago. Between wind, solar, biomass and geothermal, I think at least 30% of our energy can come from those sources in this country. The enabler is really transmission."

Texas is one of the fastest U.S. markets in which to develop a wind power project, taking two or so years as opposed to three or four. Texas is also leading the field in building transmission for wind generation. In July 2008 the Texas Public Utility Commission approved a $4.9 billion plan to build more than 2,300 miles of transmission lines that will link untapped wind energy resources in northern and western Texas with electricity load centers. Together with existing MW, the new transmission will allow for 18,000 MW in the state. "They have the mechanism in place with competitive renewable energy zones to get it built. We think others should model their transmission after Texas," said Crotty.

Nationally, leadership has been less than stellar. Failure of the U.S. Congress to renew the 1.9 cent production tax credit (PTC) due to expire December 2008 was certainly a concern. Florian Zerhusen, president and CEO of the development company Windkraft Nord USA, is optimistic. "There are too many jobs and too much investment for it not to get passed. I'm not too worried." He was right. The 2009 American Reinvestment and Recovery Act (ARRA) not only extended the production tax credit through December 31, 2012 for wind projects but also created wind project owners the option to elect the investment tax credit (ITC) in lieu of the production tax credit, or a cash grant in lieu of either the PTC or ITC.

## Big, Bigger, Biggest

Both wind turbines and projects are getting bigger. The world's largest development is currently Horse Hollow in Texas at 734 MW. BP Alternative Energy's joint venture with Clipper Windpower plc plans to develop the Titan wind farm of 5,050 MW in South Dakota (supply equal to 1.5 million average homes). Clipper will supply as many as 2,020 2.5 MW wind turbines. Wind farm projects are often flipped from one owner or investor to the next throughout their development lifetime, making attorneys perhaps the real winners in the current wind boom, quipped one developer. There really is no 'sweet spot' at which to enter a wind power project, although greenfield projects typically yield the best returns, observed Crotty of AES, who favors a balance of project types. From green field to buying spinning assets, "we'll participate at any stage," said Crotty. "But for building sales or critical mass it sometimes makes sense to take whatever opportunity is available."

Developers are also increasingly employing the more energy-productive multi-megawatt turbines, especially where land is scarce. Gamesa reported that in 2007 its 2-MW range led growth, accounting for 73% of demand. It planned to have a 4.5-MW machine installed on a wind farm by the second half of 2008.

Windkraft Nord USA's first project at Snyder Wind farm in Texas features lofty 3-MW machines from Vestas. Other 3-MW suppliers are WinWinD, Multibrid, and Alstom-Ecotécnia. Enercon is reportedly prototyping a 6 MW class turbine with a rotor diameter of 413 feet, enough to power 1,776 American homes on one wind turbine.

**Figure 99 Key Issues for U.S. Wind Power**

| |
|---|
| • Policy Uncertainty |
| • Siting and Permitting: avian, noise, visual, federal land, radar |
| • Transmission: FERC rules, access, new lines |
| • Operational impacts: intermittency, ancillary services, allocation of costs |
| • Accounting for non-monetary value: green power, no fuel price or carbon risk, reduced emissions, reduced water use |

*Source: NREL, WindEnergyUpdate, June2008*

Wind turbines have grown by leaps and bounds in the last 20 years, both in size and technology refinement. But Duprey echoed the view of other executives when he described today's wind turbine technology as "fairly mature at this point when compared to other renewables. I don't see huge technology changes ahead; there's not much more to wring out of scale effect." However, there is still room for refinement, for example, in improving the stability of integration into the grid, and blades designed for bit more efficiency, he noted.

Scope for improvement in composites for blades is "not completely tapped out; there's an opportunity build larger, lighter, stronger composites," said Bob Lacovara, director of technical services at the American Composites Manufacturers Assn. Inhibiting investment by the composites players in the U.S. is the lack of a comprehensive energy policy, which "makes it very difficult to ramp up for larger-scale production," noted Lacovara. "Building wind blades is on the same level of technology as building aircraft wings; you can't just decide to get into it. The capital expense is significant."

While mega turbines grab the headlines, there is still opportunity in the sub-megawatt class, which has attracted new entrants possibly in response to supply chain issues associated with larger machines, according to Eize de Vries, a correspondent for *Renewable Energy World* magazine. The sub-1-MW machines are selling well in emerging Asian markets, where transportation and installation logistics can be an issue, or where topography is inappropriate for large turbines. New players include Conergy of Germany, Unison of South Korea and Vergnet of France. Proven Energy, a Scottish manufacturer of small turbines, (see p.47) which claims 70% of the small wind market in the U.K., recently established a base in the North American market, where over 9,000 small units were sold in 2007 valued at $42 million, up 14% over the prior year, according to the AWEA.

**Figure 100 Top-20 Utility Wind Power Rankings**

| Total Wind Capacity (end of 2008, MW) | | | Estimated Percentage of Retail Sales (for utilities with > 100 MW of wind) | |
|---|---|---|---|---|
| Xcel Energy | 2,906 | | Minnkota Power Cooperative | 22.60% |
| MidAmerican Energy | 2,363 | | Empire District Electric Company | 20.70% |
| Southern California Edison | 1,137 | | Otter Tail Power | 14.90% |
| Pacific Gas & Electric | 981 | | Southern Minn. Muni. Power Authority | 13.00% |
| Luminant | 913 | | Austin Energy | 11.70% |
| City Public Service of San Antonio | 502 | | Xcel Energy | 10.70% |
| American Electric Power | 468 | | MSR Public Power Agency | 9.30% |
| Alliant Energy | 446 | | Great River Energy | 9.10% |
| Austin Energy | 439 | | City Public Service of San Antonio | 8.20% |
| Puget Sound Energy | 435 | | MidAmerican Energy | 8.10% |
| Exelon Energy | 351 | | Public Service New Mexico | 6.20% |
| Great River Energy | 319 | | Luminant | 5.60% |
| Empire District Electric Company | 255 | | Alliant Energy | 5.40% |
| First Energy | 244 | | Puget Sound Energy | 5.30% |
| San Diego Gas & Electric | 239 | | Seattle City Light | 5.30% |
| Portland General Electric | 225 | | Northwestern Energy | 5.00% |
| Public Service New Mexico | 204 | | Minnesota Power | 4.60% |
| MSR Public Power Agency | 200 | | Aquila | 3.90% |
| Reliant Energy | 199 | | Portland General Electric | 3.30% |
| Minnkota Power Cooperative | 193 | | Southern California Edison | 3.10% |

*Source: Wind Technology Market Report 2008 by EERE. July 2009. Original source: AWEA, EIA, Berkeley Lab estimates.*

### 6.3.6. Investor-owned utilities (IOUs)

By developing their own wind assets and purchasing wind energy from third parties, U.S. investor-owned utilities (IOUs) are at the forefront of building out wind energy capacity in the United States. IOU investment in wind energy varies greatly depending on company philosophy, regulatory drivers such as state renewable portfolio standards (RPSs), proximity to wind resources, regional transmission constraints and other issues.

To gain a broad perspective from U.S. utilities, we interviewed top executives at three IOUs in leading positions with wind energy: MidAmerican Energy Co., Pacific Gas & Electric Co. and Xcel Energy. All three companies have some experiences and viewpoints in common. They are all enthusiastic about the taller tower heights and larger rotor diameters that the wind industry is providing. “With taller towers and longer blades you get higher capacity factors,” said Tom Budler, MidAmerican’s general manager for wind development. “And if you employ the larger megawatt machines, you lower your plant costs and your installation costs by decreasing cable runs, decreasing your concrete usage and the time you spend during construction.”

These three companies are also finding their plans to build or buy additional wind power challenged by the current supply shortages and pricing increases for turbines and components. “We have had projects [proposed] that have not been able to succeed because [the proponents] weren’t able to acquire turbines,” said Karen Hyde, Xcel Energy’s vice president of resource planning and acquisition. “We’re also seeing some apportioning of turbines between projects by large developers that may have more projects than they have turbines available.” In the currently constrained market, smaller community-based wind project developers find it particularly difficult to acquire turbines, according to Hyde.

The fickle nature of the federal production tax credit (PTC) also casts uncertainty over the three utilities’ wind energy initiatives. “If you looked now at the number of announced projects for 2009, you’d see a huge drop-off,” due to the looming expiration of the PTC, said Hyde. She noted that although the PTC’s nominal value is $0.02 per kwh, tax implications raise the cost of operating a wind plant without the PTC by about $0.03 per kwh. “The cyclical nature of the PTC has been an historic problem, and it’s a shame that Congress hasn’t acted to fix this.”

As they look at getting larger percentages of their generation from wind, the variable and intermittent nature of wind power is becoming a larger challenge to integrate into grid systems that must constantly match generation to load. The utilities are actively exploring grid management methods to incorporate more intermittent wind energy, as well as storage options ranging from batteries to compressed air.

But their approaches to developing wind resources are markedly different. The most striking difference: how much wind power capacity they own versus how much they buy from independent power producers (IPPs). MidAmerican owns nearly all its wind assets, while Xcel and PG&E own very little and instead rely on power purchase agreements (PPAs) with IPPs. For MidAmerican and Xcel, the different strategies were results of different legislation and regulatory policies in their respective service territories. For PG&E, the choice was more driven by the fact that after California passed an aggressive RPS in 2002, the “very active wind industry” had more expertise and capabilities than the utility did, according to Hal LaFlash, director of emerging clean technology policy at PG&E. “We had done a lot of the original R&D work on wind in the early 80s, and we owned one of the first 2.5-megawatt turbines,” said LaFlash. “But declining natural gas prices had led PG&E to move away from wind energy as a business” in the 1990s.

Xcel also focused initially on negotiating wind PPAs because of what the IPP sector could offer. “The IPPs were the entities developing sites and taking positions in turbines, so it made sense in the beginning to have IPPs build most of the wind early on,” said Hyde. This was also what utility commissions wanted in Minnesota, Colorado and other states where Xcel operates, according to Hyde. “We went through a period from 2000 to recently when our commissions really pushed us to do PPAs.… The feeling was that our customers would best be served through competition.”

At least in part due to Xcel’s testimony, the state commissions are now looking more favorably on utilities owning their own wind assets in order to benefit ratepayers. “Say an IPP [wind energy] facility has about a 20-year life, and they sell to us maybe for 15 years. At the end of 15 years, if we owned the facility, our customers would be getting very cheap energy,” said Hyde. “If someone else owns it, we’d likely be renewing at a price that was at or just below market, but quite a bit more than what our costs would be.”

PG&E is also increasingly focused on developing and owning its own wind projects. PG&E started a Renewable Resource Development group last year. “We’ve since decided that we want to have more of a hybrid model,” said LaFlash. “We already have a significant number of PPAs, and we will start adding some ownership [of wind power projects].”

According to Matt Kaplan, research analyst with Emerging Energy Research, PG&E and Xcel are not alone in shifting toward ownership of wind assets. “There is definitely a trend of utilities moving into asset ownership for wind,” said Kaplan. He noted that this approach gives an IOU the ability to retain generation assets for longer periods, as mentioned by Hyde. “Another factor is that there are various credit rating agencies that actually count long-term PPAs as debt on a utility’s balance sheet. There’s also an increasing comfort [among IOUs] with wind power. It’s no longer viewed as a marginal source of energy.”

According to Kaplan, utility-owned wind assets will likely exceed 1 GW at the end of 2008, an increase of 25% over the approximately 800 MW owned by utilities at the end of 2007. “In 2000, only about 4 megawatts of wind was owned by utilities,” said Kaplan. “You’re seeing both utilities that have historically had wind on their systems moving into asset ownership, and you’re seeing utilities that are brand new to wind moving into wind asset ownership.”

“This does present a challenge for IPPs, as IPPs depend heavily on owning wind assets,” said Kaplan. “[The increase in utility ownership] puts a strain on their business models.” Yet some utility commissions will continue to require IOUs to issue tenders for wind power in the expectation that competition will provide the best deal for consumers, according to Kaplan. “And some IPPs are moving to merchant power markets like Texas and New York, where wind can compete with the prices on the spot markets there for power generation.”

### 6.3.7. Profile: PG&E

LaFlash of PG&E identifies transmission constraints as the top challenge the Northern California utility faces in building or procuring additional wind resources. “It has been a chicken and egg problem,” he said. “No one is going to put wind on the system if there’s no transmission available, and no one is going to build transmission [to a remote location] if there are no projects there.” LaFlash is enthusiastic about the Renewable Energy Transmission Initiative (RETI) headed by California’s Energy Commission, Independent System Operator and Public Utilities Commission.

According to a report by RETI contractor Black & Veatch, the initiative brings together utilities, generators, regulatory agencies, public interest and environmental groups to develop “specific plans for renewable energy and related transmission development.” A major thrust is prioritizing among already identified Competitive Renewable Energy Zones (CERZs) “based on their developable potential, taking into account environmental concerns, the quality of the resources, the cost to develop those resources, and the cost of transmission needed to deliver those resources to load centers.” In addition to wind, the planning effort is taking stock of a host of other renewable resources, including concentrating solar power, wave and marine current power, anaerobic digestion, biomass, geothermal, hydro and landfill gas. Because California depends heavily on imported electricity, the analysis will look at renewable energy zones as far away as British Columbia and Baja California.

PG&E currently has contracted for just over 793 MW of wind power, and wind generates about 2% of the utility's electricity. "We get more from geothermal and biomass and in a good water year, small hydro," said LaFlash, noting that biomass and geothermal have the advantages of operating at 90% capacity factors, while wind operates about 30%. Newer, larger wind turbine designs boost capacity factors to about 35%, and that has made it easier for PG&E to contract for some 530 MW of additional wind power over the next several years. How much wind capacity it adds over the longer term is an open question, as the utility must weigh wind investments against other forms of renewable energy, and also take into consideration the integration and transmission issues being worked out statewide by RETI. The state's three IOUs, Southern California Edison, San Diego Gas & Electric Co. and PG&E, not to mention its many municipal utilities, "have to operate together as one big system," noted LaFlash.

Despite the enormous coastline adjoining its service territory, PG&E hasn't aggressively pursued offshore wind development because California's coastal waters are exceptionally deep. "When you have a couple hundred feet of ocean depth, all that additional tower length makes an offshore wind project cost-prohibitive," he said. Emerging designs for floating wind platforms may offer cost-effective options, and PG&E is discussing such projects with IPP Principle Power (San Francisco). Principle Power's website says it is leveraging "intellectual property developed by experienced offshore oil and gas industry experts coupled with novel innovations by in-house engineering" to pursue a "pilot project to further prove the potential and economic feasibility of deep water offshore wind energy installations." But for now, LaFlash says, "there are still a lot of wind resources to be developed onshore."

As noted above, energy storage can allow a utility to balance and add value to intermittent resources such as wind. PG&E is seeking to develop more pumped hydro storage capacity to add to its existing 1212 MW Helms project. "We've recently filed applications with FERC for two more pumped storage projects, one on the Mokulmne River and one on Kings River," said LaFlash. "The sizes haven't been firmed up yet, but they'll be between 380 and 1,140 megawatts. We're early in the analysis process, but we think pumped storage will have a lot of value."

"We're also doing some work looking at compressed air energy storage with the Electric Power Research Institute," said LaFlash. Compressed Air Energy Storage (CAES) capacity would most likely be used to offset the energy demand of compressors that feed air to natural gas turbines. "With a typical gas turbine, about 60% to 65% of the power that the turbine produces goes into compressing the air to feed the turbine," said LaFlash. "There are [CAES] projects in the world that have been operating for 20 years. With energy prices the way they were, there wasn't much interest in adding new ones. Now this technology is getting a lot more attention." Given California's underground geology, the most likely storage sites would be natural gas reservoirs or aquifers, according to LaFlash. With funding from the state energy commission, PG&E, Southern California Edison and the Electric Power Research Institute are developing software to determine optimum storage locations.

"We're also doing a lot of work with other types of storage devices, including sodium sulfur batteries and flow batteries," said LaFlash. "We've even had flywheels being tested as devices for regulating the system [and providing] frequency management, voltage regulation and other things that California ISO needs to keep the state system running."

"Storage is a hot item," said LaFlash, noting that PG&E released in July a request for information from suppliers of energy storage technologies. The RFI asks potential vendors to describe how their technology would work in six different scenarios: substation islanding; load leveling; ancillary services like frequency regulation; ramping and peak shaving; time shifting/arbitrage/ancillary services; and optimum deployment.

### 6.3.8. Profile: Mortenson in Wind Construction

With about 9,000 MW of wind projects under its belt, Mortenson Construction (Minneapolis) has built nearly 25% of the wind power capacity in the United States and Canada. Along with Blattner Energy (Avon, Minn.), RES Americas (Broomfield, Colo.), RMT and MasTec, Mortenson is one of the top wind power engineering, procurement and construction (EPC) contractors in North America. Other firms performing EPC include Black & Veatch and Tetra Tech, and firms in fossil power such as Zachry Group are pursuing wind power projects. Mortenson had total revenues of $2.8 billion in 2009, up from $1.2 billion in 2006.

"There continues to be new competitors pursuing the EPC side of the business trying to gain market entrance," said Jerry Grundtner, vice president, project development, for Mortenson's renewable energy group. Grundtner says the barriers to entry for new contractors are high because providing the full EPC with a turnkey guarantee on price and schedule is a complex and challenging business. "It's difficult for the smaller companies to get involved in the larger projects, so that continues to be an area of focus for us, although we also construct many smaller projects."

When Mortenson completes the erection of the wind turbines and achieves individual mechanical completion the wind turbines are turned over to the turbine supplier for commissioning. Mortenson provides warranty coverage on its construction typically for one year, while the manufacturers provide longer-term warranties and O&M service.

Of the firm's 1,300 salaried employees, 225 work on wind power projects full time; and out of its 1,200 to 2,000 hourly craft labor employees up to 650 clock in on wind power projects. (Implying that wind accounts for about one-third of revenues or close to $1 billion.) Both categories of team members are in good supply due to the downturn in the construction business.

### 6.3.9. Profile: Tetra Tech

Having worked off a strong backlog early in 2009, Tetra Tech Inc. (Pasadena, CA) felt the effects of the economic meltdown on its wind energy business in 2010. The fiscal 2009 year ending on September 27, 2009 was a banner one in wind for the $2.3 billion environmental and infrastructure engineering firm, which recorded $215 in wind-related revenue compared with $160 million in fiscal 2008. The task ahead is to refill the project pipeline.

Tetra Tech expected to perform only about $50 million in wind revenue in 2010, and has this level of work already booked in its backlog, says Jorge Casado, Tetra Tech's vice president for investor relations. Highlights for fiscal 2009, included the completion of three projects for PacifiCorp totaling 237 turbines and amounting to 355.5 megawatts (MW) of capacity, at a total funded value of more than $150 million, and the construction of the 101 MW OU Spirit wind farm for Oklahoma Gas & Electric (OG&E).

In February 2010, Tetra Tech received a $40 million engineering, procurement, construction (EPC) contract from Competitive Power Ventures (CPV) for the 152 MW second phase of the OU Spirit project, known as Keenan II. CPV was the originally developer of OU Spirit, having sold the project to OG&E in July 2008.

Tetra Tech is organized along the following four business lines, bringing skills from each line to bear upon its wind business: Environmental Consulting Services (ECS); the traditional environmental consulting and engineering business; Technical Support Services (TSS), which provides study, design, and implementation services for U.S. federal, international development, and other programs; Engineering and Architecture Services (EAS), which serves the buildings, transportation, land development, and water markets; and Remediation and Construction Management (RCM), which provides EPC, program management, construction management, and operations and maintenance (O&M) services for environmental remediation, wetland restoration, and energy development projects, including wind, solar, and nuclear.

The firm entered the wind energy business in 2004 through the provision of front-end services, drawing heavily on the skills in its ECS business. In April 2007, Tetra Tech acquired The Delaney Group to boost its EPC capabilities, particularly in the wind power market. Today, most of Tetra Tech's wind-related revenue is reported as coming from the RCM business segment.

Tetra Tech says that state regulations will have a role in determining how utilities will participate in the renewables market. Utilities along the east and west coasts tend to serve deregulated markets in which they are prohibited from owning the generation capacity. By comparison, utilities in the Midwest and South can own their own generation, "so companies like NStar and National Grid in the northeastern U.S. will be striking PPAs with developers, but elsewhere the OG&Es will be developing their own power." As a turnkey service provider, MacKay sees his firm's competition breaking down into two areas. "We bump into the typical environmental firms on the front end." None of those entities jumps over into back-end construction with companies like Blattner and Mortensen. "On the front end, we see local and regional players, no question. Sometimes they have strong relationships with local developers. We run our practice as a national practice, so for our bigger clients, we can go where they go."

The company points to the renewable portfolio standards (RPSs) at the state level as having been and continuing to be the fundamental drivers for the wind energy business. "A number of states have RPSs that call for a certain percentage of electric power to come from renewables, and wind is the biggest part of that percentage. It varies by state, and some states are on target while others are behind, but no question, that's the driver."

## 6.4. Small Wind on the Rise in Homes, Farms and Retail

The solar energy industry has already had great success with PV solar panels marketed to individuals for use in homes and small buildings. Similar products have sprung up in the wind energy industry over the past several years. Companies such as Helix Wind (California), Aerovironment (California) and Earth Turbines (Vermont) have developed innovative and aesthetically pleasing designs for small wind turbines that are marketed for installation in homes, farms, small businesses, factories, and schools. While the design and effectiveness of these turbines have made them a more attractive option for small-scale use, several factors are limiting the possibilities for this renewable energy source.

Incentives aside, residential wind energy systems on average cost $4-6 less per watt of capacity than similar solar PV systems. According to the American Wind Energy Assn. (AWEA), a drop in wind turbine sales in 2005 was the result of a decrease in California state incentives for small wind systems in 2004. While small wind turbine sales in the U.S. grew 14% in 2006-2007, the drop in sales in 2005 was proof of the importance of state incentives to the growth of the small wind turbine industry. While some states do offer incentives for small wind systems, such as net metering, buydowns and grants, consistent federal incentives are required for stonger growth. Companies say that a major limiting factor to the increase in small wind turbine sales is the lack of federal Investment Tax Credits (ITCs) for small wind systems. The introduction of a 30% federal Investment Tax Credit for solar photovoltaic systems in 2005 has led to 40-55% annual solar growth. A 30% federal ITC for small wind systems would lower the initial cost of small wind turbines and most likely result in a similar increase in sales for the industry.

The installation of small wind turbines in urban environments is further limited by varying zoning and permit laws which enforce height restrictions and encumbrances, in some cases, require a case-by-case hearing before approving the installation of a small wind turbine. By 2009, the Small Wind Certification Council will begin certifying small wind systems to AWEA standards. (The United Kingdom has already set up similar standards and Canada is planning to follow suit.) The North American Board of Certified Energy Practitioners is also pursuing a training and certification program. These steps will hopefully help alleviate the restrictions and encumbrance of zoning and permit limitations.

While these factors have dampened the potential for growth in the small wind industry in the United States, annual growth continues to move the industry forward. Increased public awareness of climate change and the demand for renewable energy have boosted inquires and sales of small wind systems to a larger variety of consumers; new technology has contributed to more efficient, affordable and aesthetically attractive designs for these consumers. Small wind turbines increasingly boast smaller size, less noise, and increased productivity that can cut energy bills.

The US market for small wind turbines – those with capacities of 100 kW and under – grew 78% in 2008 with an additional 17.3 MW of installed capacity, according to a report by AWEA. This growth is largely attributable to increased private equity investment that allowed manufacturing volumes to increase, particularly for the commercial segment of the market (systems 21-100kW). The still-largest segment of the market, residential (1-10kW), was likewise driven by investment and manufacturing economies of scale, but also by rising residential electricity prices and a heightened public awareness of the technology and its attributes.

**Figure 101 Growth of U.S. Small Wind Market**

| Year | Units | kW | Sales $mil |
|---|---|---|---|
| 2001 | 2,100 | 2,100 | |
| 2002 | 3,100 | 3,100 | |
| 2003 | 3,200 | 3,200 | |
| 2004 | 4,671 | 4,878 | $15 |
| 2005 | 4,324 | 3,285 | $10 |
| 2006 | 8,329 | 8,565 | $33 |
| 2007 | 9,092 | 9,737 | $42 |

*Source: AWEA Small Wind Turbine Global Market Study 2008*

The industry projects 30-fold growth within as little as five years, despite a global recession, for a cumulative US installed capacity of 1,700 MW by the end of 2013. Much of this estimated growth will be spurred by the new eight-year 30% federal Investment Tax Credit passed by Congress in October 2008 and augmented in February 2009. The market has become dominated by grid-connected units and will likely continue in this trend as these larger systems become more affordable.

The U.S. continues to command roughly half the global market share and is home to one-third of the 219 identified worldwide manufacturers. Small wind is still in a race with the solar photovoltaic industry toward "grid parity" – price per kilowatthour on par with conventional forms of electricity – and now both industries enjoy nearly identical federal incentives for a more level playing field.

**Other Statistics**

• 80 MW of cumulative installed small-wind capacity in the US.

• U.S. manufacturers' sales account for half the global market.

• $160 million in outside investment was injected into 18 manufacturers worldwide over the past three years.

• At least 219 companies worldwide manufacture small wind systems, 35% of which are based in the U.S.

• Industry predicts a cumulative U.S. capacity of 1,700 MW within five years.

• 2008 U.S. Sales, 17.3 MW, 78% growth over 2007, 10,500 units, $77 million in sales

• 2008 Global Sales, 38.7 MW, 53% growth over 2007, 19,000 units, $156 million in sales

*Source: AWEA Small Wind Turbine Global Market Study*

### 6.4.1. Profile: Helix Wind

Helix Wind, a small wind company located in San Diego, Calif., began marketing their small wind turbine for residential and commercial installation in 2007. Their products, 2kW and 4kW VAWT designs, stand up to 35 feet tall and provide a striking aesthetic. Unlike traditional turbine propellers, Helix Wind's rotors look more like two intertwined seashells. The helical blades work by catching wind from any direction in speeds as low as 10mph; the turbine generator then provides electricity to the home or commercial building it is connected to. Depending on local utility net metering policies, excess electricity may cause the meter to spin backwards.

Ian Gardner, CEO of Helix Wind, expressed an optimistic outlook on the future of the small wind industry. According to Gardner, providing 20% of the United State's electricity from wind power by 2030 is a realistic goal, although there are obstacles to reaching it: "standardization of permitting requirements, federal incentives and the derailing of offshore petroleum exploration" are factors that must be in place for the wind industry to succeed to such a level by 2030.

**Figure 102 U.S. Small Wind Market (2007)**

| | Units | kW | Sales ($) |
|---|---|---|---|
| U.S. Manufacturers | 8,905 | 8,661 | 37,895,000 |
| Foreign Manufacturers | 187 | 1,076 | 4,073,000 |

*Source: AWEA Small Wind Turbine Global Market Study 2008*

Other challenges the company faces in expanding its business are "rising costs of raw materials, the unpredictable legal environment in the U.S. and the lengthy certification requirements to qualify for rebates and financial incentives." However, the biggest challenge the company faces in growing its business is "keeping up." It seems that the many obstacles to success for Helix Wind and the small wind industry in general are not too great a deterrent for homeowners and businesses seeking to cut back on energy bills and reduce the impact on the earth. Local financial incentives, partnered with rising awareness of climate change and clean energy, are the most powerful assets to growing the small wind turbine market.

Helix Wind's first commercial application of a 2kW Helix Wind generation system is in place at a Helix Wind development project in Barrio Logan, CA. The 2kW system is installed on the roof of the building and partially offsets the electricity consumption. With the launch of its product this year and distributors in all major geographic markets worldwide, Ian Gardner has reason to be optimistic.

### 6.4.2. Profile: AeroVironment

AeroVironment is an aeronautical engineering and environmental company which produces clean energy systems. The company started 30 years ago specializing in wind mapping and air pollution monitoring, evolving to engineer groundbreaking systems such as Helios, a solar powered unmanned aircraft built for NASA in 2001. After investigating small wind turbines and conducting wind-tunnel testing on rooftops, different rooftop wind patterns emerged: an accelerated wind zone, and no-wind zone, and a turbulent wind zone.

AV's architectural wind turbines take advantage of the accelerated wind zone with a parapet-mounted design that faces into the streamlined wind. The newest turbines have 5 blades and are 1000 W. The turbines themselves are visually interesting; metallic blades spinning captivatingly with screens in front (to protect birds) and optional canopies for further aesthetic integration with the building. Each installation involves a minimum of 10 turbines, lined up in a row and visible to onlookers.

Installations of AV's wind turbines began about 2 years ago and are located across the US, with a couple of overseas installations in the UK. The company's website (www.avinc.com/wind) currently shows 10 of their installations with notable sites at the AZ State University Institute of Sustainability, the Kettle Foods Factory (LEED Gold Certification) in Beloit, Wisc., and the newest installation at the Brooklyn Navy Yard.

Presently, AV is not offering residential installations, choosing to focus on governmental and commercial buildings with the proper architectural elements to maximize the turbines' efficiency. According to Paul Glenney, AV's Director of Clean Energy Technology Center, the company "can only accept about 1 in 20 sites interested in installation." Before installation AV also scrutinizes local wind maps, the building and its surroundings for possible obstructions to determine which side of the building will produce the most wind power. The company also offers 5-year warranties on their turbines, which have an expected lifespan of 20 years.

Despite AV's booming business (the company has several more installations planned for the end of summer 2008), Glenney expressed familiar frustrations with the obstacles that it seems all companies in the small wind industry are facing: the lack of a federal incentive and permit hurdles. "You might have to go through separate planning, zoning, and historical committees before being approved for installation." AeroVironment, along with other wind companies from the AWEA, is advocating for a 30% federal Investment Tax Credit with the hopes of securing an incentive in the future.

**Figure 103 Small Wind Turbine Equipment Providers Listed bt AWEA**

| Manufacturer | Models (Rated Capacity) |
|---|---|
| Abundant Renewable Energy | ARE110 (2.5KW), ARE442 (10KW) |
| AeroVironment | AVX-1000 (1kW system) |
| Bergey Windpower Co. | BWC XL.1 (1 kW), BWC EXCEL (10 kW) |
| Energy Maintenance Service | E15 (35 kW or 65 kW) |
| Entegrity Wind Systems | EW15 (50 kW) |
| Gaia-Wind Ltd | 11kW |

| | |
|---|---|
| Northern Power | NPS 100 (100 kW) |
| Proven Energy, Ltd. | 2.5 (2.5kW), Proven 6 (6kW), Proven 15 (15kW) |
| Southwest Windpower Co. | AIRX (400 W), Whisper 100, (900 W), Whisper 200 (1 kW), Whisper 500 (3 kW), Skystream 3.7(1.8 KW) |
| Wind Energy Solutions Canada | WES 5 Tulipo - (5 Metre Rotor Dia. - 2.5 kW), WES 18 - (18 Metre Rotor Dia. - 80 kW), WES 30 - (30 Metre Rotor Dia. - 250 kW) |
| Wind Turbine Industries Corp. | 23-10 Jacobs (10 kW), 31-20 Jacobs (20 kW) |

*Source: AWEA*

## 6.5. CCBJ's Wind Energy Market Survey 2010

This section presents results of CCBJ's survey of 30+ wind energy executives, NGOs, utilities, IPPs and investors performed in May 2010.

First in the context of the clean energy industry, executives believe wind energy is second to only energy efficiency in the sectors relating to their contribution to reducing global carbon emissions to 2050.

**Figure 104 Significance to reducing global carbon emissions**

Please rate the following in terms of its significance to reducing global carbon emissions to 2050: Please pick the option "Most Important" only once. However, you may pick multiple responses to "Very Important", "Important", "Not Very Important" and "Meaningless".

| | Most important (pick 1) | Very important | Important | Not very important | Meaningless |
|---|---|---|---|---|---|
| Energy efficiency | 31% | 50% | 13% | 0% | 6% |
| Wind energy | 13% | 50% | 25% | 13% | 0% |
| Nuclear power | 19% | 31% | 31% | 13% | 6% |
| Alternative vehicles (hybrid, electric, plug-in) | 13% | 38% | 38% | 6% | 6% |
| Energy storage and demand response | 19% | 25% | 38% | 13% | 6% |
| Conservation | 6% | 38% | 50% | 6% | 0% |
| Public transportation | 0% | 38% | 56% | 6% | 0% |
| Solar energy | 0% | 50% | 31% | 13% | 6% |
| Hydroeletricity | 0% | 33% | 53% | 7% | 7% |
| Green buildings | 0% | 31% | 56% | 6% | 6% |
| Geothermal energy | 0% | 0% | 81% | 19% | 0% |
| Biofuels for transportation | 13% | 6% | 44% | 19% | 19% |
| Carbon capture and storage | 0% | 31% | 38% | 13% | 19% |
| Bioenergy for electricity | 0% | 13% | 47% | 33% | 7% |
| Wave and tidal energy | 0% | 6% | 44% | 44% | 6% |
| Vegetarianism | 0% | 6% | 19% | 50% | 25% |

*Source: CCBJ's Wind Energy Market Survey 2010.*

## Figure 105 Barriers to growth in North American wind power in 2010

Rate the following barriers to growth in North American wind power in 2010: Please pick the option "Most Important" only once. However, you may pick multiple responses to "Very Important", "Important", "Not Very Important" and "Meaningless".

| | Most important (pick 1) | Very important | Important | Not very important | Meaningless |
|---|---|---|---|---|---|
| Inconsistency of government support | 24% | 41% | 24% | 12% | 0% |
| Regulatory uncertainty | 24% | 29% | 35% | 12% | 0% |
| Lack of access to capital | 13% | 56% | 25% | 6% | 0% |
| Rising manufacturing costs | 18% | 0% | 71% | 6% | 6% |
| Transportation costs | 12% | 6% | 35% | 35% | 12% |
| Lack of qualified personnel | 0% | 24% | 41% | 24% | 12% |
| Lack of capacity (supply cannot meet demand) | 6% | 0% | 47% | 24% | 24% |
| Lack of components supply | 0% | 6% | 35% | 41% | 18% |

*Source: CCBJ's Wind Energy Market Survey 2010*

## Figure 106 Ranking importance of market drivers in wind energy

| | Most important (pick 1) | Very important | Important | Not very important | Meaningless |
|---|---|---|---|---|---|
| Government subsidies/financial incentives | 40% | 40% | 20% | 0% | 0% |
| RPS, RES or specific government renewable energy requirements (e.g. % by 2020) | 28% | 48% | 17% | 3% | 3% |
| More available financing | 11% | 68% | 11% | 11% | 0% |
| Rising cost of oil and conventional power | 14% | 41% | 34% | 7% | 3% |
| More favorable regulatory environment for siting | 3% | 41% | 52% | 3% | 0% |
| Specific policies to limit or affix a price on carbon | 10% | 31% | 38% | 21% | 0% |
| Energy security | 3% | 38% | 38% | 21% | 0% |
| Stimulus spending in government (ARRA in the USA) | 3% | 31% | 48% | 14% | 3% |
| Climate change concerns | 4% | 29% | 50% | 14% | 4% |
| Capital flowing into ‘cleantech’ | 3% | 38% | 38% | 14% | 7% |
| Public demand for green power | 0% | 32% | 43% | 21% | 4% |
| Advent of interest in offshore wind energy | 7% | 23% | 43% | 17% | 10% |
| Accumulated critical mass of knowledge on wind power | 3% | 21% | 55% | 14% | 7% |
| Political statements of long-term wind energy goals | 3% | 33% | 17% | 40% | 7% |
| Expansion of wind energy to new regions | 3% | 24% | 34% | 31% | 7% |

*Source: CCBJ's Wind Energy Market Survey 2010*

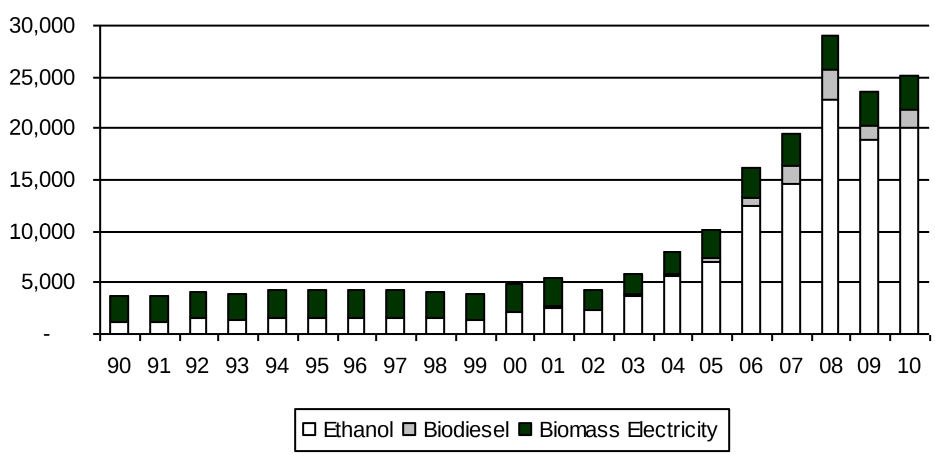
# 7. Biomass Energy

From the tallest California redwood to the tiniest alga, plants are the carbohydrate factories that make life possible for humans and other animate creatures. The increasing sophistication with which humans have harvested, managed, manipulated and processed plants has been a singular factor in our cultural evolution. As that evolution has brought us to the stage where we confront a global warming crisis of our own making, we've identified plants, collectively known as biomass, as a potential alternative energy source that will help us mitigate climate change. The thinking goes that by burning less ancient biomass—converted by time and pressure into fossil fuels—and more contemporary biomass and biofuels, we can slow the rate at which we release geologically stored carbon. At the same time, we'll improve the carbon balance, as next season's energy crops absorb the carbon dioxide emitted in the burning of this season's gasoline and power plant fuels.

This climate-healing logic, along with the equally compelling imperative to find alternatives to increasingly expensive fossil fuels, has led to policy requirements and incentives in the developed world to increase the amount of biofuels used in transport fuels and the volume of biomass consumed for heat and electricity.

EBI counts biofuels as part of the bioenergy industry but in the context of the clean energy industry biofuels is counted in the transportation segment. The biomass energy industry as presented here is the value of power generated by wood and wood-derived fuels, municipal solid waste (MSW), landfill gas and  other biomass.

**Figure 107 U.S. Bioenergy Industry, 1990-2010 ($Mil)**




*Source: EBI Inc. derived from a variety of sources of data on gallons produced and annual average 'rack' wholesale prices for ethanol (lower section) and biodiesel (middle section), and net biopower electricity generated and average annual consumer price/kWh of electricity.*

All told EBI counts the bioenergy industry at about $30 billion in 2010 with the three segments shown above. This section takes a comprehensive look at just the biopower segment (biofuels excluded). Biomass electricity generated power with a value of $3-3.5 billion in 2006-2010 (using wholesale value of electricity), with about 44% in the electric power industry and the majority generated on-site by industry.

In the biopower sector, companies in biomass gasification, anaerobic digestion, landfill-gas-to-energy and conventional combustion are seeking to tool up their technology, build more power plants and put more bioenergy on the market.

The inclusion of specialty consulting, engineering and design services puts the global biomass energy industry at $31 billion in 2009, equipment excluded. Equipment for bimass electricity is generally not specialized combustion equipment.

**Figure 108 Global Biomass Energy Industry**

| | 2007 | 2008 | 2009 | 2008 Growth | 2009 Growth |
|---|---|---|---|---|---|
| Biomass Electricity | 28.43 | 29.44 | 30.18 | 4% | 3% |
| Specialty Services: Biomass: Wood & Waste | 0.40 | 0.41 | 0.44 | 2% | 6% |
| Specialty Services: Landfill Gas | 0.59 | 0.49 | 0.57 | -17% | 15% |
| **Total Biomass Industry** | 29.43 | 30.34 | 31.18 | 3% | 3% |

*Source: EBI Inc. estimates derived from a variety of sources*

**Figure 109 U.S. Biomass Energy Industry**

| | 2007 | 2008 | 2009 | 2008 Growth | 2009 Growth |
|---|---|---|---|---|---|
| Biomass Electricity | 4.83 | 5.00 | 5.13 | 4% | 3% |
| Specialty Services: Biomass: Wood & Waste | 0.09 | 0.09 | 0.09 | -2% | 2% |
| Specialty Services: Landfill Gas | 0.13 | 0.11 | 0.12 | -20% | 11% |
| **Total Biomass Industry** | 5.06 | 5.20 | 5.34 | 3% | 3% |

*Source: EBI Inc. estimates derived from a variety of sources*

**Figure 110 California Biomass Energy Industry**

| | 2007 | 2008 | 2009 | 2008 Growth | 2009 Growth |
|---|---|---|---|---|---|
| Biomass Electricity | 0.51 | 0.57 | 0.61 | 11% | 7% |
| Specialty Services: Biomass: Wood & Waste | 0.01 | 0.01 | 0.01 | 6% | 6% |
| Specialty Services: Landfill Gas | 0.01 | 0.01 | 0.01 | -20% | 11% |
| **Total Biomass Industry** | 0.53 | 0.59 | 0.63 | 11% | 7% |

*Source: EBI Inc. estimates derived from a variety of sources*

**Figure 111 U.S. Biomass Energy Industry as a Percentage of Global Total**

| | 2007 | 2008 | 2009 |
|---|---|---|---|
| Biomass Electricity | 17% | 17% | 17% |
| Specialty Services: Biomass: Wood & Waste | 23% | 22% | 21% |
| Specialty Services: Landfill Gas | 23% | 22% | 21% |
| **Total Biomass Industry** | 17% | 17% | 17% |

*Source: EBI Inc. estimates derived from a variety of sources*

**Figure 112 California Biomass Energy Industry as a Percentage of U.S. Total**

| | 2007 | 2008 | 2009 |
|---|---|---|---|
| Biomass Electricity | 11% | 11% | 12% |
| Specialty Services: Biomass: Wood & Waste | 11% | 11% | 12% |
| Specialty Services: Landfill Gas | 10% | 10% | 10% |
| **Total Biomass Industry** | 11% | 11% | 12% |

*Source: EBI Inc. estimates derived from a variety of sources*

**Figure 113 U.S. and California Biomass Energy Industry: Employment**

| | USA $bil in 2009 | USA 2009 Jobs | Calif. $bil in 2009 | Calif. 2009 Jobs | % of USA Jobs in Calif. |
|---|---|---|---|---|---|
| Biomass Electricity | 5.13 | 12,800 | 0.61 | 1,520 | 11.8% |
| Specialty Services: Biomass: Wood & Waste | 0.09 | 800 | 0.01 | 110 | 14.2% |
| Specialty Services: Landfill Gas | 0.12 | 1,000 | 0.01 | 120 | 12.2% |
| **Total Biomass Industry** | 5.34 | 14,600 | 0.63 | 1,750 | 12.0% |

*Source: EBI Inc. estimates derived from a variety of sources*

## 7.1. Biomass Electric Power

Whether the feedstock is wood waste and residues or methane from landfill gas and other sources of decomposing organic matter, the practice of generating energy from biomass is fairly well established, if not yet widespread. With mounting awareness of climate change, looming renewable portfolio standard deadlines, and growing opposition to new coal-fired power, major electric utilities and specialized entrepreneurial firms are striving to make the case for biomass-fired power in tandem with solar, wind, and other renewables. According to U.S. Department of Energy, net electricity generation from biomass was 55 million megawatt-hours (MWh) in 2006, or 1.3% out of 4.06 billion MWh net electricity generation in total in the United States in 2006. The 55 million MWh represents a commercial value of $4.9 billion when using the U.S. average retail price of 8.9 cents/kwh in 2006, although only 44% of this generation made it out into the commercial electric power sector with the majority consumed within the industrial sector.

Wood residues like chips and sawdust, discarded branches and treetops from timber operations and post-consumer wood debris constitute the dominant feedstock for combustion facilities, and wood is likely to remain dominant. One hears of the potential exploitation of switchgrass, animal waste, nutshells, rice hulls, watermelon rinds, kudzu, olive pits, and other types of organic matter, but these are never likely to be more than niche plays or supplemental feedstocks.

Turning to a different category of biomass power, the major solid waste management companies are aggressively building the capacity to turn their landfill gas (LFG) into energy. There's growing concern, however, that these operations still allow the release of substantial volumes of methane, a far more potent greenhouse gas than carbon dioxide ($CO_2$), and that organic wastes should be diverted from landfills to other beneficial uses, such as compost. Meanwhile, anaerobic digestion of the manure generated from livestock operations or the effluent at wastewater treatment plants represents another biomass power option, one that's well-established in Europe and just getting off the ground in North America. Delivering limited power given the inputs, however, anaerobic digestion is perhaps more a residuals management alternative than a significant future source of electric power.

In California Executive Order S-06-06, an Executive Order of the State of California adopted in April 2006 started promoting the use of bioenergy, and more recent work done by the California Energy Commission with Bioenergy Action Plans has stimulated market activity.

The 2011 Bioenergy Action Plan for California evaluates and considesr the following strategies to overcome the remaining challenges to meeting the Governor's targets for bioenergy in California:

- Address siting, permitting, and regulatory barriers to increased bioenergy and biofuels production.
- Facilitate the ability of project developers to obtain project financing and identify funding opportunities.
- Continue research and development of low-emission bioenergy technologies and develop policy mechanisms that accurately account for GHG benefits associated with each technology.
- Increase the availability of affordable biomass products collected through sustainable practices.
- Develop new and revised policies necessary for meeting bioenergy and biofuel goals.

### 7.1.1. Combustion

Although the LFG-to-energy and anaerobic digestion are likely to have their place, biomass power will probably be dominated by the generation of electricity from the combustion of organic materials and perhaps a couple of other emerging technologies. Renegy Holdings, Inc. (Belmont, Calif.), which focuses exclusively on biomass-fired electric power and recently started up its first facility in Arizona, characterized the U.S. biomass market as "highly fragmented" in a company overview prepared for investors. This universe consists of about 200 wood-burning power plants distributed among approximately 100 owners, Renegy said, and many of these plants are captive boilers at pulp & paper mills.

Renegy's numbers "sound about right," commented Robert Cleaves, president of the USA Biomass Power Alliance (Portland, Maine). Yet while Renegy described the industry as "ripe for a strategic roll-up," with the facilities in the struggling pulp & paper industry serving as prime targets for acquisition, Cleaves said that little consolidation has taken place thus far. "I think the sector is poised for growth, but it will be measured growth, dictated by the investor community, which will look at the [availability of] various feedstocks and the volatility of price." Those prices have been volatile lately, he remarked.

To facilitate whatever market growth may be possible, policy makers need to place biomass on the same level with other renewables, such as wind and solar, suggested Cleaves, whose organization is striving to level the playing field. The USA Biomass Power Alliance was formed nearly 10 years ago by a group of independent power producers (IPPs) "for a single purpose," said Cleaves—"to expand Section 45 of the Internal Revenue Code to qualify these facilities for the production tax credit [PTC]. We were successful in 2004, with the Jobs Act. Congress took another run at the PTC in 2005, as part of the energy bill. Since then, our facilities have been enjoying the value of the PTC, although the value is one-half that of other renewables like wind. So we're pursuing parity with those renewables."

Biomass power plants cost about $3,000 to $4,000 per kilowatt to build, Cleaves estimated. "I think these facilities are, in certain marketplaces, competitive with other forms of energy. But we do compete with wind, so we do need the value of the PTC." Biomass power is "kind of a sleeper sector of the renewables industry," he continued. "We're not perceived as sexy, like solar panels or wind turbines. We burn things, which people don't like, [even though] we have sophisticated pollution controls."

In addition to combustion technology, there's also some use of gasification and pyrolysis to convert biomass to gas and liquid fuels that can produce electricity more efficiently from the energy in biomass. In gasification, which is an old technology finding new applications, the volatile gases in the biomass are separated from the solid fuel without combustion. Biomass pyrolysis is a solid-to-liquid conversion technology similar to gasification, but instead of producing syngas, the volatile gases are condensed into a bio-oil. According to Mark Jenner, whose firm Biomass Rules, LLC (Greenville, Ill.) provides consulting services in the area of biomass economics, commercial biomass pyrolysis plants are only just now starting to be built.

"I'm not sure that anybody is doing gasification on a wide scale, and pyrolysis is new and untested," said USA Biomass's Cleaves. Anaerobic digestion is another option, but it's as much a residuals management strategy as a power production play. "On a per-ton basis, its energy yield is small. It takes perhaps 60,000 to 100,000 tons of material going into a digester to generate 2 MW of power. With that same amount of organic solid biofuel, you could generate 10 MW through a combustion system."

Cleaves and others in the industry point out that, while there are signs of growth in the use of biomass-fired power, driven to some extent by the establishment of renewable portfolio standards (RPSs) in California and other states, that growth will be limited by the availability of fuel feedstocks, which vary by geography. "The South has ample resources, where trees grow fast... a number of our members essentially generate their own waste—for example, sugar growers generating their own bagasse, or rice growers using rice hulls. For these members, it's a closed loop. Other members rely on outside producers, like the forest industry, using tree tops and limbs. In many parts of the country, the fuel is essentially a wood chip."

Mike Norris, a vice president and business manager in the Crow's Landing, Calif., office of Covanta Energy, agrees that the growth potential for biomass power is limited, chiefly by fuel availability. "In some small capacity, there will be growth; I don't think it will double." Covanta operates five plants using urban and agricultural wood waste, and has a 55% interest in another such facility (but does not operate it); all six are located in California.

These facilities are among the 30 or so survivors of the original 60 biomass plants built in the 1980s and early 1990s in California, as part of the Standard Offer programs for alternative energy development, according to Norris. When electricity prices subsequently dropped, many of these plants were idled or dismantled. A handful of the idled plants are being re-powered today, noted Norris, and a few are adding capacity, but because the timber industry in California is much smaller than it was a couple of decades ago, the available feedstock from forestry operations is much less—thus Covanta's reliance on urban and agricultural wood waste. The urban wood consists of city site clean ups and maintenance, construction and demolition (less treated lumber) and various other materials such as the trees that may have to be removed when a city crew restores a downed power line. "We use a lot more agricultural waste now than before," Norris noted. "We have lots of orchards in Central Valley with an average life of about 25 years." Covanta is looking at establishing biomass power operations in other regions of the country.

### 7.1.2. Profile: Renegy Holdings

One company that is looking to roll up some of this idled capacity, in California and elsewhere, is the aforementioned Renegy Holdings. The firm has a stated goal of building a portfolio of biomass power-generating assets providing 1,000 megawatts (MW) of baseload power and representing potentially $900 million in annual revenues and $300 million of EBITDA. In November 2007, the company acquired an idled 13 MW biomass plant in Susanville, Calif., and in April 2008 it signed letters of intent to acquire another two biomass plants in the northern part of the state—an idled 18 MW facility in Ione, and an operating 20 MW plant in Loyalton.

According to Megan Meloni, Renegy's director of investor relations, the Susanville facility exemplifies the available consolidation opportunity. It had been operated by a leading sawmill, which used wood waste to fire a boiler that powered the mill. "The sawmills and pulp & paper industry today are pretty much in trouble, and a lot are shutting down due to various challenges," said Meloni. The Susanville sawmill "was looking to divest some non-core assets, and we saw the opportunity to purchase the facility at a significant discount compared with new construction." Renegy hopes to restart the facility sometime in 2009.

The idled Ione plant could start up even earlier, towards the end of 2008 after a "modest amount of refurbishment." The Loyalton facility sells 10 MW of its output to Sierra Pacific Power under an existing power purchase agreement (PPA) and "we are, as part of our due diligence, looking at supplying the full 20 MW," Meloni said.

Renegy is currently operating a biomass-fired plant in Snowflake, Ariz., next to an operating paper mill that's supplying Renegy with unusable fibers and sludge as fuel. "This mill has been landfilling the fibers, which become too short to be recycled, and they've been landfilling the sludge for over ten years, paying a lot of money to do it. We can take all of those materials and throw them in our boiler." She added, "Certainly, as we grow our business, we'll be looking at similar opportunities for siting next to paper mills or other facilities that can provide sources of fuel, but those opportunities are few and far between."

It is the fuel constraints that have prompted Renegy to take a step that is not yet common in the biomass power business—establish its own fuel aggregation division. "By sourcing the fuel directly by ourselves, we're really able to hedge our fuel costs over the long term," said Meloni. "Others who buy their fuel at the gate, they are subject to the price fluctuations. We're cutting out that middleman."

Renegy's fuel aggregation business, based in Snowflake, has established timber salvage and forest thinning contracts with the U.S. Forest Service. It also has contracts with a few community greenwaste sites—that is, facilities where people drop off their yard waste—and with construction and demolition (C&D) debris operations. "We're also looking at agricultural waste, like orchard prunings, nut shells, and peach pits," said Meloni. "We're nailing down long-term supplies of fuel from a variety of sources so that we don't have all our eggs in one basket."

### 7.1.3. Profile: Decker

Securing adequate fuel supplies may be the top priority when developing a biomass power project, but it's not necessarily the first step in the process, according to Mike Whiting, president of Decker Energy International (Winter Park, Fla.). "You have to start off by finding a good electricity market to sell into. That's not everywhere." With a good market chosen and a good fuel supply in hand, "you then look for a specific site with good infrastructure—good roads to bring the fuels to the plant, and good electricity transmission... You also look for a good water supply to cool the plant. And then you need a town that is open to new industrial development, and that's not everywhere either."

Whiting pointed to the company's effort to develop a biomass power plant in Connecticut, where, he said, small groups of people can wield considerably more clout in the siting and permitting process than they can in some other states. Nineteen months passed from the time that Decker Energy filed the application for its permits to the time that the draft permits were issued—two to three times longer than the permitting process in other regions of the country.

"We try to present these projects as clean energy development, but somebody who's facing one of these projects near their back yard may present it as a pollution spewing project," Whiting acknowledged. "In reality, we have no problem at all in meeting our environmental standards."

Engaged exclusively in biomass power since the 1980s, Decker Energy currently owns two operating plants—one in Grayling, Michigan, and the other in Newbern, North Carolina—and is in the process of developing several more. "There are seven projects for which we have land options and have done significant development work, and then we have several that are more ideas or concepts at this stage," Whiting stated.

The North Carolina facility "has found it very easy to find feedstocks," he noted. The Southeast "is an abundant wood basket, and trees grow so well." The fuel accepted by the facility is fairly diverse—sawdust and bark from paper mills, tree tops and limbs from logging operations, railroad ties, and even the cleaner fraction of poultry litter absorbed in sawdust.

The Michigan plant also receives paper mill and sawmill residues and logging discards, as well as some urban wood waste. It also accepts some waste tires at the state's request, as part of a solution to a local disposal problem. For this, the facility had to conduct a special test burn.

The wood supplies in Michigan are usually adequate, "but every few years we'll have issues in the winter and early spring," noted Whiting. "There's a lot of snow, which can make it difficult to get into the woods, or sometimes it's simply too cold to operate, or it's too muddy to enter the forest. We respond by stocking up in the fall. The wood's very easy to come by in the summer and fall—at least until deer season."

As a dedicated biomass energy provider for two decades, Decker Energy has seen some ups and downs. "In the mid-1990s, oil and gas prices were so low, you couldn't justify doing anything with biomass, unless you had an existing plant with existing contracts," Whiting recalled. "Then the whole energy world turned around about five years ago. Biomass is now doing better than ever. Oil at $140 per barrel is very good news for biomass."

## 7.2. Landfill Gas

One of the virtues that proponents tout for biomass power is the productive use of organic materials that would otherwise generate methane through decomposition, whether in forests or in landfills (they also sometimes list compost piles, although composting advocates make a credible case for the processing and use of organic materials to replenish soils). Of course, there's already a considerable amount of organic waste now decomposing in solid waste landfills, so the major waste management companies like Waste Management and Allied Waste are aggressively pursuing the option of converting LFG to energy. According to data compiled by Biomass Rules, some 1,400 MW of electricity was being generated by landfill-gas power plants in the United States as of the beginning of 2008.

Allied Waste had 55 LFG-to-energy facilities in operation as of the second quarter of 2008, with another dozen or so in various stages of development, while Waste Management, at the end of 2007, had implemented 108 “beneficial use” LFG projects at its 277 active landfills. Waste Management commissioned seven LFG-to-energy projects in 2007, and another ten were scheduled for construction in 2008. Waste Management’s existing facilities generate more than 450 MW of electric power. Altogether, “we’re adding 60 projects from now to 2012, which will build out all of the Waste Management facilities that can support LFG to energy,” said spokeswoman Lynn Brown.

Where it isn’t feasible to convert the methane generated at its landfills to electricity, the company is looking at converting the gas to diesel fuel or to other products that can provide heat or power. In April, for example, Waste Management announced a joint venture with Linde North America to build what the partners are describing as the world’s largest facility for converting LFG to a liquefied natural gas vehicle fuel, at Waste Management’s Altamont Landfill near Livermore, Calif. Also, in August 2007, Waste Management announced the EcoLine project with the University of New Hampshire, under which gas from the company’s landfill in Rochester, New Hampshire, will be purified and then transported through a 13-mile pipeline to UNH’s Durham campus, where it will replace utility-supplied natural gas at the university’s cogeneration plant.

“The hope is to collect all the gas there is to collect from our landfills,” Brown declared. The company also plans to expand into “the third-party arena,” assisting municipalities that own their own landfills in their efforts realize the benefits of LFG to energy.

As Brown suggested, converting LFG to energy is not technically or economically feasible at every MSW landfill. To be sure, the methane being generated invites evaluation to determine the best possible use. “There’s a tremendous amount of energy in landfills, whether they’re expanding or closed,” noted BiomassRules’ Jenner. “It becomes a question of whether it makes economic sense to retrofit the landfill to get that energy out. One way is to convert the LFG to energy. An even cheaper way is to convert the gas to fuel. It’s easiest to sell the methane as a natural gas equivalent rather than convert it to electricity. If you can do that, it’s great.”

Waste Management’s UNH project is representative of an emerging trend, Jenner observed. A comparable project will be one announced in April by the city of Sioux Falls, S.D., which plans to invest $14.3 million in the construction of a 10-mile pipeline that will deliver methane from a local landfill to an ethanol production facility. The plant, said Jenner, is installing a biomass boiler that will burn the methane along with wood waste, with the latter supplementing the former. “There are other uses for landfill gas than producing electricity,” Jenner pointed out. “Using it as an industrial source for heat is becoming more popular. “

The larger question is how far LFG to energy can go, or even how far it ought to go. Few people dispute the virtue of doing something with the methane that’s already accumulating in existing landfills, but expanding landfills to make more methane would not be the wisest course, Jenner advised. In fact, there’s a growing cry, particularly among advocates of composting, urging the accelerated diversion of organic wastes from landfills in the first place. This movement notwithstanding, numerous LFG-to-energy projects are moving forward.

## 7.3. Anaerobic Digestion

Anaerobic digestion is emerging as an option for handling the organic fraction in municipal solid waste (MSW) and other organic wastes, and producing energy from the biogas generated is one of the benefits. In fact, North America is a bit behind the curve in the deployment of anaerobic digestion for this purpose. The technology has been deployed for at least 15 years in Europe, and the companies specializing in anaerobic digestion there have been exporting their technologies and experience to other continents as well.

Europe has historically had higher energy costs than the United States, so the biogas generated by anaerobic digestion has been regarded much more valuable than it has been in the United States up to now, said Keith Logan, vice president of sales and marketing for Schmack BioEnergy LLC (Cleveland, Oh.). “Biogas was not really an option here,” Logan remarked. “Coal was too inexpensive.”

According to Mark Hall, senior vice president at Environmental Power Corp. (Tarrytown, N.Y.), a total of about 120 anaerobic digesters, most of them small units, are currently in operation in the United States. This is quite a small number compared with the 3,700 units operating in Germany and the thousands more across Europe, he noted. “Europe is far ahead not only in deploying a wide array of technologies but also a wide range of unit sizes. They are also doing co-digestion, which involves treatment of a combination of waste streams such as manure from farms and biosolids from wastewater treatment and other sources of proteins and carbohydrates, which are raw food for the bacteria to produce a more methane-rich biogas.” According to AD-Nett, a central source of information about the European anaerobic digestion market, 11 European Union (EU) countries had a combined installed anaerobic digestion capacity of more than 573 MW in 2005, with Germany leading the way at about 250 MW.

Schmack BioEnergy, Environmental Power, and Canada Composting (Newmarket, Ontario) are among a mere handful of companies that are striving to deploy anaerobic digestion in North America. All three have gone the route of licensing technology that has been successful in Europe. Canada Composting and Schmack BioEnergy are targeting municipal wastewater and solid waste management operations, while Environmental Power, through its subsidiary Microgy, is pursuing the use of anaerobic digestion on a large scale to manage animal wastes at large confined animal feeding operations (CAFOs). All three companies also see the food processing industry as an important potential client base.

“My company has built the first two commercial-scale anaerobic digestion plants for food waste in North America,” declared Canada Composting President Kevin Matthews. The first of these, a co-generation facility in Newmarket, went into operation 2000, while the second, for the city of Toronto, started up in 2002. “When I started in this business back in 1990, I thought the world was going to go in this direction because everyone was talking about composting and diversion from landfills. Now it’s 2008, and this part of the world is just getting into it.”

Canada Composting’s technology is licensed from the German company BTA International, which has deployed the process at about 30 locations around the world in addition to the two Ontario facilities. All of these installations, except the one in Toronto, are producing electricity from the gas, and Toronto will eventually do so, according to Matthews.

The “claim to fame” of the technology, said Matthews, is a cleaning process called “hydropulping,” which “allows us to take the food waste streams with various levels of contamination—plastics, knives, forks, etc.—and clean them up for digestion.” For yard waste, he explained, aerobic technology “is fine—there’s nothing better. But with food waste, you have the water content and the contamination, and you have to apply some other processes—for odor control, for example—and that gets quite expensive.”

The environmental consulting firm Brown and Caldwell is working with Canada Composting in California, on a project for Norcal Waste Systems and its subsidiaries, San Francisco's MSW management services provider, to implement anaerobic digestion at Norcal's composting facilities. In addition, the water/wastewater engineering firm Metcalf & Eddy is collaborating with the company in the development of applications for the wastewater treatment industry. Even with companies bearing stellar reputations such as these on its side, however, Matthews acknowledged that anaerobic digestion faces an uphill struggle towards market acceptance. Landfilling remains a very inexpensive option for disposing of organics, and the waste management industry isn't jumping on the bandwagon. Municipal officials that want to do the right thing and pursue more sustainable approaches to waste management are caught in the middle. "Landfills yield 50% margins," noted Matthews. "Why go with a system that yields 20% margins? When the municipalities say to their contractors, do this or we'll go elsewhere, then they'll move."

Licensing a technology developed by Germany's Schmack BioGas AG, Schmack BioEnergy started up an anaerobic digestion facility last December for the city of Akron, Ohio. The system is designed to handle 5,000 dry tons per year of biosolids from wastewater treatment while powering a 335 kilowatt (kW) gas engine generator set.

"Right now, it's very expensive for municipalities to manage their biosolids disposal costs," Schmack's Logan explained. "The typical method today is incineration, which is difficult in terms of getting air permits." Landfilling and land application are possible alternatives, of course, although land application has been controversial in light of the alleged potential for pollution by inadequately treated biosolids and in light of the very real problem of odors, noted Logan. Anaerobic digestion, he argued, offers a way to avoid these problems while generating energy for the municipality and saving money.

For municipalities, Schmack's business plan involves building, owning, and operating the digestion systems. For food manufacturers, the company would build and operate the systems but not own them. Logan said that the food processing industry represents a promising market segment because the organics in their wastewater can reach concentrations sufficient to create a value stream if a biogas-producing system is installed.

"We see lots of opportunities, but we have to find the ones that are economically viable," said Logan. "That's the challenge at this stage." He added confidently, however, that "the available market to penetrate in the U.S. is enormous."

### 7.3.1. Farm Waste

Perhaps the largest opportunity for anaerobic digestion is on the farm. In the United States, there are at least 7,000 farms with over 500 cows or 2,000 swine, and these operations produce a lot of waste that is typically stored in lagoons, producing foul odors and potentially contaminating nearby waterways should those lagoons fail—which they've been known to do.

This is the primary market targeted by Environmental Power's Microgy unit through the deployment of a Danish anaerobic digestion technology. "Our business model is to build the largest-scale energy production facilities that we can using anaerobic digestion," reported Mark Hall, who added that the size and complexity of these operations requires that Microgy, and not the farm, own and operate them. The first three Microgy facilities started up operations in 2004 in Wisconsin, each on farms with about 1,000 head of cattle. "That's the smallest that we can do with our technology," Hall claimed. He stressed, however, that there is significant opportunity to implement anaerobic digestion on a smaller scale. "I'm bullish on making smaller anaerobic digestion projects work, in the 100- to 500-head range." He suggested that, through the acquisition or development of other anaerobic digestion technologies, Microgy would be very much in that game.

The company's largest project—and the largest of its kind in North America, according to Hall—is the Huckabay Ridge facility in Texas, which started up in January 2008. The facility receives the manure from about 10,000 head of cattle from multiple dairies and produces about 635,000 million British thermal units (MMBTUs) of energy value per year for delivery back into the grid. "We're cleaning up our gas to utility-quality standards and delivering it to the utility's customers. We're selling the gas to the Lower Colorado River Authority under an 18-month agreement to get up and running, and then we'll be selling it to Pacific Gas & Electric under a 10-year contract. They will use the gas in their power plants, because when they convert our biogas to electricity, they will earn a renewable energy credit."

Microgy will soon commence construction of two other facilities in Texas of approximately the same size, and then three more are in the pipeline for California. All of these, like the Huckabay Ridge facility, will serve multiple dairies. Microgy is also constructing a facility at the JBS Swift meat-packing plant in Grand Island, Nebraska, a large plant that processes up to 6,000 head per day. At the JBS Swift facility, two anaerobic digesters will generate up to 235,000 MMBTUs of biogas per year from manure and "paunch," which is the contents of a cow's stomach in various stages of digestion.

Environmental Power, a public company whose stock is traded on the Nasdaq exchange, is not profitable yet, Hall confided. "We'll cross over to break-even sometime in the first or second quarter of 2009 if we stay on target. Our guidance is $40 million in revenues by the end of the second quarter of next year."

Anaerobic digestion would benefit from the kind of federal incentives that currently go to other forms of renewable energy, according to Schmack BioEnergy's Logan. "I think it's important for the federal government to get behind biogas development the way they have for solar and wind. There's been some work on that, but we're not there yet. With the right incentives in place, we can provide some efficient use for the biogas waste stream."

Environmental Power's Hall agreed, adding that the lack of parity in incentives for renewables development compounds the challenges. "We're in the same competitive space for construction resources, equipment, raw materials, and labor as the companies that construct facilities that look similar from the outside, like the biodiesel plants. Those facilities are heavily subsidized, and we're not, so there's a preference [for investors] to go to those guys, which makes it more challenging for us to obtain financing. We think that it would be extremely helpful for our industry to be at least treated the same as other renewable resources, and have our non-fossil, very flexible, renewable output get the same incentives."

He concluded that his company's real competition is not other providers of anaerobic digestion technology, but rather alternative approaches for generating credits for the carbon markets. The competition consists of those entities that "want to cover a lagoon to capture the methane and flare it and take advantage of the voluntary market. Those are low-tech, low-cost solutions, prices of carbon offsets are high, and methane offsets are high quality, so there's lots of interest in that option right now." Over the long run, however, "as these digesters come along, you'll see more of these lagoons joined together and more capture and use of the energy value."

### 7.3.2. Biomass Power In Europe and Asia

Outside of the United States, biomass-fueled electricity generation has emerged as a leading option in efforts to increase the percentage of renewables in the electric power mix of energy-intensive economies. In Europe, for example, biomass power is well-established and poised for additional growth, while Southeast Asia, and in particular China, where about 50 new biomass-fired power plants are in the works.

In Europe, biomass power "is enormously popular, and the projects are much larger," noted Robert Cleaves, president of the USA Biomass Power Alliance. "The largest grid-connected biomass-fired plant in the United States is 50 to 60 MW, and in Europe, they are twice that size."

A study released in June 2008 by the market research firm Frost & Sullivan (London, U.K.) found that biomass power constitutes approximately two-thirds of the renewable energy development taking place in Europe's rapidly growing renewable energy market. According to Frost & Sullivan, biomass power meets about 5% of all non-transport energy needs across Europe, and in countries such as Finland, Sweden, and Austria, that figure is as much as 15 to 20%.

"Soaring oil prices, combined with the lack of secure supplies of oil and natural gas, have heightened the benefit of producing power locally," the research firm said in announcing the study. In response to these drivers, biomass power is poised for continued solid growth, taking its place with wind and solar power development.

Growth in biomass power development does face some obstacles in Europe. Facility development entails high capital costs, although some countries offset these costs with various forms of incentives. Fuel quality is also an issue, as fuels are bulky and have a high moisture content owing to Europe's relatively wet climate.

Another problem is one of perception, said Frost & Sullivan. Biomass "is still referred to as a 'fuel of the past,' owing to its historically low efficiency and high emissions." Developers have the opportunity to dispel this view by properly installing clean-burning combustion units that meet current emission standards, particularly those for particulate matter.

**Figure 114 Sample Carbon-Offset Biomass Projects In Asia**

| Project/developer | Country | Feedstock |
|---|---|---|
| Rural biogas plants, Action Carbone | China | Animal/human manure |
| Malavalli Biomass Power Plant | India | Agricultural waste |
| Decentralized Energy Systems Pvt Ltd. | India | Ag waste/cultivated biomass |
| Shalivahana Projects Ltd. | India | Rice husks, sawdust, other |
| Rural farm projects, CO2logic | India | Agricultural waste |
| Indur Green Power Pvt. Ltd. | India | Agricultural waste |
| Triveni Engineering & Industries Ltd. | India | Agricultural waste |
| Lahari Power & Steels Ltd. | India | Surplus biomass residues |
| Sri Balaji Biomass Power Pvt. Ltd. | India | Agricultural waste |
| Alkyl Amines Chemicals Ltd. | India | Bagasse |
| SKG Sangha (anaerobic digestion) | India | Kitchen waste/animal manure |
| Biogas Sector Partnership-Nepal | Nepal | Food waste/animal manure |
| Chumporn Palm Oil Industry | Thailand | Biogas from sewage |
| General Starch Co. Ltd. | Thailand | Biogas from sewage |

*Source: www.carboncatalog.org*

In Asia, biomass is taking a respectable place among the projects that are generating carbon credits under the Kyoto Protocol's Clean Development Mechanism (CDM). Many of these are under development in India, as portrayed on the table. Of these, one of the more ambitious projects is the 100 Village Program, supported by the Belgian carbon offset project developer CO2logic. Under this program CO2logic is helping to develop about 100 biomass-fired power plants, each with a capacity of about 100 kilowatts (kW), in Araria, Bihar, Gaiyari, and numerous other locations.

China may be prepared to take the lead in Asia's biomass power market through a plan by Wuhan Kaidi Electric Power Engineering Co., Ltd. to build 50 biomass-fired facilities over the next two-and-a-half years. The plants, which will use wood trimmings, rice husks, straw, and animal manure for fuel, will be built in the Hubei, Hunan, Anhui, Fujian, Jiangsu, Jiangxi, and Shanxi regions, with the coal-rich Shanxi province hosting 14 of these facilities alone.

Each of these power plants will feature two 12-MW power blocks that will generate a total of 7.2 billion kilowatt-hours (kWh) of electric power per year—enough to support an average of 70,000 families in China, according GE Energy, which is providing the distributed control systems for the 50 facilities. The first of the facilities was scheduled to be operational in August 2008.

## 7.4. A Word on Biofuels

The European Union has led the world in biofuels mandates, enacting in 2003 a directive to boost biofuels to 5.75% of transport fuels by 2010, later amending the directive to include a 10%-by-2020 goal. The United States followed suit, passing increasingly ambitious biofuels mandates culminating in 2007 legislation that set a 7.8%—or 9 billion gallons—renewable fuel standard for 2008, followed by progressive increases to 36 billion gallons by 2022. Other developed nations are either considering or have already enacted biofuels mandates as part of their strategies to mitigate climate change and reduce petroleum dependence. Many developing nations are also initiating mandates but with more focus on their own indigenous biofuels industries.

E.U. nations and the U.S. federal and state governments have also enacted subsidies, the richest of which are the U.S. $0.51 per gallon ethanol tax credit and $1 per gallon biodiesel tax credit. With growing demand and favorable subsidies, investment capital has surged into the E.U. and U.S. biofuels sectors. Brazilian ethanol, meanwhile, has grown without direct subsidies due to government policies encouraging flex-fuel vehicles that can run on up to 100% ethanol, as well as the superior performance of sugarcane as an ethanol feedstock. Led by the United States, Brazil and the European Union, worldwide biofuels production tripled from 2000 to 2007 reaching 15.2 billion gallons of ethanol and 2.6 billion gallons of biodiesel in 2007, a $43 billion industry according to EBI research. Interim figures for 2008 point to production increases in biodiesel, a leveling in ethanol output, but average annual price increase of 15-20% for ethanol and 20-25% for biodiesel for overall growth in the global biofuels business of 34% to $58 billion.

But the 2008 price and back-logged-production-fueled growth belies a turn in market dynamics that happened some time back. By early 2007, the rapid growth in biofuels was increasingly blamed for rising food and animal feed prices. Livestock producers, dairy farmers and meat processors began to complain about ethanol subsidies and renewable fuel standards. The rising prices for corn, soy, wheat and other feedstocks also caused the margins of many ethanol and biodiesel producers to contract or even disappear. Investment by venture capitalists and private equity firms in the biofuels sector began to slow in 2007, ultimately dropping by a third from 2006 levels, according to New Energy Finance. (2008 data, however, indicated record investment amounts in biofuels, but this has been in second-generation biofuels derived from non-food feedstocks.)

However, the biofuels industry is not without resources to battle back. One of the most formidable is the argument that biofuels have moderated recent increases in fuel prices. According to F.O. Licht's *World Ethanol and Biofuels Report*, the International Energy Agency

(IEA) has estimated that daily biofuels production in 2008 averaged 1.35 million barrels a day, about 1.5% of global oil production. But with the current supply-demand imbalance, that 1.5% makes a large difference, according to experts. “In the current very tight market, it’s a very substantial amount,” said IEA Executive Director Nobuo Tanaka in a July interview with *Petrochemicals News* “Without biofuels, [oil] price could be much higher.”

Jeff Broin, head of the United States’ leading corn ethanol producer POET, cited studies that estimate ethanol saved U.S. consumers $0.29 to $0.40 per gallon of gasoline in 2008. “We’re competing with a highly subsidized energy industry which is the oil industry,” said Broin, citing the costs of the Iraq war and defending the Persian Gulf. “We believe the incentives for ethanol are a very small cost for our country to bear.”

Politically speaking, the U.S. ethanol industry will also continue to benefit from the great strength that the farm industry has in the U.S. Congress, especially the Senate where sparsely populated corn-belt states like Iowa (2.9 million) and Nebraska (1.8 million) have equal voting power with much more populous states. Indeed, despite repeated calls for the reduction or restructuring of farm subsidies in both the United States and Europe—calls especially vociferous from developing countries whose unsubsidized farm commodities can’t compete—those subsidies have proven to be very resilient politically.

In terms of ethanol or E85 fueling stations, the Midwest has the most with California having 45 or 2% out of the U.S. total of 2,100 in 2008.

**Figure 115 Alternative Fueling Station Total Counts by State and Fuel Type**

| STATE | B20 | CNG | E85 | Biodiesel B20 | Nat.Gas CNG | Ethanol E85 |
|---|---|---|---|---|---|---|
| Minnesota | 0 | 1 | 350 | 0% | 0% | 17% |
| Illinois | 5 | 25 | 205 | 1% | 3% | 10% |
| Iowa | 3 | 0 | 141 | 0% | 0% | 7% |
| Indiana | 7 | 9 | 128 | 1% | 1% | 6% |
| Wisconsin | 1 | 16 | 128 | 0% | 2% | 6% |
| Missouri | 4 | 9 | 97 | 1% | 1% | 5% |
| Michigan | 15 | 14 | 93 | 2% | 2% | 4% |
| South Carolina | 30 | 4 | 90 | 5% | 0% | 4% |
| Colorado | 19 | 22 | 85 | 3% | 3% | 4% |
| South Dakota | 2 | 0 | 81 | 0% | 0% | 4% |
| Ohio | 19 | 10 | 62 | 3% | 1% | 3% |
| New York | 16 | 99 | 58 | 2% | 12% | 3% |
| Nebraska | 3 | 1 | 52 | 0% | 0% | 2% |
| **California** | **41** | **210** | **45** | **6%** | **25%** | **2%** |
| USA Total: | 652 | 842 | 2096 | | | |

*Source: U.S. Department of Energy.*

**Figure 116 Global Biofuels**

| | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| **Ethanol Production (millions of Gallons):** | | | | | |
| Brazil | 3,989 | 4,227 | 4,491 | 5,019 | |
| USA | 3,535 | 4,264 | 4,855 | 6,499 | |
| Rest of World | 3,989 | 3,659 | 4,491 | 3,680 | |
| **Global Ethanol (millions of Gallons):** | 10,770 | 12,150 | 13,489 | 15,198 | |
| **Global Ethanol (millions of dollars)** | **$18,201** | **$21,870** | **$34,802** | **$34,043** | **$43,865** |
| **Global Biodiesel (millions of Gallons):** | **589** | **1,079** | **2,190** | **2,630** | **3,243** |
| **Global Biodiesel (millions of dollars** | $1,378 | $3,184 | $6,942 | $9,151 | $14,076 |
| **Global Biofuels (millions of Gallons):** | 11,359 | 13,229 | 15,679 | 17,828 | 3,243 |
| **Global Biofuels (millions of dollars** | $19,580 | $25,054 | $41,744 | $43,195 | $57,940 |

*Source: Derived from F.O. Licht data*

### 7.4.1. California's Low Carbon Fuel Standard Breaks New Ground

With its low carbon fuel standard (LCFS), California's Air Resources Board is putting the state's fuel suppliers on a carbon diet. The LCFS rule breaks new policy ground in many respects: As ARB staff wrote in a March 2009 summary, "There are no similar existing regulations [nationally or internationally]."

The implications of the LCFS are enormous and far reaching. New carbon credit markets will likely emerge within the LCFS to support electricity and natural gas vehicle fueling, with revenues going to players ranging from large electric and gas utilities to entrepreneurial vehicle charging and compressed natural gas (CNG) service stations—maybe even hydrogen vendors.

Advanced biofuel manufacturers could build dozens of new biorefineries around the state or elsewhere in the United States. Low-carbon ethanol imports from Brazil may increase—despite the $0.54 per gallon tariff on the imports—while Midwest corn ethanol producers are already innovating to become more carbon-efficient and gain a better carbon ranking from the ARB. High-carbon crude producers such as Alberta's oilsands producers have another incentive to get their carbon capture and storage projects online so they can reduce the California carbon scores of their crude products.

**How LCFS Works**

The LCFS works by requiring gasoline and diesel fuel producers and importers, starting this year, to demonstrate to ARB that the total volume of transportation fuel they sell in the state produces 0.25% less carbon emissions than standard products, a value set at 95.86 grams $CO_2$ emissions per megajoule (MJ) of energy for gasoline and 94.71 $gCO_2/MJ$ for diesel. The carbon-intensity target continues declining yearly to reach a 10% reduction in 2020.

According to ARB, the LCFS provides flexibility to producers and importers to determine how best to meet these requirements through any feasible mix of fuels with different carbon intensities; the use of LCFS credits, obtained from parties who have reduced their carbon emissions more than the required levels, is also allowed to meet requirements.

Carbon intensities are assigned to various fuel types based on ARB-defined "pathways" that take into account lifecycle emissions from production, processing, transport and indirect land-use impacts. For example, sugarcane ethanol is considered to have very low direct emissions—from 12 to 32 grams per MJ depending on factors such as whether the plantation is generating power from its waste—but high indirect emissions—46 grams per MJ—due to the fact that sugarcane displaces quantities of food and feed crops, according to ARB.

These displaced crops must be replaced, causing grasslands and forests to be converted to agriculture. The land use change emissions associated with corn ethanol are currently estimated to be somewhat lower, at 30 $gCO_2/MJ$.

Put in motion by a 2007 executive order from former Governor Arnold Schwarzenegger, the LCFS is a "discrete early-action" measure under California's Global Warming Solutions Act of 2006 (AB32). ARB expects the LCFS to yield 15 million metric tons of $CO_2$-equivalent emission cuts cumulatively by 2020, about 10% of the state's total goal under AB 32.

Fuel producers' LCFS obligations are in addition to the mandatory emissions caps for their refineries under California's cap and trade law. Under that program, refineries, will reduce emissions through measures such as upgrading the efficiency of boilers and heaters, or buying credits from sponsors of projects in urban forestry, dairy methane capture and other approved offset methodologies.

After an epic stakeholder consultation process, the ARB board approved the LCFS in April 2009. Many elements of rulemaking are still evolving, with workgroups and advisory panels meeting to consider such measures as revising carbon intensity factors for various biofuel types to reflect innovations in biofuel production or advancements in the science of lifecycle assessment. ARB is also fielding continuing objections from the petroleum industry and defending the LCFS in several lawsuits by U.S. corn ethanol producers and petrochemical refiners.

## 7.5. CCBJ's Bioenergy Survey

This section presents selected results of a CCBJ survey of more than 50 bioenergy executives and investors performed in July 2008.

### 7.5.1. Highlights of CCBJ's Bioenergy Survey

• Median annual growth in biofuels production forecast in the USA for 2008-2012 by respondents is 15-20%, and 10-15% annual growth in 2012-2020.

• 59% of respondents believe biofuels mandates will be repealed or adjusted downward in the United States (10-20% reduction most likely); 56% in Europe.

• Respondents believe 5-7% of transport fuel will be supplied by biofuels worldwide in 2020 and 7-9% in 2030.

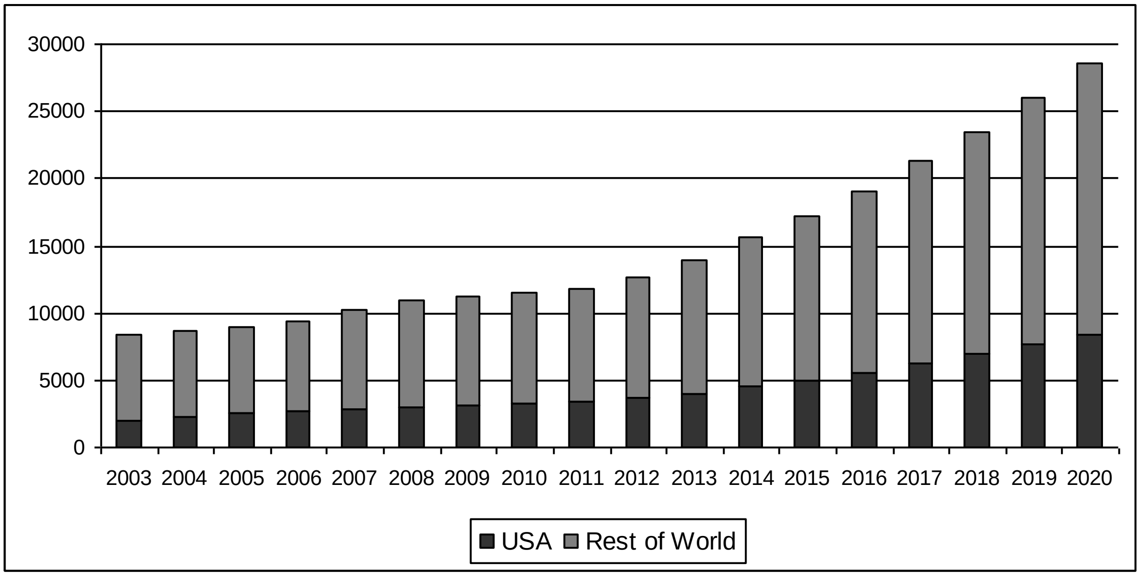
• Respondents believe plug-in hybrids and electric vehicles have significantly greater potential than fuel-cell and hydrogen vehicles with PHEVs accounting for around 10% of U.S. passenger miles in 2020 and electric 6%.

• 60% think cellulosic ethanol will become more cost effective for production than corn or sugarcane between 2012 and 2018, 20% say never; 71% think algae-derived biofuel will be more cost effective then corn/sugarcane between 2012 and 2020, 9% say never.

• Most believe alternative biodiesel feedstocks such as jatropha, palm and algae will provide less than 10% of biodiesel production by 2020. But while the first two are expected to remain at less than 10% even in 2030, 62% of respondents believe algae will account for more than 10% of biodiesel production by 2030; 31% of respondents believe algae will account for more than 20%.

# 8. Geothermal Energy

**Figure 117 Geothermal Capacity, 2003-2020 (MW installed and operational)**




*Source: EBI Inc., derived from a market model dervied from a variety of sources including Geothermal Energy Association, International Geothermal Association, Emerging Energy Research, New Energy Finance and company, government and academic sources.*

In the Low-Carbon & Renewable Power segment of the Clean energy industry, geothermal is an under-rated performer. Geothermal power's workmanlike quality stems from the fact that it offers something that wind and solar cannot provide: reliable baseload power that can be counted on to deliver megawatt-hours 24 hours a day, 365 days a year. In fact, for a utility or regional transmission organization, a geothermal power plant shows up on a resource plan grid like a conventional power plant.

In a broad context there are really three ways to look at geothermal energy:

1) Traditional steam-generated electricity generation, or hydrothermal, as it is often known, is site-dependent and has rather limited potential of perhaps 30,000 MW in the United States;

2) Enhanced geothermal systems (EGS) allow electricity generation from hot dry rock, thus opening up the map and the potential for geothermal power. But it is still early stages for EGS; and

3) Direct use geothermal encompasses space heating, hot water, process heat, pools, greenhouses and aquaculture. Direct use is exploited in more countries than electricity generation, but EBI classifies it as an energy efficiency application in that it replaces conventional sources of energy. The main growth in direct use during the last decade has been geothermal or ground-source heat pumps for space heating.

Hence the focus of this review is on electricity generation and its tie in with the power sector. Geothermal electricity "bridges both the conventional feedstock and renewable energy options for electric power generation rather uniquely," wrote Deloitte in a February 2008 report for the U.S. Department of Energy (DOE). Geothermal's baseload characteristics allow "it to compete with other baseload feedstocks such as coal, natural gas and nuclear. At the same time, geothermal energy is a clean, renewable resource that competes with other renewable energy options such as wind and solar [making] it an attractive option for reliable and scalable generation while satisfying renewable energy voluntary or mandatory portfolio standards."

**Figure 118 Geothermal Capacity (MW installed and operational), 2003-2020**

| | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|
| USA | 2,020 | 2,250 | 2,564 | 2,687 | 2,790 | 2,958 | 3,258 | 3,558 | 3,908 |
| Rest of World | 6,382 | 6,400 | 6,458 | 6,765 | 7,403 | 7,959 | 8,209 | 8,409 | 8,859 |
| Global | 8,402 | 8,650 | 9,022 | 9,452 | 10,193 | 10,917 | 11,467 | 11,967 | 12,767 |
| | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** |
| USA | 3,736 | 4,036 | 4,486 | 4,986 | 5,586 | 6,236 | 6,936 | 7,636 | 8,336 |
| Rest of World | 8,934 | 9,934 | 11,084 | 12,234 | 13,484 | 15,034 | 16,584 | 18,384 | 20,284 |
| Global | 12,670 | 13,970 | 15,570 | 17,220 | 19,070 | 21,270 | 23,520 | 26,020 | 28,620 |

*Source: EBI Inc., derived from a market model derived from a variety of sources including Geothermal Energy Association, International Geothermal Association, Emerging Energy Research, New Energy Finance and company, government and academic sources.*

Yet, geothermal both in the United States and the rest of the world is not being deployed at a particularly brisk pace. At the end of 2008, cumulative worldwide installed capacity was between 10,900 MW, including 2,950 MW in operating capacity in the United States, according to estimates from New Energy Finance (NEF) and Emerging Energy Research. (Some 400-500 MW of capacity at the 1,400-MW Geysers project in California is on standby leading to some discrepancy in different sources.)

Globally the pipeline of hydrothermal electricity projects currently in development exceeds the installed capacity by about 500 MW. The United States, Indonesia, the Philippines, Iceland and New Zealand account for 77% of the 10.7-MW pipeline, according to NEF estimates as of April 2009.

## 8.1. Geothermal Industry Statistics & Review

**Figure 119 Geothermal Capacity (GWh generated), 2003-2009**

| | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|---|
| USA | 15,867 | 16,292 | 16,161 | 16,025 | 16,101 | 17,070 | 18,802 |
| Rest of World | 39,133 | 39,604 | 40,625 | 42,747 | 46,306 | 48,888 | 50,480 |
| **Global** | **5,000** | **55,896** | **56,786** | **58,772** | **62,407** | **65,959** | **69,282** |

*Source: EBI Inc., derived from a market model derived from a variety of sources including Geothermal Energy Association, International Geothermal Association, Emerging Energy Research, New Energy Finance and company, government and academic sources.*

**Figure 120 Global Geothermal Industry ($mil), 2003-2010**

| Global Geothermal Industry ($mil) | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|
| Electricity Generation | 1,971 | 1,956 | 2,554 | 2,791 | 3,189 | 3,561 | 3,703 | 3,813 |
| Equipment Sales | 350 | 434 | 561 | 844 | 1,088 | 747 | 435 | 568 |
| Services | 558 | 722 | 1,054 | 1,319 | 879 | 497 | 630 | 1,080 |
| **Total** | **2,879** | **3,112** | **4,169** | **4,953** | **5,156** | **4,806** | **4,768** | **5,462** |
| Total Global Geothermal Industry Growth (%) | | 8.1% | 34.0% | 18.8% | 4.1% | -6.8% | -0.8% | 14.5% |

*Source: EBI Inc., Services include exploration & resource assessment, well field drilling & development, plant design & construction.*

**Figure 121 World installed capacity and production of geothermal power plants 1995-2050**

| Year | Installed Capacity (GW) | Electricity Production (GWh/yr) |
|---|---|---|
| 1995 | 6.8 | 38,035 |
| 2000 | 8 | 49,261 |
| 2005 | 8.9 | 56,786 |
| 2010 | 11 | 74,669 |
| 2020 | 24 | 171,114 |
| 2030 | 46 | 343,685 |
| 2040 | 90 | 703,174 |
| 2050 | 140 | 1,103,760 |

*Source: The Possible Role And Contribution Of Geothermal Energy To The Mitigation Of Climate Change. IPCC Geothermal 11 February 2008*

**Figure 122 U.S. Geothermal Industry ($mil), 2003-2010**

| Geothermal Industry ($mil) | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|
| Electricity Generation | 633 | 634 | 810 | 849 | 920 | 1,031 | 1,092 | 1,147 |
| Equipment Sales | 224 | 381 | 306 | 163 | 201 | 226 | 219 | 243 |
| Services | 490 | 393 | 203 | 244 | 266 | 250 | 270 | 450 |
| **Total** | **1,346** | **1,408** | **1,319** | **1,256** | **1,388** | **1,507** | **1,581** | **1,841** |
| Total USA Geothermal Industry Growth (%) | | 4.6% | -6.4% | -4.8% | 10.5% | 8.6% | 4.9% | 16.4% |

*Source: EBI Inc.*

**Figure 123 Global Geothermal Energy Industry 2007-2009**

| | 2007 | 2008 | 2009 | 2008 Growth | 2009 Growth |
|---|---|---|---|---|---|
| Geothermal Electricity Sales | 3.19 | 3.56 | 3.70 | 12% | 4% |
| Geothermal Equipment Sales | 1.09 | 0.75 | 0.44 | -31% | -42% |
| Geothermal Services | 0.88 | 0.50 | 0.63 | -43% | 27% |
| **Total Geothermal Industry** | 5.16 | 4.81 | 4.77 | -7% | -1% |

*Source: EBI Inc., from a market model derived from a variety of sources including Geothermal Energy Association, International Geothermal Association, Emerging Energy Research, New Energy Finance and company, government and academic sources. Services include exploration & resource assessment, well field drilling & development, plant design & construction.*

**Figure 124 U.S. Geothermal Energy Industry 2007-2009**

| | 2007 | 2008 | 2009 | 2008 Growth | 2009 Growth |
|---|---|---|---|---|---|
| Geothermal Electricity Sales | 0.92 | 1.03 | 1.09 | 12% | 6% |
| Geothermal Equipment Sales | 0.20 | 0.23 | 0.22 | 13% | -3% |
| Geothermal Services | 0.27 | 0.25 | 0.27 | -6% | 8% |
| **Total Geothermal Industry** | 1.39 | 1.51 | 1.58 | 9% | 5% |

*Source: EBI Inc., from a market model derived from a variety of sources including Geothermal Energy Association, International Geothermal Association, Emerging Energy Research, New Energy Finance and company, government and academic sources. Services include exploration & resource assessment, well field drilling & development, plant design & construction.*

**Figure 125 California Geothermal Energy Industry 2007-2009**

| | 2007 | 2008 | 2009 | 2008 Growth | 2009 Growth |
|---|---|---|---|---|---|
| Geothermal Electricity Sales | 0.79 | 0.88 | 0.93 | 11% | 6% |
| Geothermal Equipment Sales | 0.11 | 0.13 | 0.12 | 12% | -4% |
| Geothermal Services | 0.14 | 0.13 | 0.14 | -7% | 8% |

| | | | | | |
|---|---|---|---|---|---|
| **Total Geothermal Industry** | 1.05 | 1.14 | 1.20 | 9% | 5% |

*Source: EBI Inc., from a market model derived from a variety of sources including Geothermal Energy Association, International Geothermal Association, Emerging Energy Research, New Energy Finance and company, government and academic sources. Services include exploration & resource assessment, well field drilling & development, plant design & construction.*

**Figure 126 U.S. Geothermal Industry as a Percentage of Global Total**

| | 2007 | 2008 | 2009 |
|---|---|---|---|
| Geothermal Electricity Sales | 29% | 29% | 29% |
| Geothermal Equipment Sales | 18% | 30% | 50% |
| Geothermal Services | 30% | 50% | 43% |
| **Total Geothermal Industry** | 27% | 31% | 33% |

*Source: EBI Inc., from a market model derived from a variety of sources including Geothermal Energy Association, International Geothermal Association, Emerging Energy Research, New Energy Finance and company, government and academic sources. Services include exploration & resource assessment, well field drilling & development, plant design & construction.*

**Figure 127 California Geothermal Industry as a Percentage of U.S. Total**

| | 2007 | 2008 | 2009 |
|---|---|---|---|
| Geothermal Electricity Sales | 86.2% | 85.7% | 85.5% |
| Geothermal Equipment Sales | 56.7% | 56.2% | 56.0% |
| Geothermal Services | 53.3% | 52.8% | 52.6% |
| **Total Geothermal Industry** | 75.6% | 75.8% | 75.8% |

*Source: EBI Inc., from a market model derived from a variety of sources including Geothermal Energy Association, International Geothermal Association, Emerging Energy Research, New Energy Finance and company, government and academic sources. Services include exploration & resource assessment, well field drilling & development, plant design & construction.*

**Figure 128 U.S. and California Geothermal Industry: Employment**

| | USA $bil in 2009 | USA 2009 Jobs | Calif. $bil in 2009 | Calif. 2009 Jobs | % of USA Jobs in Calif. |
|---|---|---|---|---|---|
| Geothermal Electricity Sales | 1.09 | 1,200 | 0.93 | 1,040 | 85% |
| Geothermal Equipment Sales | 0.22 | 600 | 0.12 | 320 | 56% |
| Geothermal Services | 0.27 | 1,800 | 0.14 | 1,140 | 63% |
| **Total Geothermal Industry** | 1.58 | 3,600 | 1.20 | 2,500 | 69% |

*Source: EBI Inc., from a market model derived from a variety of sources including Geothermal Energy Association, International Geothermal Association, Emerging Energy Research, New Energy Finance and company, government and academic sources. Services include exploration & resource assessment, well field drilling & development, plant design & construction.*

### 8.1.1. How Geothermal Stacks Up Against Other Renewables

Not only is geothermal's 10,000 MW in 2008 global capacity easily less than 10% of the comparable capacity figure for wind power (121 GW worldwide) and less than two thirds of solar PV's installed capacity (15 GW), but geothermal electricity generation represents a comparatively anemic growth rate. At the end of 2003, global geothermal capacity was at 8,400 MW, meaning average annual growth from 2003-2008 was about 3.4%. Not bad if you're in the canned soup business, but in the clean energy business that kind of growth doesn't generate much excitement. By contrast, PV's 5.95-GW jump in 2008 as tallied by SolarBuzz represented one year growth of 110%. Wind power's leap forward in 2008 as tallied by the Global Wind Energy Council was 29%.

Even with the recent growth in wind and solar, renewable sources remain fairly insignificant in the 19 million GWh global electricity picture. In terms of electricity production, however, geothermal's superior capacity factor makes its contribution to global electricity generation more substantial than solar and close to half that of wind—at least in 2006, the most recent year for which the International Energy Agency publishes data. According to the IEA, geothermal electricity accounted for 59,200 GWh or 0.31% of global electricity generated, with wind at 0.7% and solar 0.2% in the same year. Coal (41%), gas (20%), hydro (16%), nuclear (15%) and oil (6%) made up 98% in 2006, according to IEA. Of course, lumping geothermal with the other renewables does de-emphasize its higher capacity factor and predictable baseload contribution valued by utilities.

EBI defines the geothermal industry in three subsegments: electricity generation; equipment sales; and services. The latter includes exploration & resource assessment, well field drilling & development and plant design & construction. Electricity represents about 70% of the global total, but the ramping up of growth until the 2008 financial meltdown had corresponding investments in site evaluation, drilling, etc. that tilted the share of revenues more to services in growing markets, the U.S. included. EBI forecasts indicate that following a delay resulting from the freezing of credit and financing, the geothermal market will resume a growth trajectory and reach $5 billion in the U.S. and $15 billion globally by 2016.

**Figure 129 Typical Market Drivers for Renewable Energy**

| Driver | Developed markets | Emerging markets |
|---|---|---|
| Power prices | + | ++ |
| Demand growth | ++ | +++ |
| Reliance on energy imports | +++ | ++++ |
| Environment | ++++ | + |

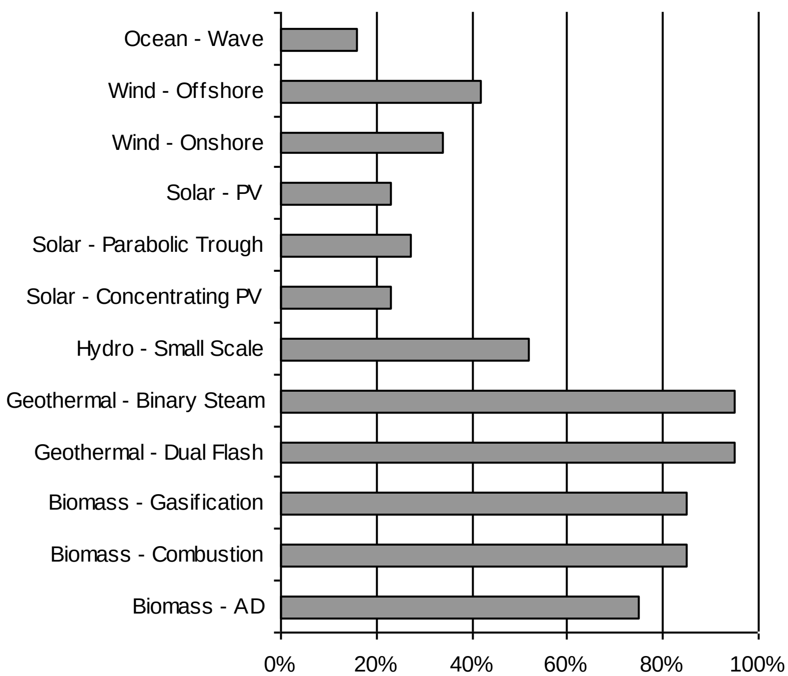
*Note: Each + indicates relative importance of market driver; Drivers are the same worldwide, but priorities vary. Source: Ormat Technologies, Inc., presentation by Rahm Orenstein at Greenpower Conferences' March 2009 Geothermal Innovation and Investment conference.*

Revenues available to specialist consulting & engineering firms could arguably be the total service amounts of roughly $1 billion globally in the past few years, with a jump to $2-3 billion provided no further curtails in the current pipeline or forecasted growth trajectory. A significant portion of these revenues, however, would be drilling or construction, meaning pure C&E project revenue would likely be closer to half these figures.

According to a variety of analysts and our interviews with industry leaders and experts, the growth of geothermal has historically been hampered by several constraints and challenges. In the first place, without a technological revolution like that promised by enhanced geothermal systems (EGS, also known as hot dry rock technology), geothermal power can only be developed in countries with suitable underground geothermal resources. Most geothermal resources are located along the seismically active Ring of Fire that roughly follows the coasts of the Pacific Ocean. Other resource areas include Eastern China and the Himalayan Belt, the Caribbean, Iceland, The Azores, Canary Islands, Italy, parts of Northern and Eastern Europe, the Eastern and Southern Mediterranean and Kenya, Tanzania and other countries is the East Africa Rift zone.

In the second place, geothermal development is to a certain degree a speculative enterprise. Like wildcatters in the oil industry, geothermal developers must spend millions of dollars drilling for underground resources that they're not sure are present—or present in the quantities that will lead to their expected return on investment. "Geothermal projects have distinctly different challenges than other, more traditional, renewable technologies such as wind, solar, and biomass," notes the DOE's office of Energy Efficiency and Renewable Energy (EERE) in its *Geothermal Tomorrow* report. "Geothermal projects require subsurface exploration and well field development and have greater upfront risk because the geothermal resource is not confirmed without drilling."

**Figure 130 Capacity Factors for Selected Renewables (Average Net Capacity %)**

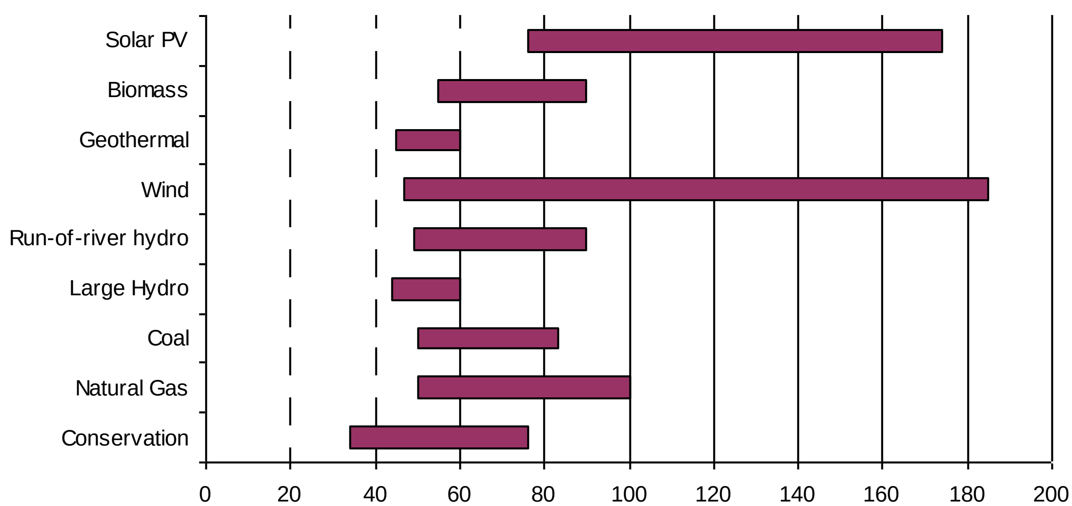



*Source: Pathway to Accelerated Commercialization by Raser Technologies. Original Source: Glitner Geothermal Report, September 2007*

Geothermal developers at Greenpower Conferences' March 2009 Geothermal Innovation and Investment conference in San Francisco said that typically 20% to 30% of the wells they drill—wells costing from $1.5 million to $10 million—end up hitting "dryholes." While not always physically dry, these dryholes are of sub-commercial enthalpy (heat energy). Compounding this dryhole risk is the fact that in the United States and some other regions, many of the best and most easily accessible geothermal resources—those with surface expressions like hot springs and fumaroles—have already been developed. To tap undeveloped resources for new power plants, developers must take on more risk in their drilling and development efforts.

As described in the developers roundtable article that follows this overview, as recently as the summer of 2008 developers could obtain debt financing to finance some of this resource and wellfield development work. Today the pendulum has swung the other way. Those lenders willing to finance geothermal projects require that developers sink wells and have proven resources—"steam behind the pipe" as they call it—before they will finance power plant construction. Separately with the depressed market caps of publicly held geothermal developers, private equity funders would rather buy companies or their assets than invest in new projects. Financial institutions in the market for tax credits are few and far between. And except for companies with a technology play in the emerging EGS segment, venture capitalists aren't interested in geothermal companies because of the lack of upside potential.

**Figure 131 Levelized Costs: Generation Cost Range ($/MWh)**




*The present value of the total cost of building and operating a generating plant over its economic life, converted to equal annual payments. Source: Pathway to Accelerated Commercialization by Raser Technologies. Original Source: B.C. Hydro - Challenges & Choices (2006); Jacob & Company Securities estimates. Levelized cost is the present value of the total cost of building and operating a generating plant over its economic life, converted to equal annual payments.*

In this difficult environment, geothermal developers are urging the U.S. Department of Energy to use some of its ARRA funding—$400 million for geothermal and $6 billion for innovative technology loan guarantees—to subsidize drilling. As of May 2009, DOE had not issued guidance on this question. In international developments, the recession's impact on Icelandic geothermal firms has been amplified by the collapse of Iceland's currency. With the krona almost worthless on the international market, Icelandic geothermal developers that had set their sights on developing projects in foreign markets have scaled back to focus on the significant potential in their homeland.

**Figure 132 Source shares in world electricity generation 2006 (International Energy Agency)**

| | GWh | % |
|---|---|---|
| Coal/Peat | 7,756,602 | 41% |
| Gas | 3,804,928 | 20% |
| Nuclear | 2,793,030 | 15% |
| Oil | 1,096,047 | 6% |
| Other sources | 10,276 | 0% |
| Hydro power | 3,036,471 | 16% |
| Biomass | 173,332 | 1% |
| Waste* | 66,049 | 0% |
| Wind energy | 130,073 | 1% |
| Geothermal energy | 59,240 | 0% |
| Solar thermal energy | 1,061 | 0% |
| Solar PV energy | 2781 | 0% |
| Tide, Wave, Ocean energy | 550 | 0% |
| | | |
| **Total world generation** | **18,930,440** | **100%** |
| **Non-renewables total** | **15,498,737** | **82%** |
| **Renewables total** | **3,431,703** | **18%** |

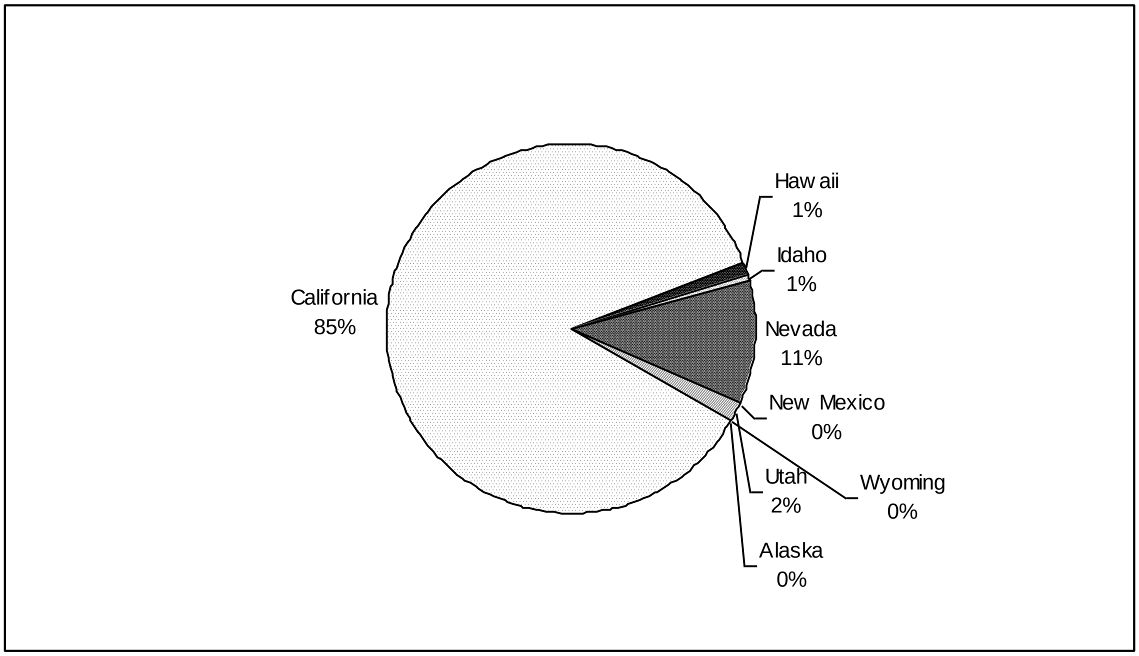
*Source: IEA. www.iea.org. * Includes non-renewable and renewable waste*

## 8.1.2. Long-Term Market Drivers

The phrase “when the economy recovers” is becoming a cliché of analysts and commentators looking at virtually all industries, but there’s really no other way to say: When the economy recovers, and when the prices of oil and gas resume their inevitable rise into the $100-plus territory, the geothermal power industry’s prospects will improve. The EBI global market forecast, not that dissimilar from the base-case capacity-growth scenario of Emerging Energy Research (EER), has 2011-2014 annual growth in the high teens, with double-digit growth persisting to 2020.

Market drivers for geothermal power are fundamentally sound: In the developed world, renewable energy standards and greenhouse gas caps are pushing utilities toward low-carbon generation, and geothermal’s baseload qualities give it advantages over solar and wind. As outlined in the chart on page 3, energy supply and security are also drivers, as is power price in regions such as the Caribbean and parts of South Asia that are highly dependent on imported diesel oil for power supply. Some developing country markets are using feed-in tariffs popularized mostly for other renewables in Germany and other developed nations.

**Figure 133 U.S. Geothermal Power Capacity On-Line by State in 2009**




*Source: Geothermal Energy Association*

With renewed growth, however, the geothermal power segment will have to contend with a couple of looming challenges. One is lack of access to drilling rigs. When oil prices were in the stratosphere and demand was outstripping supply, geothermal developers had a difficult time contracting for rigs and crews. With the drop in prices and demand, that has gotten easier; but rising prices and demand will inevitably cause drilling demand to rise. Another challenge will be recruiting and training staff. "The professional staff available in geothermal is minute," said Doug Glaspey, CEO of U.S. Geothermal, at the Greenpower March conference. "In order to grow, you have to have skilled professionals, and that's a very difficult thing to accomplish in this business today." Investment capital is also required, and although the flow of venture money into cleantech businesses was tallied at over $8 billion in 2008, geothermal is not the sexiest category.

EER states that geothermal power plant investment could reach $13-20 billion by 2020, representing cumulative investment in geothermal exploration, drilling, and power plant construction. In comparison with EER's broader power generation forecasts, geothermal is the fourth-largest market for cumulative renewable power generation investment between 2009 and 2020, behind onshore wind, solar PV, and biomass, but ahead of offshore wind, CSP, and small hydro globally by 2020.

EER's base-case growth scenario forecasts 20 GW of geothermal installed during the 2010s, with their high-growth scenario at about 1.5 times that or about 30 GW. The vast majority of growth in both scenarios is North America and Southeast Asia, although the rest of the world accounts for as much as 25-30% of growth in some years of EER's forecast. A few new markets are expected to see sustained growth, led by Chile, Turkey, Russia, East Africa, and Central America. Established markets in Iceland, Mexico, and New Zealand are also expected to continue to tap their potential. Australia is what EER calls the largest region of uncertainty, as its substantial goal of bringing online over 2 GW of geothermal by 2020 remains contingent on successful deployment of unproven EGS.

**Figure 134 Western States' Near-Term New Geothermal Power Capacity**

| | Capacity MW | Number of Sites |
|---|---|---|
| Alaska | 20 | 3 |
| Arizona | 20 | 2 |
| Colorado | 20 | 9 |
| California | 2,400 | 25 |
| Hawaii | 70 | 3 |
| Idaho | 860 | 6 |
| Nevada | 1,500 | 63 |
| New Mexico | 80 | 6 |
| Oregon | 380 | 11 |
| Utah | 230 | 5 |
| Washington | 50 | 5 |
| **Total** | **5,630** | **138** |

*Note: Each + indicates relative importance of market driver; Drivers are the same worldwide, but priorities vary. Source: Ormat Technologies, Inc., presentation by Rahm Orenstein at Greenpower Conferences' March 2009 Geothermal Innovation and Investment conference.*

As mentioned, the United States leads the world in online capacity of geothermal energy and continues to be one of the principal countries to increase its geothermal growth. Geothermal electric power generation is centered in eight U.S. states: Alaska, California, Hawaii, Idaho, Nevada, New Mexico, Utah and Wyoming with Oregon and Colorado coming on line. Total U.S. installed capacity was 3,040 MW as of March 2009, according to GEA's *U.S. Geothermal Power Production and Development Update* that includes some units on standby. Near-term capacity potential is higher than the existing installed base as indicated in the table above showing that 138 identified site offer 5,660 MW of potential capacity. Indeed with a pipeline of more than 4.4 GW of confirmed projects, the U.S. geothermal market is very active and poised to more than double existing capacity over the next five years, says EER, with U.S. carbon legislation and national RPS expected to drive sustained growth from 2015-2020.

The global geothermal pipeline now exceeds 10 MW of projects under development, which if completed would almost double the installed global geothermal capacity of 10.5 GW built up over the past 30 years.

Currently, there are over 215 commercial geothermal electricity projects operating in 24 countries. The largest dry steam field in the world is The Geysers, 116 km north of San Francisco. The Geysers began in 1960 and has 1360 MW of installed capacity. Calpine Corp. now owns 19 of the 21 plants in The Geysers and is currently the United States' largest producer of geothermal energy. The other two plants are owned jointly by the Northern California Power Agency and the City of Santa Clara's municipal Electric Utility (now called Silicon Valley Power). Since the activities of one geothermal plant affects those nearby, the consolidation plant ownership at The Geysers has been beneficial because the plants operate cooperatively instead of in their own short-term interest. The Geysers is now recharged by injecting treated sewage effluent from the City of Santa Rosa and the Lake County sewage treatment plant. This sewage effluent used to be dumped into rivers and streams and is now piped to the geothermal field where it replenishes the steam produced for power generation.

Another major geothermal area is located in south central California, on the southeast side of the Salton Sea, near the cities of Niland and Calipatria, Calif. There were 15 geothermal plants producing electricity in the area. CalEnergy owns about half of them and the rest are owned by various companies. Combined plants have a capacity of about 570 MW. The Basin and Range geologic province in Nevada, southeastern Oregon, southwestern Idaho, Arizona and western Utah is an area of rapid geothermal development. Several small power plants were built during the late 1980s during times of high power prices. Plants in Nevada at Steamboat near Reno, Brady/Desert Peak, now produce about 240 MW. Nevada and Utah account for 86% of the new leases granted by the U.S. government in 2007-2008.

While geothermal electricity using existing technology indeed has good short-term prospects, the best sites are already snapped up. If geothermal is to make a big dent in renewables' inevitable penetration of the U.S. electricity business, EGS will have to play a role. Regardless, manufacturers, consulting engineers, investors and policymakers believe that non-hydro renewables will account for roughly 8-10% of electricity by 2020 and 20-25% by 2050, according to compiled results of CCBJ surveys that incorporated the identical question. How America reaches these thresholds remains to be seen, but it seems certain that there will be an ample supply of scientists, engineers, entrepreneurs, businessmen and corporations to chase the goal.

## 8.2. Direct Use Geothermal

Electricity is produced from geothermal sources in 24 countries. Direct application of geothermal energy has been reported by 72 countries. In 2005, the worldwide use of geothermal energy was 57 TWh/yr of electricity and direct use was 76 TWh/yr, as reported by the Intergovernmental Panel on Climate Change (IPCC), a scientific intergovernmental body set up by the World Meteorological Organization and by the United Nations Environment Program. Six developing countries are in the top 15 countries in direct use, with China at the top of the list. Direct use utilizes low-enthalpy geothermal fields that don't produce hot water at temperatures sufficient to generate power. While many firms engaged in geothermal electricity also work on direct-use projects, the segment is more driven by utilities, governments or companies using the heat directly. (Note: IPCC has released forecasts for geothermal electricity with global capacity reaching 24 GW in 2020, 46 GW in 2030, 90 GW in 2040 and 140 GW in 2050)

Direct Use Applications: Direct applications of geothermal energy are for space heating 52%, hot water (bathing and swimming) 30%, horticulture (greenhouses and soil heating) 8%, industry 4%, and aquaculture (mainly fish farming) 4%, according to John Lund in his paper *World-Wide Direct Uses of Geothermal Energy 2005.* Ground-source heat pumps are growing due to their ability to utilize groundwater or ground-coupled temperatures. According to IPCC, scenarios for future development show only a moderate increase in traditional direct use applications, but an exponential increase in heat pumps, as geothermal heat pumps can be used for heating and/or cooling in most parts of the world. In addition, geothermal heat pumps driven by fossil-fuel electricity reduce CO2 emissions by at least 50% compared with fossil-fuel fired boilers. If the electricity that drives the geothermal heat pump is produced from a renewable energy source like hydropower or geothermal energy the CO2 emission savings are up to 100%. The total CO2 emission reduction potential of geothermal heat pumps has been estimated to be 1.2 billion tones per year or about 6% of global CO2 emissions.

**Figure 135 Top Fifteen Countries Utilizing Geothermal Energy in 2005**

| Geothermal Electricity Production | GWh/yr |
|---|---|
| USA | 17,917 |
| Philippines | 9,253 |
| Mexico | 6,282 |
| Indonesia | 6,085 |
| Italy | 5,340 |
| Japan | 3,467 |
| New Zealand | 2,774 |
| Iceland | 1,483 |
| Costa Rica | 1,145 |
| Kenya | 1,088 |
| El Salvador | 967 |
| Nicaragua | 271 |
| Guatemala | 212 |
| Turkey | 105 |
| Guadeloupe (France) | 102 |
| **Total** | **56,491** |

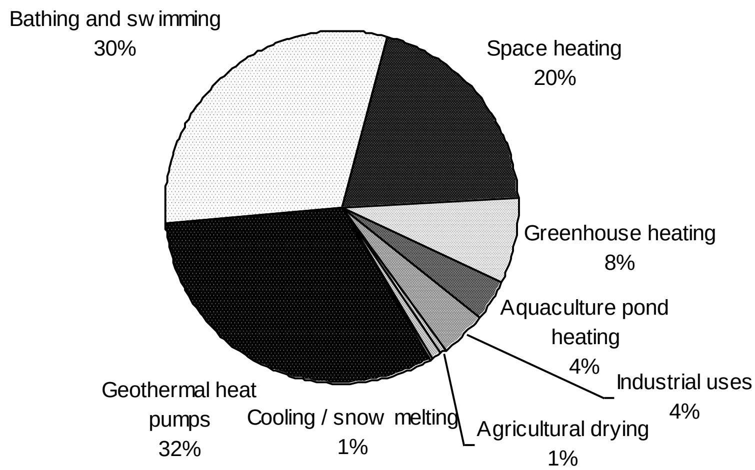
*Source: Bertani (2005)*

**Figure 136 Geothermal Direct Use in 2005**

| Geothermal Direct Use | GWh/yr |
|---|---|
| China | 12,605 |
| Sweden | 10,000 |
| USA | 8,678 |
| Turkey | 6,900 |
| Iceland | 6,806 |
| Japan | 2,862 |
| Hungary | 2,206 |
| Italy | 2,098 |
| New Zealand | 1,968 |
| Brazil | 1,840 |
| Georgia | 1,752 |
| Russia | 1,707 |
| France | 1,443 |
| Denmark | 1,222 |
| Switzerland | 1,175 |
| Others | 12,730 |
| **Total** | **76,000** |

*Source: Lund et al. (2005)*

**Figure 137 Direct applications of geothermal worldwide in 2004 by percentage of total energy use**




*Source: Lund et al. (2005)*

## 8.3. Geothermal Industry Companies

The geothermal power industry consists of project developers that identify, finance and build geothermal power plants; consulting engineering and technical firms that identify and quantify geothermal resources, conduct environmental analyses, design, operate and maintain projects; drilling firms that drill wells for exploration and production; engineering, procurement and construction (EPC) firms that build geothermal power plants; manufacturers of turbine generator sets, heat exchangers and other equipment; and other specialty firms. Some firms perform multiple roles, for example, manufacturers sometimes develop their own projects and EPC firms often provide multiple technical services with in-house staff. Exploring for and developing geothermal power resources requires specialized expertise that is concentrated in a few countries including Japan, Iceland, the United States, Canada, New Zealand, Australia and the Philippines.

The number of firms in the industry is very small compared to other energy sectors. There are **11 manufacturers of geothermal turbine generator** sets and related power plant components. They include:

Alstom (France)

Ansaldo (Italy)

Fuji Electric (Japan)

GE Energy (United States)

Mitsubishi Heavy Industries (Japan)

OAO Kalugo Energo (Russia)

Ormat Technologies (United States)

Siemens (Germany)
Turboden (Italy)
Toshiba (Japan) and
UTC/Pratt & Whitney (United States).

At a recent international trade show of the **Geothermal Energy Association** in the United States, there were fewer than 100 exhibitors.

**Geothermal project developers and power plant owners** can be divided into two categories: 1) major independent power producers (IPPs) and utilities and 2) pure-play geothermal developers.

1) **IPP category** includes (U.S. companies unless stated):
ArcLight Capital Partners/Terra-Gen Power
Calpine
Chevron
ENEL (Italy)
EnBW (Germany)
Geysir Green Energy (Iceland)
LaGeo (El Salvador)
Mid-American/CalEnergy
Ormat Technologies and
PNOC EDC (The Philippines).

Unocal and Chevron had historically been active developers of geothermal power in Southeast Asia. In 2005, Chevron acquired Unocal, and Chevron today is the world's largest private owner of geothermal power plants with combined capacity of 1,273 MW in the Philippines and Indonesia.

2) **Pure-play developers** include:
Magma Energy (Canada)
Nevada Geothermal Power (Canada)
Polaris Geothermal (Canada)
Ram Power, Raser Technologies
Sierra Geothermal (Canada)
U.S. Geothermal
Vulcan Power and
Western GeoPower (Canada).

**Enhanced geothermal systems** (EGS) firms include:
AltaRock
Green Rock Energy (Australia)
Panax Geothermal (Australia)
Petratherm (Australia) and
Potter Drilling.

**Leading technical and engineering consultancies and EPC contractors** include:
AMEC

Enex (Iceland)
GeothermEx
Geothermal Development Associates
Geothermal Resource Group
Horizon Well Logging
Hot Dry Rocks (Australia)
Mannvit Engineering (Iceland)
Ormat Technologies
Power Engineers
SAIC
SKM Consulting (Australia)
West Japan Engineering Co. and
Wood Group (United Kingdom)

**Leading drilling and drilling services companies** include:
Baker Hughes (United States)
B.J. Services (United States)
Boart Longyear (United States)
Halliburton (United States)
Iceland Drilling (Wales)
Schlumberger (France, United States and The Netherlands)
Thermasource (United States) and
Weatherford (United States).

## 8.4. Challenges for Geothermal Developers

For many geothermal power plant developers in North America, the worldwide economic free-fall that began in September 2008 turned 2009 into a year of holding on and trying to survive. Despite holding leases to tens of thousands of acres of geothermal-rich land in the western United States, most developers lack risk capital to invest in the upfront geo-scientific work and exploratory drilling that is needed to verify the extent and quality of geothermal resources under the ground.

Before the banking crisis, developers could obtain debt financing before they had validated and drilled the production wells to tap geothermal resources—or had "steam behind the pipe" in industry parlance. Not so today. "We've come out of a period in which there has been hyper-liquidity, a buyer's market for capital if you will. In the period we're in now, the pendulum has swung the other way," according to Ric Abel, Managing Director, Electric Finance Group, Prudential Capital Group. "While in the past developers could get debt sooner in the life of a project and finance their drilling with a larger percentage of debt, today drilling and proving up the resource is seen as an equity risk."

Abel spoke at the March 2009 San Francisco Geothermal Innovation and Investment Forum sponsored by Greenpower Conferences. He was one of several representatives of lending institutions who discussed just how much financial conditions have tightened up for geothermal developers since the fall of 2008.

Investors had similarly bad news. Venture capitalists from Google.org and KPCB said they're only investing in technology firms with a strong upside potential, like those aiming to gain a position in the emerging enhanced geothermal systems (EGS) industry (also known as hot dry rock or HDR).

Private equity investors told the audience that because of the depressed market caps of publicly held geothermal developers, investors would prefer to buy geothermal companies or their operating power plants rather than invest in new geothermal projects. "Right now because of the large number of [geothermal] companies looking for financing as well as the significantly shrunken pool of available capital we expect that [development] deals will be few and far between going forward. The return hurdles and pre-requisites for successful private equity investment will be a lot higher," Paul Ho, managing director of Hudson Clean Energy Partners, said.

This was not news to the North American geothermal project developers who were in the audience, five of whom would later sit on a panel together representing their firms: Magma Energy, US Geothermal, Ram Power, Nevada Geothermal Power and Sierra Geothermal Power. These companies are part of a relatively new wave of pure-play geothermal project developers that emerged in this century, driven by the California energy crisis, the adoption of renewable energy standards in western states and the emergence of climate change and energy security concerns. Unlike Ormat and a handful of larger independent power producers and energy companies playing in U.S. geothermal project development—such as CE Generation and Enel North America—these firms are in the early stages of building their portfolios of geothermal projects. Tim Stephure, a geothermal expert at Emerging Energy Research, calls them "junior developers." Some have purchased existing plants with an eye toward expanding or repowering those facilities, but all are focused on new developments.

Development capital—lots of it—is needed for the upfront work that developers must do not only to verify that adequate geothermal resources lie under the ground they've leased or purchased, but also to sink wells accurately enough to tap those resources. In this economic environment, until they've got "steam behind the pipe," they can't access private equity funding, tax-credit equity or project-finance debt. And even when they can meet the risk requirements of such funders, funding is harder and more expensive to obtain than any time in recent memory.

As Abel pointed out, prior to the recession, developers could often obtain debt financing for some of this risky resource development activity. Not only is that no longer the case, but prospective equity investors are requiring more resource development work—more steam behind the pipe—before they'll invest in projects. And lenders are requiring higher levels of equity investment before they'll lend money for a project. One geothermal veteran told EBI: "The big economic problem affecting us now is the amount of debt you can get as part of your total project cost. This amount used to be 70-80%, and you'd only have to come up with 20-30% equity. First of all, nobody is really doing any deals right now. Banks don't have money they're willing to loan on such projects. But the numbers we're hearing tossed around [by lenders willing to lend] are more like 40-50% equity."

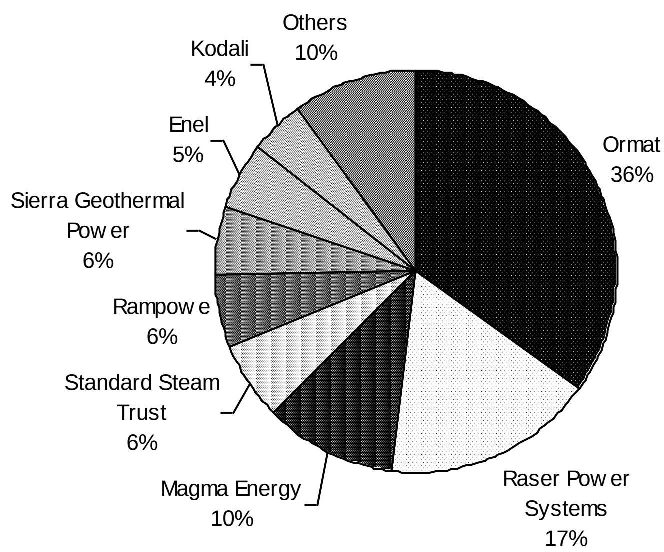
Panelists agreed that the last significant geothermal financing deal in the United States was Nevada Geothermal Power's $180 million line of credit to build a 50-MW project near Winnemucca, Nevada. But as CEO Brian Fairbank said in an interview, the financing was much less favorable than what the company had anticipated. And in the climate at that time, the developer's success in getting steam behind the pipe for 50 MW had not led to any breakthroughs in financing an additional 50 MW at the same site.

Before a developer worries about financing, however, it must have land leased for development, either from private owners, states or the federal Department of Interior, which controls through the Bureau of Land Management (BLM) millions of acres in the West. After May 2007, when the BLM finalized its rules for auctioning leases under the Energy Policy Act of 2005, there was a "land rush" as firms bid for favorable parcels. Auctions in 2007 brought in bids ranging from an historic high of $14,000 per acre for a 470-acre parcel adjacent to The Geysers in California to bids in the neighborhood of $300 to $500 per acre in Nevada, according to BLM. Data compiled by Emerging Energy Research shows that since 2007 the three top lessees are Ormat, with about 150,000 acres; Raser Power Systems with some 75,000 acres; and Magma Energy with about 45,000 acres. These three are followed by some 20 developers with anywhere from a few hundred acres to 20,000-plus acres under lease.

The BLM has been paid more than $63 million for geothermal leases since 2007, according to Kermit Witherbee, national geothermal program manager for the agency. According to Witherbee, the perceived value of auctioned leases has dropped significantly. In the agency's December 2008 auction, the average price was between $30 and $50 per acre.

For developers without existing leases or rights to private or federal lands, the prospects of gaining a toehold in geothermal development are increasingly slim. Most of the favorable geothermal sites—outside of off-limits areas like Yellowstone National Park—have already been developed or acquired. "Those of us who have been around for a few years kind of got the first pick on some of these prospects that [already] had drilling [done] and had discoveries," said Doug Glaspey, CEO of U.S. Geothermal. "Those are the sites we went to first, and those are rapidly being consumed not only by ourselves but by new entrants in the market. So the quality of [geothermal site] prospects is going down. That means the risk to define and develop new resources is going higher and higher."

**Figure 138 BLM Geothermal Competitive Leases by Acres, 2007–Present**




*Source: Compiled by Emerging Energy Research; By state the 2007-2008 leases are 52% in Nevada, 34% in Utah and 9% in Oregon, 4% in Idaho. Others include Agua Caliente, Oski Energy, Geothermal Technical Partners, Silver State Geothermal, Vulcan Power, Geothermal Rail Ind. Dev., Miller Dusty, S4 Consultants, Montera Energy Ventures, US Geothermal, Calpine, First Covenant Construction, US Renewables Group, Kelsey South, High Valley. Figures in acres rounded to the nearest thousand acres. BLM is Bureau of Land Management.*

**Figure 139 Leading Geothermal Power Market Participants, Table 1**

| Power Plant Owners And Developers |
|---|
| **Major IPPs and Utilities**<br><br>Mighty River Power (New Zealand)<br>ArcLight Capital Partners/Terra-Gen Power (USA)<br>Calpine (USA)<br>Chevron (USA)<br>ENEL (Italy)<br>EnBW (Germany)<br>Geysir Green Energy (Iceland)<br>LaGeo (El Salvador)<br>Mid-American/CalEnergy (USA)<br>Ormat Technologies (USA)<br>PNOC EDC (The Philippines) |
| **Pure-Play Geothermal Developers**<br><br>Magma Energy (Canada)<br>Nevada Geothermal Power (Canada)<br>Polaris Geothermal (Canada)<br>Ram Power (USA)<br>Raser Technologies (USA)<br>Sierra Geothermal (Canada)<br>U.S. Geothermal (USA)<br>Vulcan Power (USA)<br>Western GeoPower (Canada) |
| **Power Plant Equipment Suppliers** |
| Alstom (France)<br>Ansaldo Energia (Italy)<br>Fuji (Japan)<br>GE/Nuovo Pignone (USA)<br>Mitsubishi (Japan)<br>OAO Kalugo Energo (Russia)<br>Ormat Technologies (USA)<br>Siemens (Germany)<br>Toshiba (Japan)<br>Turboden (Italy)<br>UTC/Pratt & Whitney (USA) |

*Source: EBI, EER, NEF and Geothermal Resources Council*

**Figure 140 Leading Geothermal Power Market Participants, Table II**

| **Energy Conversion Technology Developers** |
|---|
| Borealis/Power Chips (Gibraltar)<br>ElectraTherm (USA)<br>Exorka (Germany)<br>O-Flex<br>Ormat Technologies (USA)<br>Turbine Air Systems (USA)<br>UTC/Pratt & Whitney (USA) |
| **Technical And Engineering Consultancies & EPC Contractors** |
| AMEC (USA)<br>Enex (Iceland)<br>GeothermEx (USA)<br>Geothermal Development Associates (USA)<br>Geothermal Resource Group (USA)<br>Horizon Well Logging (USA)<br>Hot Dry Rocks (Australia)<br>Mannvit Engineering (Iceland)<br>Ormat Technologies (USA)<br>Power Engineers (USA)<br>SAIC (USA)<br>SKM Consulting (Australia)<br>West Japan Engineering Co.<br>Wood Group (United Kingdom) |
| **Drilling And Drilling Services Firms** |
| Baker Hughes (USA)<br>B.J. Services (USA)<br>Boart Longyear (USA)<br>Halliburton (USA)<br>Iceland Drilling (Wales)<br>Schlumerger (France, USA, Netherlands)<br>Thermasource (USA)<br>Weatherford (USA) |
| **EGS Developers And Technology Firms** |
| AltaRock (USA)<br>Geodynamics (Australia)<br>Green Rock Energy (Australia)<br>Panax Geothermal (Australia)<br>Petratherm (Australia)<br>Potter Drilling (USA) |

*Source: EBI, EER, NEF and Geothermal Resources Council*

# 9. Wave, Tidal and River Power

As utilities and governments worldwide seek to meet growing power demand while mitigating greenhouse gas emissions, many are turning to hydropower. The source of nearly 17% of worldwide electricity production in 2006, according to the U.S. Energy Information Agency, the use of hydropower varies dramatically depending on the available resources and the development stage of countries and regions. Canada used hydropower to generate 352 billion kilowatt hours (352 TWh) in 2006, 59% of electricity consumed, while the entire continent of Africa produced just 90 TWh in that year. In the United States, hydropower produced 289 TWh in 2006, 7% of total electricity consumed.

Large dams generate the vast majority of hydroelectricity and, despite conflicts over their environmental and humanitarian consequences, new dams are being proposed and built all around the world. In the United States, there is an effort to create new hydropower capacity by installing turbines on existing dams that currently don't generate power, as well as adding increments of new capacity with additional turbines or upgrades to existing hydropower dams. Smaller run-of-river hydropower operations that divert water without dams can also be expected to contribute to emissions-free power capacity significantly; and many of these are being built in developing countries with carbon credit funding through the Clean Development Mechanism.

**Figure 141 New U.S. Hydropower by 2025**

| | MW |
|---|---|
| New conventional hydropower (<30MW) | 2,700 |
| Capacity gains at existing dams | 2,300 |
| New capacity at existing non-powered dams | 5,000 |
| Ocean wave energy technologies | 10,000 |
| **Other hydrokinetic (RISEC, TISEC)** | **3,000** |
| **Total** | **23,000** |

*Source: EPRI Assessment of Waterpower Potential and Development Needs, 2007*

The emerging wave & tidal segment is a new class of devices that generate power from ocean waves and tides and from the instream flow of rivers. Collectively, this emerging subsegment of the clean energy industry's low-carbon and renewable power segment is referred to alternately as **hydrokinetic energy** (reflecting the fact that power is generated with the kinetic energy of moving water instead of the potential energy of stored water) or **advanced waterpower** (to distinguish the new devices from conventional hydropower), but is also frequently referred to by the more simple term **wave & tidal power**.

Wave & tidal power hardly registered on the renewable power radar screen in 2008, and mid-range forecasts by EBI put wave & tidal at under 1%, or $700 million of the $71 billion U.S. renewable energy industry in 2014. Greentech Media and the Prometheus Institute for Sustainable Development forecast that while in 2008 fewer than 10 MW of ocean power capacity has been installed worldwide, they believe that "in six years the industry has the potential to break 1 GW of installed capacity on an annual market size of over $500 million." In addition they contend that "more than $2 billion will be invested in that time in commercial production and installation.

Based on current trends, a similar amount will be invested in research, design and development during that time."

Wave & tidal power systems do have something that the two renewable leaders wind and solar lack. A weakness of wind and solar power is the intermittence of the resources. While wave & tidal systems will not provide the steady baseload power that geothermal and biomass power can provide, modeling indicates that devices that extract energy from rivers, tides and waves may have higher capacity factors than either wind or solar.

### 9.1.1. Investor Interest Strong

A growing number of utility managers and government energy officials say that while the ultimate contribution of wave energy can't be quantified yet, the enormous potential energy available demands attention and investment. On California's 1,200-kilometer coastline, for example, the power of waves equates to an average of about 37 GW, according to the California Energy Commission (CEC). As much as 7 GW—more than 10% of the state's peak load—may be accessible by wave energy farms. "That is an upper limit estimate, and the reality will probably be less, but it's such a large resource for renewable and carbon-free clean energy, that we would be almost derelict not to investigate it," said Bill Toman who manages Pacific Gas & Electric's WaveConnect project in Northern California.

Since the first wave energy converter (WEC) was built and operated (in labs and test tanks only) by Scottish geoengineering professor Stephen Salter, a series of entrepreneurs, researchers and engineers have tried to tackle the challenge of making electricity from waves. It isn't an easy task. For one thing, turning wave movement—described by the CEC as "an irregular and oscillating low-frequency energy source"—into electric power requires technology inherently different from the rotary technologies of generators and turbines that have created grid electricity since the late 1800s.

According to Roger Bedard, the ocean energy leader for the Electric Power Research Institute (EPRI), WEC designers initially concentrated on these technological challenges while not paying enough attention to another one: storms like those off the coast of Scotland that can generate waves more than 25 meters tall. "In the 70s, a number of people and companies designed first-generation wave devices thinking of the best performance. They got good performance but they didn't survive storms," he said. "Many of the WECs that are being tested and deployed today are the products of a "second-generation of technology that emerged in the 1990s and was based on three factors: survivability, survivability and survivability."

Investors are showing more confidence in the ability of WEC designers to survive and thrive in the emerging wave energy market. An October 2008 report by the Prometheus Institute and Greentech Media tallied more than $500 million in investments in 35 ocean power companies since 2001.

In 2008, Oceanlinx (Botany, Australia) and Pelamis Wave Power (Edinburgh, Scotland) led in venture capital funding: Oceanlinx received $11 million from New Energy Fund, Espírito Santo Ventures and Emerald Technology Ventures; Pelamis raised $7 million from existing shareholders Emerald Technology Ventures, Statoilhydro Venture, BlackRock, Atmosand SPG Sustainable Performance Group and government-backed Scottish Venture Fund. In terms of publicly held companies, the major player is Ocean Power Technologies (OPT, Pennington, NJ) which raised a reported $40 million in a 2003 IPO on the London AIM exchange and approximately $90 million in its 2007 NASDAQ IPO.

Greentech Media and the Prometheus Institute for Sustainable Development in their report *Forecasting the Future of Ocean Power* said that analyzing the growth of the ocean power industry through investment inflow is a good way of assessing market trends. The report executive summary reported that in three of the years between 2001 and 2006 investment levels hovered around the $50 million range with 2007 passing $200 million. Three companies each raised $15 million VC in 2007, while Ocean Power Technologies managed a $90 million IPO on the Nasdaq. Also in 2007, the U.K. got serious about building a world-class ocean power program, doling out £13 million in DII grants to eight ocean power technology companies and one water transport company. Big VC rounds raised by Oceanlinx and Pelamis Wave Power, as well as Ocean Power Technologies's first IPO on London's AIM, drove investment in 2008.

The Prometheus Institute also noted that the United Kingdom could generate close to 20 percent of its electricity from its potential ocean power resource. In Canada this figure is more than 25 percent, while in the U.S. it slightly less than 9 percent. They assert that the diffusion of ocean power companies across a small number of largely similar countries reflects the resource-dependent nature of the industry and is reflective of a strong maritime heritage with the availability of support and service companies with extensive experience in marine construction and engineering. This includes active ports, as well as the availability of nearshore transmission and distribution systems. Extending power lines is both expensive and permits are difficult to obtain. Initial siting will occur where nearshore grid connections are easily available. Prometheus Institute concludes that "it is likely these countries will continue to lead the ocean power industry, and that this lead will solidify as stronger market-oriented support policies become established to move the industry from its current state."

### 9.1.2. California's First Commercial Plants

Recent analysis by EPRI estimated that in the United States, 10 GW of ocean wave power capacity will be on the grid in coastal states by 2025. One of the most well-endowed U.S. utilities is Pacific Gas & Electric (PG&E), with much of its vast service territory directly adjacent to California's coastline. "PG&E is in a very unique situation regarding wave energy," said Bedard. "PG&E has orders of magnitude more wave energy in their service territory than any other utility in the country."

The utility is seeking to develop two experimental wave farms off Humboldt and Mendocino counties. Known collectively as WaveConnect, the projects would be organized in similar fashion to the government-sponsored Wave Hub in southwest England. PG&E will develop a common underwater infrastructure of mooring and transmission cables and invite WEC technology companies to hook up their machines and test them in the swells. "They'll be chosen through a solicitation process, and we'd sign power purchase agreements for their energy," said Toman.

With the clock ticking on its three-year preliminary permit issued by the Federal Energy Regulatory Commission (FERC) in March 2008, PG&E was frustrated when the California Public Utility Commission deferred its decision on PG&E's request for renewable energy funds to perform environmental analyses, stakeholder meetings and other work associated with designing the project and applying for a FERC license. In late January 2009, however, the commission approved $4.8 million, money that will provide the needed cost share for $1.2 million PG&E had been granted earlier by the U.S. Department of Energy.

PG&E plans to seek a five-year license under FERC's hydrokinetic pilot project licensing process, which was designed to evaluate and grant provisional, short-term licenses for wave, tidal and instream river energy projects. The utility must also seek additional approval from the CPUC to put the project and the power purchase agreements (PPAs) with WEC developers in its rate base—the asset base that determines its regulated rate of return on investment. Assuming these approvals come forth, the utility and its prospective WEC partners could set up and operate the 5-MW first phase as early as 2012 at each of the two sites. After analyzing the wave farms' operations over some reasonable period, PG&E would then make a decision about moving forward with 40-MW projects at both sites, according to Toman.

**Figure 142 U.S. Wave Energy Projects (in MW)**

| Developer | Project Name- Site | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|---|---|
| Ocean Power Tech | Kaneohe, HI | 0.04 | | | | | | | | |
| Ocean Power Tech | New Jersey | 0.04 | | | | | | | | |
| Finavera | Makah Bay, WA | | CANCELLED | | | | | | | |
| Ocean Power Tech | Reedsport, OR | | | 2 | | | 8 | | 40 | |
| Oregon Wave Energy | Coos Bay, OR | | | | | 5 | | 25 | | 70 |
| Oregon Wave Energy | Newport, OR | | | | | | 5 | | 25 | |
| Finavera | Humboldt County, CA | | CANCELLED | | | | | | | |
| PG&E | Humboldt County, CA | | | | | | 5 | | | 40 |
| PG&E | Mendocino County, CA | | | | | | 5 | | | 40 |
| Ocean Power Tech | Humboldt County, CA | | | | | | | | 20 | |
| Oceanlinx | Maui, HI | | | | | | 2.7 | | | |
| Green Wave Energy | San Luis Obispo, CA | | | | | | | | 5 | |
| Green Wave Energy | Mendocino County, CA | | | | | | | | 5 | |
| Grays Harbor Ocean Energy | Washington | | | | | | | 6 | | 40 |
| Douglas County Wave Energy | Oregon | | | | | | 2 | | | |
| Tillamook Intergovernmental | Oregon | | | | | | 2 | | | 5 |
| Yearly capacity installed | | 0.08 | 0 | 2 | 0 | 5 | 29.7 | 31 | 95 | 195 |
| **Cumulative capacity** | | **0.08** | **0.08** | **2.08** | **2.08** | **7.08** | **36.78** | **67.78** | **162.78** | **357.78** |

*Source: EPRI Assessment of Waterpower Potential and Development Needs, 2007*

With its large balance sheet and $6 million in public money, PG&E may have what it takes to navigate the uncharted regulatory waters that lie in the path of any U.S. wave energy project developers. In spite of FERC's pilot licensing process, Bedard and other observers say that WEC projects still face a daunting permitting process that usually requires reviews by more than 25 federal and state agencies. Smaller developers can easily drown in the process. "Most of these [WEC] companies are small operations run by guys who've mortgaged their homes to get their businesses started," said Bedard. "To deal with this process requires significant resources."

Bedard points out that the first deployment of a WEC in U.S. waters—OPT's 40-kW PowerBuoy in Hawaii—"avoided FERC" because it sits in U.S. Navy waters. "The first wave plant that received a construction license [from FERC] was the Makah Bay [Washington] project over a year ago. It took [the developer] seven years to get the license, and it will never get built because the license they received was conditional on them getting approvals from 25 other agencies." As if to prove Bedard's point, Makah permit-holder Finavera Renewables announced Feb. 6, 2009 that it was abandoning its Makah license and exiting the wave energy business.

Bedard said the FERC pilot licensing process is still too much like the conventional hydropower permitting process, in which dam operators receive 30- to 50-year licenses. "They're applying a process that doesn't fit," he said of FERC. "These are modular devices that can be monitored, adapted and taken out if necessary. When you put a dam in, you can't take it out."

Neil Rondorf, a program manager with SAIC (San Diego and McLean, Va.) who is heading a DOE-funded project to develop industry standards for WECs, agrees with Bedard that permitting wave energy farms will be a particularly difficult challenge in the United States. He advocates that the various resource and environmental agencies charged with reviewing potential impacts cooperate with the emerging industry lest they cripple it in its infancy. "Without cooperation and the right approach to regulating the initial demonstration projects, the precautionary principle will become the exclusionary clause," said Rondorf.

**Figure 143 Most Attractive Markets for Wave & Tidal Energy**

| Top Five |
|---|
| England |
| France |
| Ireland |
| Portugal |
| Scotland |
| |
| **Other Leaders** |
| Australia |
| Canada |
| Chile |
| New Zealand |
| Spain |
| South Africa |
| USA |

*Source: Pelamis Wave Power; based on wave resources, market prices for electricity and government incentives like tax credits, preferential tariffs and marine supply obligations.*

## 9.1.3. Leading Companies in Wave & Tidal

In their *Forecasting the Future of Ocean Power* report, Greentech Media and Prometheus Institute identify 24 companies developing WECs. Of six types of WEC technology, the largest number of companies—10—is pursuing the point absorber approach. Looking like large offshore buoys, these devices have the advantage of absorbing energy from waves coming from all directions, notes the report. "Their behavior is much the same as that of a cork in a bathtub, bobbing in reaction to multi-directional ripples. All other wave energy devices are designed to absorb oncoming energy from only one direction or dimension in space." Point absorbers require advanced tuning systems, however; a need that some companies have overlooked, according to the report.

Co-author Travis Bradford said that there is a "high degree of certainty" that at least one and probably several of the companies designing WECs will see commercial success within a few years. Bradford declined to hazard a guess at which companies are in the best position to become the first WEC developers to achieve widespread commercial deployment. But anyone's list would likely include at least two companies:

Ocean Power Technologies. OPT is scaling up its 40-kW PowerBuoy (a point absorber) to 150-kW and 500-kW models. OPT expects to deploy devices in Oregon, Spain and Scotland in 2009 following three deployments in 2008 for the U.S. Navy which is sponsoring research to supply a Marine base in Hawaii and to power its Deep Water Acoustic Detection System (DWADS) equipment, plus a system in Spain for Iberdrola.

OPT has agreements with major energy companies and international renewable energy project developers, including Iberdrola and Total SA. It was accepted to install a 5-MW demonstration power station at England's Wave Hub. In partnership with Australia's Griffin Energy and Leighton Holdings, OPT is exploring 10-MW demonstration plants in Australia. And in January 2009, it announced an agreement with Lockheed Martin to collaborate on wave power projects in North America.

Pelamis Wave Power. The Scottish company earned the distinction of supplying the world's first commercial wave power plant when its three 750 kW WECs began sending electricity to the Portuguese grid last year.

Even with solid technology, some venture-funded start-ups that successfully deploy test devices will find themselves without the financial resources to develop WEC power stations, predicted Bradford. "When they get to the stage of doing their first commercial projects, all of a sudden the amount of money needed in series C and D is going to have another zero on the end," he said. The WEC companies that survive the development stage and move into successful commercial production will be those with the right "combination of technology, partnerships, time in the water and their balance sheet." And in these regards, he ranks Pelamis and OPT very highly, noting that Pelamis has financial backing from GE and that OPT has the newly minted Lockheed Martin agreement, plus $90 million in cash on hand as of the close of the third quarter 2008.

### 9.1.4. River and Tidal Instream Energy Conversion

Compared to the energy available in ocean waves, the megawatt-hours that can potentially be harvested from devices sitting in rivers and tidal channels is relatively small, at least in the United States, according to EPRI. EPRI estimates that by 2025, about 3 GW of new river and tidal power capacity could be online. By contrast EPRI predicts 10 GW of wave energy will be powering coastal grids by then, mostly in the West.

But development activity for river instream energy conversion (RISEC) and tidal instream energy conversion (TISEC) projects in the United States appears to be strongly outpacing that for ocean wave power. In 2008, the Federal Energy Regulatory Commission (FERC) issued 110 preliminary permits for RISEC projects, compared to six wave energy projects. (Preliminary permits are essentially three-year windows of opportunity for developers to conduct the necessary permitting activities in order to submit a full license application.) FERC issued just five tidal energy preliminary permits in 2008, but in 2007 it issued 27 preliminary permits for TISEC projects, three for wave projects and none for RISEC projects.

Most of the 2008 RISEC projects were proposed by two technology developers—Hydro Green Energy (Houston) and Free Flow Power (FFP) (Gloucester, Mass.). Hydro Green was the first company to license and install a commercial RISEC device in a U.S. river.

Hydro Green's rival Free Flow Power is credited with showing the greatest ambition for deployment of its devices, which will be stacked in arrays on two sides of poles sunk in river beds. The company had preliminary permits for 55 sites on the Lower Mississippi where it wants to build 1.8 GW of RISEC power capacity. "We can extract approximately 6 megawatts per mile of useable reach," said Free Flow Power's Chief Technical Officer Christopher Williams.

Both Hydro Green and FFP as well as other prospective RISEC technology and project developers will have to complete voluminous environmental studies prior to obtaining long-term licenses to operate. The impacts of turbines on fish populations are a top concern, as are potential shoaling and scouring action on the riverbeds.

### 9.1.5. Leading Players in Tidal Power

Both Hydro Green and FFP are aiming to deploy their RISEC machines to capture tidal energy as well. EPRI's advanced waterpower expert Roger Bedard said that RISEC devices can indeed function as TISEC machines if they're adapted to deal with the bidirectional water flows created by ebbing and flowing tides. "The machines also have to be able to withstand salt water, which involves different materials and coatings," said Bedard.

Tidal power is nothing new. In fact, a 240-MW tidal power plant that uses turbines embedded in a dam-like barrage has operated on the estuary of the Rance River in France since 1966. There are only two other tidal power plants worldwide, a 20-MW plant on the Bay of Fundy in Nova Scotia and a 0.4-MW plant near Murmansk in Russia. But a very large amount of tidal power may be coming to the U.K. grid within 10 to 15 years as the Department of Energy and Climate Change (DECC) weighs options for tidal power projects for the massive Severn Estuary in southeastern England.

**Figure 144 Installed and Planned U.S. Tidal Energy Capacity (in MW)**

| Developer | Project Name - Site | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|
| Verdant | E. River, NY + other sites NY & NJ | 0.07 | 4.9 | 10 | 15 | 20 |
| ORPC | Western Passage + other sites in Maine | 0.02 | | 5 | | 45 |
| Oceana | Golden Gate, CA | | | | 5 | |
| SNOPUD | Admiralty Strait, WA | | | | | 5 |
| TBD | Cook Inlet, AK | | | | | 5 |
| Yearly capacity installed | | 0.09 | 4.9 | 15 | 20 | 75 |
| **Cumulative capacity** | | **0.09** | **4.99** | **19.99** | **39.99** | **114.99** |

*Source: EPRI Assessment of Waterpower Potential and Development Needs, 2007*

After issuing a call for proposals, DECC and its principal consultant Parsons Brinckerhoff short-listed five possible projects involving either barrages or lagoons. They ranged from a $3.4 billion project that would produce 1.6 billion kilowatt hours (1.6 TWh) per year to a $31 billion option capable of generating 16.8 TWh annually, some 5% of the country's electricity needs. Next comes a series of environmental analyses on the various options. DECC expected to have these done by 2010, after which a decision would be made on whether to proceed. That decision would be followed by a three- to five-year "planning and consenting process," and—if approved—a five- to seven-year construction program.

While Severn is the most ambitious tidal power project under serious consideration, there are many others in development worldwide. Some are driven by governments seeking to explore options for tidal resources, while others are driven by TISEC technology companies and their partners.

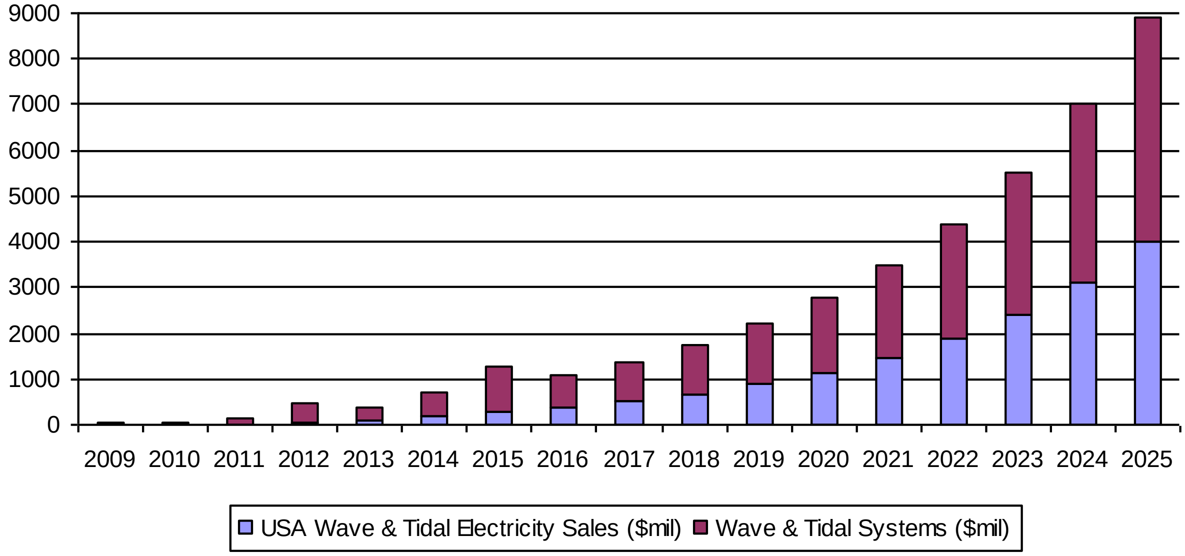
Internationally, two TISEC technology developers appear to be on the leading edge: Marine Current Turbines (MCT; Bristol, England) and OpenHydro (Dublin). MCT has installed the largest TISEC device in the world, a 1.2 MW SeaGen tidal stream turbine off Northern Ireland. With electricity flowing to the grid of ESB Independent, the project is being evaluated by Det Norsk Veritas, according to MCT's website. The company's next project will be a 10.5 MW project with npower renewables (Swindon, U.K.) off the coast of Anglesey, North Wales. "It is hoped the tidal farm will be commissioned around 2011/2012," states MCT on its website. MCT is also "investigating the potential for tidal energy schemes in other parts of the UK and Ireland, and in North America."

MCT's SeaGen consists of twin axial flow rotors of 15 to 20 meters in diameter mounted on a 3-meter wide monopile driven into the sea floor. While future generations of SeaGen may be completely submerged, current devices include a significant above-surface structure to which the turbines can be raised for maintenance. By contrast, Open Hydro's turbines are designed to be mounted on the sea floor. The company touts this as an advantage: "no part of the structure will be visible from the surface and [the machines] will be deep enough not to interfere with shipping traffic."

Open Hydro is testing a 300-kW machine at the European Marine Energy Center facility off Scotland's Orkney Island. It recently started manufacturing a 1 MW turbine and has project deals with Nova Scotia Power and Snohomish County on Washington State's Puget Sound. Recently the company announced that it took a 20% equity stake in Alderney Renewable Energy on Alderney, one of the Channel Islands between England and France. The island firm has an exclusive 65-year license from the States of Alderney to generate tidal and wave energy and initial rights to a European grid connection, according to the OpenHydro news release. The two firms are eyeing a 285-MW tidal energy project that could eventually be built out to 3,000 MW.

**Figure 145 U.S. Wave and Tidal Industry 2007- 2025**

| | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|---|---|---|---|
| USA Wave & Tidal Electricity Sales ($mil) | 0.029 | 0.064 | 2.80 | 9.05 | 19.981 | 66.679 | 98.796 | 168.070 | 295.443 | 390.606 |
| Wave & Tidal Systems ($mil) | 0.320 | 0.36 | 27.60 | 60.00 | 100.000 | 418.800 | 261.988 | 559.384 | 997.653 | 688.032 |




*Source: EPRI Assessment of Waterpower Potential and Development Needs, 2007*

# 10. Carbon Capture & Storage

By all accounts, the world's people and businesses will demand ever larger amounts of electricity over the next 50 years. Due to a formidable array of economic, geographic and political factors, coal will fuel much of that growth in electrical generation.

Despite sharp price increases recently, coal is still relatively cheap. Depending on the type, coal provides energy at costs ranging from one-third to less than one-fifth the cost per Btu of natural gas. It is abundant in China, the United States, India, Australia, South Africa and Russia, and it is widely traded, giving importing nations an alternative to politically risky natural gas suppliers.

But because coal-fired power plants emit at least 50% more carbon dioxide (CO2) per kilowatt-hour (kWh) than natural gas-burning plants, there is international consensus that growth in coal power must be accompanied by deployment of carbon capture and storage (CCS) systems. "Only CCS can reconcile the continued use of our enormous coal resources with the need to reduce CO2 emissions," wrote Steven Specker, CEO of the Electric Power Research Institute in the Spring 2007 *EPRI Journal*. "The development of this technology is essential for ensuring the sustainability of coal and other industrial processes," echoed E.U. Energy Commissioner Andris Piebalgs at a meeting of energy companies in September 2007.

The Intergovernmental Panel on Climate Change (IPCC) estimates that CCS will be needed to supply at least 15%—and as much as 55%—of the greenhouse gas (GHG) emission reductions needed to stabilize climate over the next century. In terms of quantities, CCS will be relied upon to sequester at least 220 billion tons of CO2 and as much as 2,200 billion tons through the 21st Century. (For reference, global anthropogenic CO2 emissions from fossil fuel consumption were about 28 billion metric tons in 2005.)

**Figure 146 Profile of Worldwide Large Stationary $CO_2$ Sources**

| Process | Number of sources | Emissions (MtCO2) |
|---|---|---|
| **Fossil Fuels** | | |
| Power | 4,942 | 10,539 |
| Cement Production | 1,175 | 932 |
| Refineries | 638 | 798 |
| Iron and steel industry | 269 | 646 |
| Petrochemical industry | 470 | 379 |
| Oil and gas processing | Not available | 50 |
| Other sources | 90 | 33 |
| **Biomass** | | |
| Bioethanol and bionenergy | 303 | 91 |

*Source: U.N. Intergovernmental Panel on Climate Change, Special Report of Carbon Capture and Storage, Sources with emissions of more than 0.1 million tonnes of CO2 (MtCO2) per year. Profile by process or industrial activity of worldwide large stationary CO2 sources with emissions of more than 0.1 million tonnes of CO2 (MtCO2) per year*

Yet the challenge of building adequate CCS systems is staggering. Enormous pipeline networks will have to be built in coal-consuming countries. In MIT's May 2007 study, *The Future of Coal*, the authors estimated that if just 60% of the CO2 currently produced by U.S. coal-based power plants were captured for geologic sequestration, the volume of CO2 pressurized, transported and injected underground on a daily basis would approach that of today's daily U.S. oil consumption. From EBI's perspective, if 60% of the U.S. power production from coal were fitted with CCS at reasonable costs substantially lower than today's R&D variety, this would represent the commercial potential of a $50-billion business in 2020.

In addition to new pipelines and injection wells, a vast array of measuring, monitoring and verification (MMV) systems must be deployed above CO2 reservoirs to safeguard and remediate leakage; and, akin to the requirements for storing nuclear waste, the monitoring of CO2 must continue for centuries. Entirely new liability and regulatory frameworks are needed to regulate CO2 injection and to quantify and manage risks such as potential contamination of nearby groundwater supplies.

The challenges for just capturing CO2 from existing and new coal-based power plants are just as daunting. While all the elements of capture systems have been deployed, at least on pilot scales, there has never been a full-sized power plant built with CCS. To scale up from the existing laboratory and pilot-scale demonstrations to the size of a typical coal plant—500 MW to 600 MW—presents a legion of unknowns. "The costs of these systems cannot be stated with a high degree of confidence," noted the authors of the 2005 U.N Intergovernmental Panel on Climate Change (IPCC) report *Carbon Dioxide Capture and Storage*. IPCC's best estimate at the time: to equip a new pulverized coal (PC) or integrated gasification combined cycle (IGCC) plant with CCS would raise the cost of electricity from $.01- $.05/kWh. In coal-dependent regions, where current electricity prices are relatively low, adapting CCS on a large scale could raise electricity costs by as much as 100%.

## 10.1. Electricity and Coal Statistical Review

Since the IPCC report was issued, increases in material and labor costs for heavy construction have rendered cost estimates even more vague. "What's a [CCS-equipped coal] plant going to cost? We haven't a clue because we haven't built any," said John Gibbins of the Energy Technology for Sustainable Development Group at Imperial College London. "What we do know is that the previous estimates were wrong. In the past you would have gotten wrap-around guarantees, a turnkey fixed price. That's very unlikely today because [power plant construction] has turned into a seller's market." MIT's study sharpens the current estimate range closer to $.02/kWh to $.03/kWh in additional CCS costs for PC and IGCC plants, a figure used by EBI in our models on the commercial potential of the CCS business. Interestingly, more than 80% of CCBJ survey respondents believe operating costs of coal plants will increase in the 10-40% range, but this excludes the high construction and storage infrastructure costs.

The up-front capital costs of construction are undoubtedly the most significant of the cost barriers. According to EBI's database of existing and proposed projects that include CCS or are 'CCS-ready', the aggregate average cost of construction is $2.2 million/MW of electric generating capacity, compared to a 2004 average of $1.3 million/MW for coal plants not involving CCS. Assuming an increase of 15-20% in base costs between 2004 and 2007, this indicates that CCS is adding about 40% to plant construction.

**Figure 147 World Electricity Generation by Fuel, 2004-2030 (in Trillion Kilowatt hours)**

| | Oil | Coal | Natural Gas | Renewables | Nuclear | Total |
|---|---|---|---|---|---|---|
| **2004** | 937.2 | 6,722.8 | 3,230.5 | 3,085.5 | 2,619.2 | 16,595.2 |
| **2010** | 987.9 | 8,073.8 | 4,281.5 | 3,666.2 | 2,722.3 | 19,731.7 |
| **2015** | 1,064.8 | 9,378.3 | 5,154.9 | 3,920.6 | 2,972.4 | 22,491.1 |
| **2020** | 1,106.2 | 10,711.4 | 5,914.3 | 4,199.4 | 3,255.2 | 25,186.6 |
| **2025** | 1,149.1 | 12,101.6 | 6,580.9 | 4,503.8 | 3,472.0 | 27,807.3 |
| **2030** | 1,178.3 | 13,649.6 | 7,423.3 | 4,803.9 | 3,618.7 | 30,673.8 |

*Source: DOE, EIA, http://www.eia.doe.gov/oiaf/ieo/ieographic_data.html*

**Figure 148 World Coal Consumption by Region, 2004-2030 (quadrillion BTUs)**

| | China | United States | India | Rest of World | Total |
|---|---|---|---|---|---|
| **2004** | 41.1 | 22.6 | 8.1 | 42.7 | 114.5 |
| **2010** | 55.3 | 24.2 | 9.3 | 47.5 | 136.3 |
| **2015** | 65.3 | 25.6 | 10.7 | 49.9 | 151.6 |
| **2020** | 75.6 | 27.3 | 12.2 | 52.1 | 167.2 |
| **2025** | 85.0 | 30.6 | 13.7 | 53.6 | 182.9 |
| **2030** | 95.2 | 34.1 | 15.2 | 54.6 | 199.1 |

*Source: DOE, EIA, http://www.eia.doe.gov/oiaf/ieo/ieographic_data.html*

The MIT Future of Coal report authors estimate that adding CCS apparatus to a new 500-MW coal plant would increase costs by 74% for subcritical pulverized coal (PC) technology, 61% for supercritical PC, 54% for ultrasupercritical PC and 32% for IGCC (excluding transport and injection costs). It bears repeating that heavy construction costs have gone up since 2005, the year on which MIT's cost estimates were based. The cost of an average planned large-scale 1,600-MW SCPC coal plant with CCS from EBI's list in 2008 is $2.5-3 billion, and the cost of a typical planned IGCC 630-MW coal plant with CCS is $1.5-2 billion.

**Figure 149 Coal Consumption in China by Sector, 2004, 2015, and 2030 (quadrillion BTUs)**

| | 2004 | 2015 | 2030 |
|---|---|---|---|
| **Electricity** | 22.7 | 39.0 | 55.9 |
| **Industrial** | 15.6 | 23.1 | 36.5 |
| **Other Sectors** | 2.7 | 3.2 | 2.8 |
| **Total** | **41.1** | **65.3** | **95.2** |

*Source: DOE, EIA, http://www.eia.doe.gov/oiaf/ieo/ieographic_data.html*

**Figure 150 Selected Major Carbon Capture & Storage Projects in 2008**

| Owner/Operator | Location | Type |
|---|---|---|
| **Existing** | | |
| Salah Gas | Salah, Algeria | NG production |
| Blue Source | Multiple, Wyo, Colo. | NG processing |
| Dakota Gasification | N. Dakota | Syngas manufacturer |
| Statoil | Sleipner, Norway | NG production |
| Alcoa | Kwinana, Aust. | Aluminum plant |
| **Proposed** | | |
| AEP | Oklahoma | PC Power |
| AEP | W. Virginia | IGCC Coal Power |
| AEP | Ohio | IGCC Coal Power |
| Alcoa | Kwinana, Aust. | Aluminum plant |
| Callide | Queensland, Aust | Oxyfuel Coal Power |
| Centrica | Teesside, UK | IGCC Coal Power |
| Clean Energy Systems | Bakersfield, Calif. | Oxyfuel gas power |

| | | |
|---|---|---|
| Duke Energy | Edwardsport, Ind. | IGCC Coal Power |
| Duke Energy | Cliffside, NC | PC Power |
| E.ON | Killingholme, UK | IGCC Coal Power |
| E.ON | Kingsnorth, UK | SCPC Power |
| Energy Northwest | Kalama, Wash. | IGCC Pet Coke Power |
| EPCOR | Alberta, Canada | IGCC |
| Excelsior Energy | Mesaba, Minn. | IGCC |
| FirstEnergy | Akron, Ohio | Capture Test on PC Plant |
| Fund. Ciuden de la Energia | El Bierzo, Spain | Oxyfuel Coal Power |
| FutureGen | TBA | IGCC Coal Power |
| Gorgon | Australia | NG processing |
| GreenGen | Tianjin, China | IGCC Coal Power |
| H Energy (BP & Rio Tinto) | Carson, Calif. | IGCC Pet Coke Power |
| Hydrogen Energy | Kwinana, Australia | IGCC Coal Power |
| Hypogen (EC Project) | Norway, UK, Germany | Coal/NG offshore CCS |
| Jamestown Bd Public Utilities | Jamestown, NY | CFB Coal Power |
| Monash Energy | Latrobe Valley, Australia | IGCC Coal Liq/Power |
| Norwegian Ministry of | Karsto, Nor. | NG production |
| Petroleum and Energy | Mongstad, Nor. | NGCC CHP |
| NRG | Tonawanda, NY | IGCC |
| Peabody Energy | TBA in USA | Syngas production |
| Peabody Energy | Southern Illinois | SCPC |
| Powerfuel | Yorkshire, UK | IGCC Coal Power |
| RWE | Tilbury, UK | SCPC |
| RWE | Blyth, UK | SCPC |
| RWE | Germany | SCPC |
| SaskPower | Saskatchewan, Canada | Oxycoal technology |
| Seminole Electric Coop. | Tampa, Fla. | SCPC |
| StatoilHydro | Barents Sea | NG production |
| Tenaska | Sweetwater, Texas | SCPC Power |
| Tenaska | Taylorsville, Ill. | IGCC Coal Power |
| Vattenfall | Schwarze Pump, Germany | Oxyfuel Coal Power |
| Xcel | Colorado | IGCC Coal Power |
| ZeroGen | Brisbane, Australia | IGCC Coal Power |

*Source: EBI Inc. database of CCS projects; NG = Natural Gas; SCPC = supercritical pulverized coal, NGCC = Natural Gas Combined Cycle, PC = pulverized coal, IGCC = integrated gasification combined cycle, CHP = Combined Heat and Power*

As the list of prominent demonstration projects above indicates, post-combustion capture strategies are being deployed on existing coal-fired plants, while the two leading new-build CCS projects will be IGCC plants. New plants can also be built with post-combustion capture as well as oxyfuel technology (firing with oxygen instead of air to create a concentrated CO2 effluent), but an existing plant cannot be converted to an IGCC configuration.

As noted by the MIT's May 2007 Future of Coal report, choosing capture technology for a new plant "involves a delicate balancing of considerations." Future tightening of standards for criteria pollutants (SO2, NOx and mercury) favors IGCC. The ability to use lower-ranked coal and to cycle plants more in response to loads argues for post-combustion technology.

Worldwide, one government stands out in its commitment to CCS: Alberta. The oilsands-dependent province is banking on CCS as a means to mitigate CO2 emissions from oilsands mining and refining, as well as coal power plants. Alberta has three million people and it's spending $2 billion on CCS. Among the demo projects will be an IGCC project near Edmonton built by Capital Power Corp. (formerly Epcor). "There's also going to be what they're calling the CO2 trunk line, a pipeline that will be strategically located to pass by a lot of the major sources of CO2, both existing coal plants and also oil and gas refineries, and bring it down to oilfields."

### The EOR Bridge

Using CO2 for enhanced oil recovery (EOR) can generate revenue to help defray the costs of CCS. With EOR, highly pressurized CO2 (or in some cases steam, water or other substances) is injected into declining oil reservoirs. These "floods" increase viscosity and drive the remaining oil toward wells.

First implemented 30 years ago in the Permian Basin of Texas, the CO2-based EOR market has grown on the back of rising oil prices to the point where a 3,500-mile pipeline network distributes more than 30 million metric tons of CO2 annually to oil producers as far as Saskatchewan and the U.S. Northwest.

Most CO2 used in EOR is from natural underground CO2 reservoirs, but in the last decade, increasing amounts have come from anthropogenic sources like natural gas processors that must separate CO2 from methane to produce pipeline-quality gas. In North Dakota, a coal gasification plant has been shipping CO2 for EOR to oilfields in Saskatchewan since 2000. In the near future, coal-plant operators with CCS hope to sell their captured CO2 to oilfield operators.

## 10.2. Technology and EPC Vendors in CCS

For energy companies, utilities and power plant developers who are contemplating carbon capture and storage (CCS) to control greenhouse gas emissions from coal power plants, there can be few questions more important and challenging than deciding which technological pathways to pursue.

The choice of which pathway to select is predicated first on whether a company is looking to retrofit an existing coal plant or build a new greenfield plant. "There is a large inventory of existing [pulverized coal or PC] power plants, many still operating at fairly high efficiencies with substantial remaining life," said David South, a researcher and consultant whose Technology & Market Solutions firm advises energy companies on environmental and regulatory issues and strategies. In the United States, South commented, much of the existing PC fleet has been upgraded recently to meet changes in air quality laws. "Technological solutions came forward that allowed the industry to maintain these units and yet be in compliance. Because of that, and the cost of replacement and the value of these sites where current coal-fired plants are, [post-combustion] carbon capture technologies are being explored, developed and tested on existing units."

For new-build projects, all three options are possible, with the additional option of building greater efficiency—and lower CO2 emissions per kWh—into PC plants by engineering them to operate at higher temperatures and pressures; known as supercritical or ultrasupercritical PC. Studies based on reference plant designs have shown that IGCC with carbon capture will produce electricity less expensively than PC plants with post-combustion capture, largely because the separation is done on the front end with a relatively pure stream of $CO_2$ from the manufactured syngas, while post-combustion methods must extract $CO_2$ from flue gas which contains more impurities. IGCC also offers the advantage of lower emissions of $SO_2$, $NO_x$ and mercury.

**Figure 151 Three CCS Technologies**

| Owner/Operator | Location |
|---|---|
| **1) Integrated Gasification Combined Cycle (Igcc) With CO2 Capture.** | This technology involves gasifying coal, then using a shift reactor, then gas cleanup equipment to remove the CO2 and other pollutants from the syngas stream, combusting the hydrogen-rich gas in turbines, and using waste heat to make steam to drive a steam turbine. |
| **2) Pulverized Coal (PC) With Post-Combustion Capture** | With this approach, coal is burned in a boiler surrounded by tubes in which steam is created to drive turbines. The CO2 is removed after combustion from the flue gas along with other pollutants. |
| **3) Oxyfuel Firing With Post-Combustion Capture** | This approach is the same as 2), except the coal is combusted using oxygen instead of air, yielding a relatively pure stream of CO2 which makes carbon capture easier. In addition to PC plants, oxyfuel will work with circulating fluidized-bed (CFB) combustion. (A CFB plant could theoretically use post-combustion capture without oxyfuel, but because of CFB's flue gas characteristics, oxyfuel firing is considered the most viable option for CFB combustion.) |

*Source: EBI Inc.*

**Figure 152 Competitors in CCS Technology**

| Competitors in CCS Technology |
|---|
| **Major IGCC Alliances** |
| Bechtel (EPC) - GE (Gasifier) |
| Fluor (EPC) - Conoco-Phillips (Gasifier) |
| Black & Veatch (EPC) - Uhde (Gasifier, Shell technology) |
| |
| **Other Gasifier Manufacturers** |
| Siemens |
| KBR |
| Mitsubishi Heavy Industries |
| Lurgi (Air Liquide) |
| British Gas/Lurgi (Allied Syngas) |
| |
| **Oxyfuel combustion technology** |
| Babcock & Wilcox (EPC) |
| Foster Wheeler (EPC) |

| |
|---|
| |
| **Industrial gas suppliers** |
| Air Liquide |
| Air Products |
| Praxair |
| |
| **Post-combustion capture technology** |
| Alstom |
| Kerr McGee |
| Fluor |
| MHI |
| Powerspan |
| BASF |
| HTC Purenergy |
| Carbozyme |

*Source: EBI Inc. Note: Gasifier technology companies are mostly licensors*

## 10.3. CCBJ's Carbon Capture & Storage Survey 2008

This section presents results of CCBJ's Carbon Capture and Storage Survey conducted in May and June 2008.

**Figure 153 Percentage of U.S. Electricity Generation Coal in 2020**

U.S. DOE's Energy Information Administration says coal was responsible for 49% of U.S. electricity generation in 2006. What percentage of U.S. electricity generation do you believe coal will represent in 2020?

| | # of responses | % of total |
|---|---|---|
| <10% | 0 | 0.0% |
| 10-20% | 0 | 0.0% |
| 20-30% | 0 | 0.0% |
| 30-35% | 3 | 6.0% |
| 35-40% | 9 | 18.0% |
| 40-45% | 6 | 12.0% |
| 45-50% | 14 | 28.0% |
| 50-55% | 13 | 26.0% |
| 55-60% | 5 | 10.0% |
| 60-70% | 0 | 0.0% |
| >70% | 0 | 0.0% |
| **Total** | **50** | **100.0%** |

*Source: CCBJ's Carbon Capture & Storage Survey 2008*

**Figure 154 Percentage of U.S. Electricity Generation Coal in 2050**

What percentage of U.S. electricity generation do you believe coal will represent in 2050?

| | # of | % of total |
|---|---|---|

| | responses | |
|---|---|---|
| <10% | 0 | 0.0% |
| 10-20% | 3 | 6.0% |
| 20-30% | 8 | 16.0% |
| 30-35% | 7 | 14.0% |
| 35-40% | 6 | 12.0% |
| 40-45% | 4 | 8.0% |
| 45-50% | 6 | 12.0% |
| 50-55% | 8 | 16.0% |
| 55-60% | 5 | 10.0% |
| 60-70% | 3 | 6.0% |
| >70% | 0 | 0.0% |
| **Total** | **50** | **100.0%** |

*Source: CCBJ's Carbon Capture & Storage Survey 2008*

**Figure 155 Estimated Year for 10% Development of Technology, Installation, and Operation of CCS Systems**

By what year do you think the development of carbon capture & storage technology and installation and operation of CCS systems will be associated with at least 10% of US electricity generation?

| | # of responses | % of total |
|---|---|---|
| 2009-2010 | 1 | 2.0% |
| 2011-2012 | 1 | 2.0% |
| 2013-2014 | 2 | 4.0% |
| 2015-2016 | 8 | 16.0% |
| 2017-2018 | 9 | 18.0% |
| 2019-2020 | 5 | 10.0% |
| After 2020 | 22 | 44.0% |
| Never | 2 | 4.0% |
| **Total** | **50** | **100.0%** |

*Source: CCBJ's Carbon Capture & Storage Survey 2008*

**Figure 156 Total U.S. Electricity Generating Capacity Equipped with CCS by 2020**

What portion of total U.S. electricity generating capacity from all sources do you estimate will be equipped with CCS by 2020?

| | # of responses | % of total |
|---|---|---|
| Less than 5% | 11 | 23.4% |
| <10% | 17 | 36.2% |
| 10-20% | 10 | 21.3% |
| 20-30% | 4 | 8.5% |
| 30-40% | 2 | 4.3% |
| 40-50% | 1 | 2.1% |
| 50-60% | 1 | 2.1% |
| 60-70% | 0 | 0.0% |
| 70-80% | 0 | 0.0% |
| More than 80% | 1 | 2.1% |
| **Total** | **47** | **100.0%** |

*Source: CCBJ's Carbon Capture & Storage Survey 2008*

# 11. Energy Efficiency & Demand Response

## 11.1. EE&DR Market Overview

Politically speaking, energy efficiency is hot. Thirty years after U.S. President Jimmy Carter urged Americans to conserve in the wake of oil price shocks, energy efficiency has recovered from the disrespect of the Reagan era, the disincentives of cheap oil and gas, and the loss of state mandates that disappeared in the mid-1990s with U.S. electricity market restructuring.

Fueling the renaissance are the same drivers that animate the rest of the clean energy industry: policies that encourage or require utilities and end-users to invest in carbon-reduction measures; the desire of businesses, institutions, governments and individuals to do something—and to show they're doing something—about the threat of climate change; and the rising costs of energy. Additionally, champions of energy efficiency now lead the White House and the Department of Energy. President Obama called energy efficiency "one of the fastest, easiest, and cheapest ways to make our economy stronger and cleaner."

Indeed, for climate-change mitigation and energy security goals, nothing beats energy efficiency. Studies by United Nations Foundation, World Business Council for Sustainable Development, Electric Power Research Institute, McKinsey & Co., American Council for an Energy Efficient Economy (ACEEE) and others have shown that energy use either in the United States or globally could be reduced 15-25% from a business-as-usual scenario by 2030 through efficiency measures. With estimated global greenhouse gas (GHG) emissions for 2030 on the order of 40 billion metric tons of CO2-equivalent, a 20% drop represents 8 billion tCO2-e or more than today's total North American emissions.

Focusing on non-transportation energy efficiency, captures the vast majority of GHG emissions and the commercial energy efficiency market. An emphasis on buildings is not misplaced as the Intergovernmental Panel on Climate Change (IPCC) estimates that energy usage in buildings accounts for 35% of emissions. In the United States, just residential and commercial buildings account for 37% of US GHG emissions.

But as a business segment, energy efficiency resists definition and quantification. This is because in addition to being a business, it is a movement and a mostly gradual evolution toward more sustainable practices in design, manufacturing and building operations. Appliance standards and building codes have become progressively more stringent over the last several decades, contributing to the decline in U.S. greenhouse gas (GHG) intensity from 1990 through 2007; so separating market-standard products from energy-efficient ones is not a straightforward proposition.

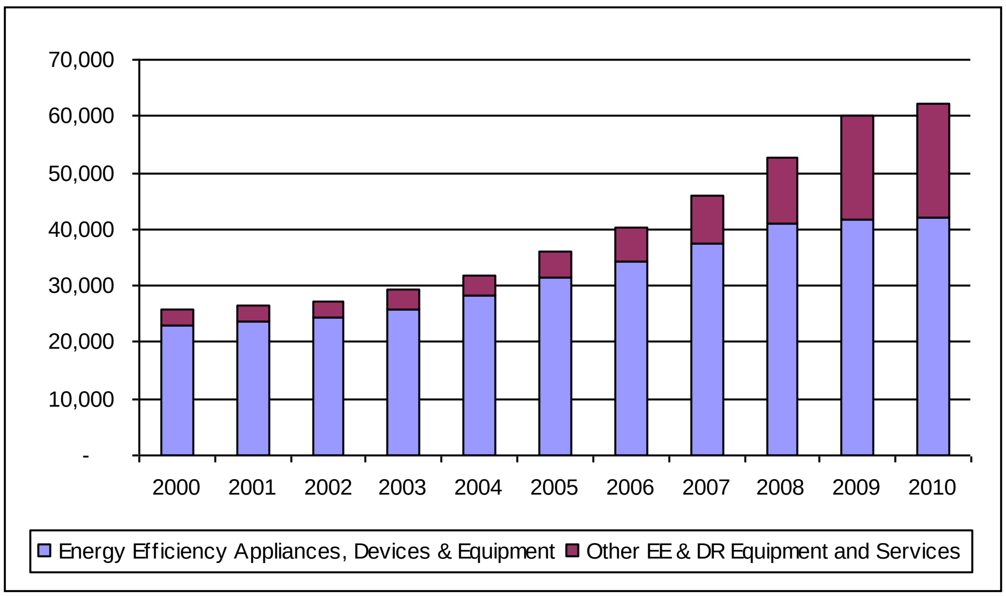
For many categories of residential energy-consuming equipment and appliances, the U.S. Environmental Protection Agency's Energy Star rating system provides a viable and well-established standard. However, in many categories like computers and printers, the vast majority of products—as much as 99% in some categories—are Energy Star rated. While computer and peripheral manufacturers should be lauded for producing 90%-plus energy-efficient products, this data highlights the need for better answers to the question "just how efficient is energy efficient?"

Services that result in improved energy efficiency can also be hard to categorize. In most states, a housing subdivision or office park built in 2008 will be much more energy efficient than one built 20 or 30 years ago because of building codes and improvements in design principles and materials. But are the design, engineering and construction contracts for those projects part of the energy-efficiency industry or part of the mainstream construction industry?

To quantify the energy efficiency industry, EBI first aggregated the reasonably well documented energy service company sector (also known as ESCOs) with our own research on consulting & engineering firms and other specialty energy services to come up with about **$6 billion in U.S. energy efficiency services revenues in 2008, about 10% of which are generated in California.**

Energy efficient appliances, devices, control systems and other equipment required more use of somewhat subjective standards of classification for sales by product category. This result was triangulated with compiled EE spending figures by major sectors in the economy and recognized economic models used by analysts at ACEEE and elsewhere that estimate annual EE investment based on rates of energy efficiency improvement, the average price of energy and a conservative investment payback period. Last, these figures were reconciled with an energy efficiency company model derived from EBI's sales estimates of the leading firms and a number of companies of various sizes in EBI's energy efficiency database

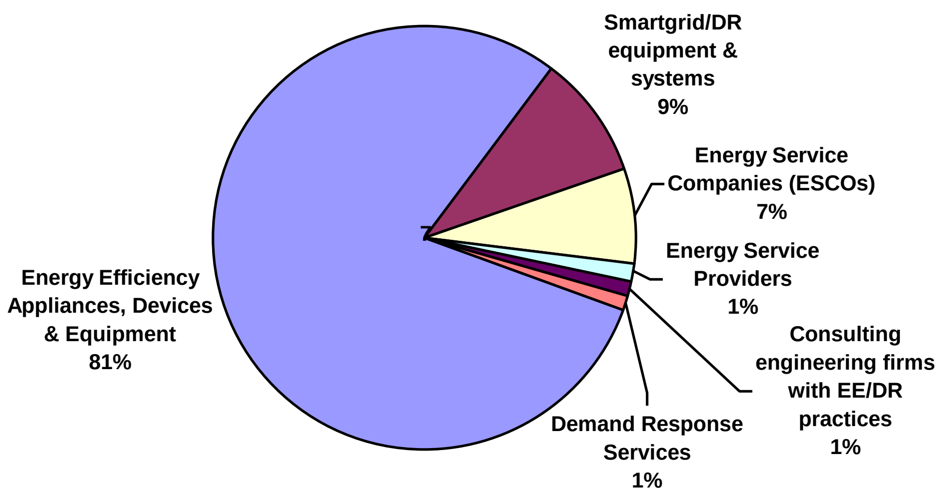
**Figure 157 U.S. Energy Efficiency & Demand Response Industry 2000-2010**




*Source: EBI Inc., from a market model derived from a variety of sources including American Council for an Energy-Efficient Economy, Energy Information Administration, Electric Power Research Institute, McKinsey, MIS, WBCSD, U.S. Department of Energy, Lawrence Berkeley National Laboratory and others.*

It's important to note that we also included demand response equipment and services in EBI's broader Energy Efficiency & Demand Response (EE&DR) segment of the clean energy industry. While primarily aimed at increasing grid reliability and meeting growing peak loads cost effectively, demand response can mitigate carbon emissions by reducing overall energy consumption and enabling the integration of more renewable energy into utility grids. In combination with smart grid technology, demand response can also support the dynamic shifting of discretionary loads (clothes washing, electric vehicle charging) to times when intermittent renewables like wind power are generating, and even to improve the efficiency of coal-fired power plants. Finding where it is wasted and how operational adjustments, equipment upgrades or building retrofits can offer value to owners is a much more complex endeavor. Because most homeowners and business managers resist EE investments with paybacks of more than two to three years, most of the EE improvements made in the last 25 years have been the low hanging fruit of energy efficiency. Much of this fruit has been harvested by a relatively unsophisticated user community. The majority of the harvest awaits, but it will demand the sophistication of a technically-competent, financially-savvy and well-capitalized EE&DR industry to take advantage of it.

**Figure 158 U.S. Energy Efficiency & Demand Response Industry 2009: $51 billion**




*Source: EBI Inc.*

## $50 Billion and Counting

EBI estimates the Energy Efficiency & Demand Response segment of the clean energy industry to have generated $51 billion in revenues in the United States in 2008, most of which is attributable to energy efficiency. Just EE appliances, devices, control systems and equipment represented 81% with energy services and consulting & engineering making up the rest. These estimates are in line with the “efficiency-premium” conclusions drawn by economic studies done by ACEEE and very conservative when compared to others trumpeting a trillion-dollar EE industry.

In spite of the spread in size, most researchers agree that recent growth has been noteworthy: note the 20-30% of some renewable energy segments, but well ahead of the growth of the economy and the overall rate of government, institutional, corporate and residential expenditures that pace EE investments. EBI puts EE&DR annual growth between 2005 and 2008 at 12-14%, led by the emergence of DR equipment in the form of smart meters and DR services. However, EE on its own has grown 10-11% on those years, up from 3-8% per year from 2000-2005 and harkening back to the first efficiency boom fueled by the run-up in energy prices in the early 70s. After 6% growth in 2009, EBI’s current forecast expects some leveling in EE revenues growth to 6-8% per year with still slower capital expenditures during the recession and recovery.

Our analysis of the $787-billion stimulus plan identified $52.2 billion in clean energy industry-related spending out of the $500 billion total spending authorized (the remaining $287 billion are tax programs). Of the $52 billion, $21.5 billion or 41% is related to energy efficiency and $13.4 billion or 26% pertains to grid and transmission infrastructure. Much of this funding has yet to be awarded, but it is certainly on the radar screen if not in the crosshairs of most of the EE&DR industry with 92% of CCBJ survey respondents intending to take a crack at ARRA projects.

**Figure 159 U.S. Energy Efficiency & Demand Response Industry 2007-2009**

| | 2007 | 2008 | 2009 |
|---|---|---|---|
| Energy Efficiency Appliances, Devices & Equipment | 37,761 | 41,056 | 40,922 |
| Smartgrid/DR equipment & systems | 1,107 | 2,413 | 4,846 |
| Energy Service Companies (ESCOs) | 3,173 | 3,378 | 3,676 |
| Energy Service Providers | 635 | 676 | 735 |
| Consulting engineering firms with EE/DR practices | 465 | 510 | 612 |
| Demand Response Services | 232 | 367 | 513 |
| **Total EE & DR Industry** | **43,373** | **48,400** | **51,303** |
| **Growth** | **9.2%** | **11.6%** | **6.0%** |

*Source: EBI Inc., from a market model derived from a variety of sources including American Council for an Energy-Efficient Economy, Energy Information Administration, Electric Power Research Institute, McKinsey, MIS, WBCSD, U.S. Department of Energy, Lawrence Berkeley National Laboratory and others.*

**Figure 160 The Global Energy Efficiency & Demand Response Industry**

| | 2007 | 2008 | 2009 | 2008 Growth | 2009 Growth |
|---|---|---|---|---|---|
| Energy Efficiency Appliances, Devices & Equipment | 120.83 | 131.38 | 130.95 | 9% | 0% |
| Energy Efficiency Services (ESCO, ESP, C&E) | 13.67 | 14.61 | 16.07 | 7% | 10% |
| Smartgrid/DR equipment & systems | 3.54 | 7.72 | 14.10 | 118% | 83% |
| Demand Response Services | 0.42 | 0.66 | 0.92 | 58% | 40% |
| **Total EE & DR Industry** | **138.47** | **154.37** | **162.04** | **1%1** | **5%** |

*Source: EBI Inc., from a market model derived from a variety of sources including American Council for an Energy-Efficient Economy, Energy Information Administration, Electric Power Research Institute, McKinsey, MIS, WBCSD, U.S. Department of Energy, Lawrence Berkeley National Laboratory and others.*

**Figure 161 U.S. Energy Efficiency & Demand Response Industry**

| | 2007 | 2008 | 2009 | 2008 Growth | 2009 Growth |
|---|---|---|---|---|---|
| Energy Efficiency Appliances, Devices & Equipment | 37.76 | 41.06 | 40.92 | 9% | 0% |
| Energy Efficiency Services (ESCO, ESP, C&E) | 4.27 | 4.56 | 5.02 | 7% | 10% |
| Smartgrid/DR equipment & systems | 1.11 | 2.41 | 4.85 | 118% | 101% |
| Demand Response Services | 0.23 | 0.37 | 0.51 | 58% | 40% |
| **Total EE & DR Industry** | **43.37** | **48.40** | **51.30** | **12%** | **6%** |

*Source: EBI Inc., from a market model derived from a variety of sources including American Council for an Energy-Efficient Economy, Energy Information Administration, Electric Power Research Institute, McKinsey, MIS, WBCSD, U.S. Department of Energy, Lawrence Berkeley National Laboratory and others.*

**Figure 162 California Energy Efficiency & Demand Response Industry**

| | 2007 | 2008 | 2009 | 2008 Growth | 2009 Growth |
|---|---|---|---|---|---|
| Energy Efficiency Appliances, Devices & Equipment | 3.47 | 3.70 | 3.60 | 6% | -3% |
| Energy Efficiency Services (ESCO, ESP, C&E) | 0.34 | 0.37 | 0.39 | 8% | 7% |
| Smartgrid/DR equipment & systems | 0.18 | 0.34 | 0.63 | 91% | 86% |
| Demand Response Services | 0.02 | 0.03 | 0.04 | 56% | 36% |
| **Total EE & DR Industry** | **4.01** | **4.42** | **4.66** | **10%** | **5%** |

*Source: EBI Inc., from a market model derived from a variety of sources including American Council for an Energy-Efficient Economy, Energy Information Administration, Electric Power Research Institute, McKinsey, MIS, WBCSD, U.S. Department of Energy, Lawrence Berkeley National Laboratory and others.*

**Figure 163 U.S. Energy Efficiency & Demand Response Industry as a Percentage of Global Total**

| | 2007 | 2008 | 2009 |
|---|---|---|---|
| Energy Efficiency Appliances, Devices & Equipment | 31% | 31% | 31% |
| Energy Efficiency Services (ESCO, ESP, C&E) | 31% | 31% | 31% |
| Smartgrid/DR equipment & systems | 31% | 31% | 34% |
| Demand Response Services | 56% | 56% | 56% |
| **Total EE & DR Industry** | **31%** | **31%** | **32%** |

*Source: EBI Inc., from a market model derived from a variety of sources including American Council for an Energy-Efficient Economy, Energy Information Administration, Electric Power Research Institute, McKinsey, MIS, WBCSD, U.S. Department of Energy, Lawrence Berkeley National Laboratory and others.*

**Figure 164 California Energy Efficiency & Demand Response Industry as a Percentage of U.S. Total**

| | 2007 | 2008 | 2009 |
|---|---|---|---|
| Energy Efficiency Appliances, Devices & Equipment | 9.2% | 9.0% | 8.8% |
| Energy Efficiency Services (ESCO, ESP, C&E) | 7.9% | 8.0% | 7.8% |
| Smartgrid/DR equipment & systems | 16.0% | 14.0% | 13.0% |
| Demand Response Services | 7.3% | 7.2% | 7.0% |
| **Total EE & DR Industry** | **9.2%** | **9.1%** | **9.1%** |

*Source: EBI Inc., from a market model derived from a variety of sources including American Council for an Energy-Efficient Economy, Energy Information Administration, Electric Power Research Institute, McKinsey, MIS, WBCSD, U.S. Department of Energy, Lawrence Berkeley National Laboratory and others.*

**Figure 165 U.S. and California Energy Efficiency & Demand Response Industry: Employment**

| | USA $bil in 2009 | USA 2009 Jobs | Calif. $bil in 2009 | Calif. 2009 Jobs | % of USA Jobs in Calif. |
|---|---|---|---|---|---|
| Energy Efficiency Appliances, Devices & Equipment | 40.92 | 179,500 | 3.60 | 15,790 | 8.8% |
| Energy Efficiency Services (ESCO, ESP, C&E) | 5.02 | 29,600 | 0.39 | 2,310 | 7.8% |
| Smartgrid/DR equipment & systems | 4.85 | 21,700 | 0.63 | 2,820 | 13.0% |
| Demand Response Services | 0.51 | 2,900 | 0.04 | 210 | 7.0% |
| **Total EE & DR Industry** | **51.30** | **233,700** | **4.66** | **21,130** | **9.0%** |

*Source: EBI Inc., from a market model derived from a variety of sources including American Council for an Energy-Efficient Economy, Energy Information Administration, Electric Power Research Institute, McKinsey, MIS, WBCSD, U.S. Department of Energy, Lawrence Berkeley National Laboratory and others.*

### 11.1.1. Drivers: State and Federal Policy

Even with the ARRA funding, states are still in the lead with incentives and policies that move the market and create business for consultants, engineers and energy service companies. "States are adopting aggressive energy efficiency policies, increasing investments in efficiency programs, and improving efficiency in their own facilities and fleets," reported ACEEE earlier this year. The progress is not uniform, noted ACEEE which ranked states such as Wyoming, Alabama and the Dakotas at the bottom of its annual Scorecard, but the trend is unmistakably positive.

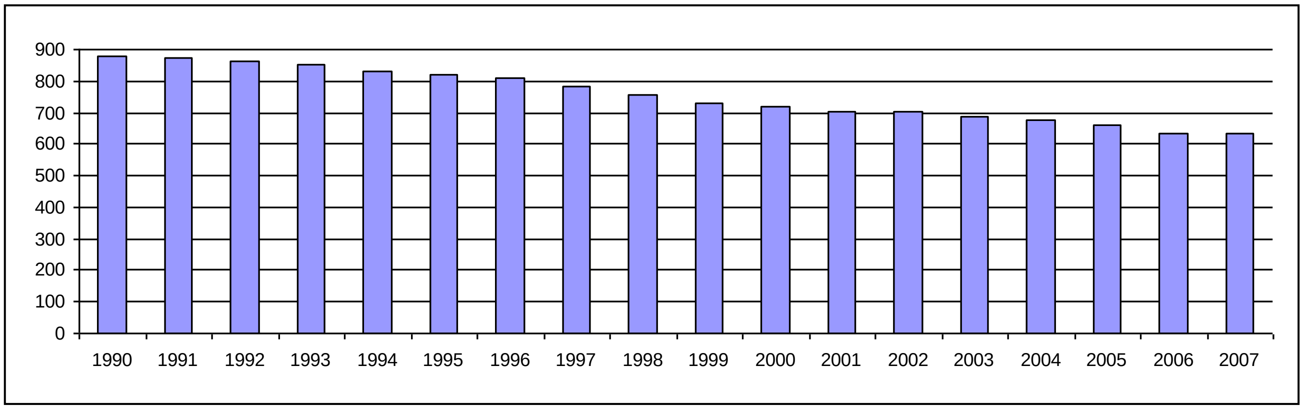
A tough measure that many states are adopting is known as an energy efficiency resource standard (EERS)—a mandate that utilities meet a certain percentage of future energy demand with energy efficiency—just as a renewable energy standard (RES) that requires 20% renewables use requires them to hit growth targets for renewable energy. An EERS is usually paired with a rate-payer funded program run by utilities or third-party operators.

**Figure 166 Potential from Energy Efficiency and Demand Response Programs in the U.S. (2010-2030)**

| Summary of Energy-Efficiency Measures |
|---|
| **Residential Sector Measures** |
| Efficient air conditioning (central, room, heat pump) |
| Efficient space heating (heat pumps) |
| Efficient water heating (e.g. heat pump water heaters & solar water heating) |
| Efficient appliances (refrigerators, freezers, dishwashers, clothes washers, clothes dryers) |
| Efficient lighting (CFL, LED, linear fluorescent) |
| Efficient power supplies for Information Technology and consumer electronic appliances |
| Air conditioning maintenance |
| Heat pump maintenance |
| Duct repair and insulation |
| Infiltration control |
| Whole-house and ceiling fans |
| Reflective roof, storm doors, external shades |
| Roof, wall and foundation insulation |
| High-efficiency windows |
| Faucet aerators and low-flow showerheads |
| Pipe insulation |
| Programmable thermostats |
| In-home energy displays |
| **Commercial Sector Measures** |
| Efficient cooling equipment (chillers, central AC) |
| Efficient space heating equipment (heat pumps) |
| Efficient water heating equipment (heat pumps) |
| Efficient refrigeration equipment & controls (e.g. efficient compressors, floating head pressure controls, anti-sweat heater controls, etc.) |
| Efficient lighting (interior and exterior; LED exit signs, task lighting) |
| Lighting controls (occupancy sensors, daylighting, etc.) |
| Efficient power supplies for Information Technology and electronic office equipment |
| Water temperature reset |
| Efficient ventilation (air handling and pumps; variable air volume) |
| Economizers and energy management systems (EMS) |
| Programmable thermostats |
| Duct insulation |
| Retro-commissioning |
| **Industrial Sector Measures** |
| Efficient process heating |
| High-efficiency motors and drives |
| High-efficiency Heating, Ventilation and Air Conditioning (HVAC)<br>Efficient lighting |

*Source: Technical Report, January 2009. Electric Power Research Institute*

**Figure 167 U.S. Greenhouse Gas Intensity (MTCO2e per $Million in GDP**




*Source: American Council for an Energy-Efficient Economy: The Size of the U.S. Energy Efficiency Market; Skip Laitner 2008*

Even with a federal EERS, still to be sorted out are the regulatory regimes that compensate utilities for energy efficiency programs—an activity that reduces their revenues. “There are a few different ways that public utility commissions regulate energy efficiency and demand response,” said George Fitzpatrick, managing director of energy efficiency practice for consulting engineering firm Black & Veatch. “Some commissions have allowed utilities to make investments in energy efficiency and demand response and to earn a return on the investment made. There’s also some allowance for lost margin if you put a number of programs in place and you can prove through objective measuring and verification protocol that you reduced consumption and suffered a loss of revenue, some utility commissions will allow recovery. That’s probably the most favorable way from the utilities’ perspective.... The second best way is what’s known as decoupling in which the utility actually decouples their returns to shareholders from the amount of kilowatt-hours sold,” said Fitzpatrick. “There are number of different ways that has happened so that at end of day, utilities are indifferent whether or not they build generation or put in energy efficiency projects. There are still some problems with that approach from state to state, some negative issues concerning return on equity.”

“The third and least favorable way from the utilities’ perspective is that commissions allow them to expense out their energy efficiency and demand response investments,” said Fitzpatrick. “In certain states like Pennsylvania, there is no incentive compensation or return on investment that’s allowed. There are other states where they are allowed to get incentive returns or regular returns. Kansas for example is offering incentive returns on investment” in energy efficiency and demand response.

## Energy Efficiency: Proverbial Low Hanging Fruit for Climate Change

Because of the size of the target and the relatively low cost of energy-efficiency measures when compared to other strategies, there is no larger climate change mitigation opportunity than energy efficiency in buildings. The Intergovernmental Panel on Climate Change (IPCC) estimates that energy use in buildings now accounts for 35% of greenhouse gas (GHG) emissions, and that increased energy efficiency can economically reduce GHG emissions worldwide by 2030 by at least 4.7 billion metric tons of CO2-equivalent units (tCO2-e).

There is a complicated McKinsey/Vattenfall chart (www.mckinsey.com-/mgi/publications/Carbon_Productivity/slideshow/slideshow_4.asp) that shows the relative costs and mitigation potential of technologies and practices available to reduce GHG emissions. Upgrading insulation, reducing standby losses (phantom loads), installing energy-efficient lighting and cooling equipment anchor the cash-positive side of the chart because they pay for themselves more quickly than other measures.

**Figure 168 U.S. Greenhouse Gas Intensity and Related Factors, 1990 to 2007**

| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 |
|---|---|---|---|---|---|---|---|---|---|
| Gross Domestic Product (Billion 2000 Dollars) | 7,112.5 | 7,100.5 | 7,336.6 | 7,532.7 | 7,835.5 | 8,031.7 | 8,328.9 | 8,703.5 | 9,066.9 |
| Greenhouse Gas Emissions (MMTCO2e) | 6,241.8 | 6,190.4 | 6,315.6 | 6,409.1 | 6,522.9 | 6,575.2 | 6,748.2 | 6,826.0 | 6,836.0 |
| Greenhouse Gas Intensity (MTCO2e per Million 2000 Dollars) | 877.6 | 871.8 | 860.8 | 850.8 | 832.5 | 818.7 | 810.2 | 784.3 | 753.9 |
| **Change from Previous Year (Percent)** | | | | | | | | | |
| Gross Domestic Product | | -0.2% | 3.3% | 2.7% | 4.0% | 2.5% | 3.7% | 4.5% | 4.2% |
| Total Greenhouse Gases | | -0.8% | 2.0% | 1.5% | 1.8% | 0.8% | 2.6% | 1.2% | 0.1% |
| Greenhouse Gas Intensity | | -0.7% | -1.3% | -1.2% | -2.2% | -1.7% | -1.0% | -3.2% | -3.9% |

| | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | P2007 |
|---|---|---|---|---|---|---|---|---|---|
| Gross Domestic Product (Billion 2000 Dollars) | 9,470.3 | 9,817.0 | 9,890.7 | 10,048.8 | 10,301.0 | 10,675.8 | 10,989.5 | 11,294.8 | 11,523.9 |
| Greenhouse Gas Emissions (MMTCO2e) | 6,896.6 | 7,075.0 | 6,957.7 | 7,043.7 | 7,098.8 | 7,230.1 | 7,256.9 | 7,179.7 | 7,282.4 |
| Greenhouse Gas Intensity (MTCO2e per Million 2000 Dollars) | 728.2 | 720.7 | 703.5 | 700.9 | 689.1 | 677.2 | 660.4 | 635.7 | 631.9 |
| **Change from Previous Year (Percent)** | | | | | | | | | |
| Gross Domestic Product | 4.4% | 3.7% | 0.8% | 1.6% | 2.5% | 3.6% | 2.9% | 2.8% | 2.0% |
| Total Greenhouse Gases | 0.9% | 2.6% | -1.7% | 1.2% | 0.8% | 1.8% | 0.4% | -1.1% | 1.4% |
| Greenhouse Gas Intensity | -3.4% | -1.0% | -2.4% | -0.4% | -1.7% | -1.7% | -2.5% | -3.7% | -0.6% |

*Source: American Council for an Energy-Efficient Economy: The Size of the U.S. Energy Efficiency Market; Skip Laitner 2008*

But in spite of this fortuitous alignment of policy and economic drivers, there is still a problem. Most corporations, small business and households don't think investments in energy efficiency provide value quickly enough to justify their costs. McKinsey doesn't reveal the assumptions underlying its chart, but it is safe to conclude that the payback periods incorporated in its analysis are longer than those viewed as favorable by most owners of homes and buildings.

Surveys show that businesses view payback periods of two to four years as the minimum required to justify significant investment in energy efficiency measures. Homeowners can be just as parsimonious. Other factors get in the way, too. Many people don't like the light quality northe constant hum of compact fluorescent light bulbs. For businesses, the disruptions caused by a renovation can lead managers to postpone installation of new lighting or HVAC systems until their current systems need replacement.

Businesses also need to prioritize cash for productive assets and core functions—especially in the current economic climate; therefore they lack the funds to invest in energy-savings devices that don't directly benefit core operations. Other market barriers include the fact that company divisions making investments in facility upgrades are not the ones recognizing energy savings; upfront costs for conducting energy audits, establishing monitoring and verification (M&V) systems and arranging financing are high relative to the short-term savings; and for industrial facilities, potential efficiency projects can be sidelined by the need to maintain continuous operations.

**Figure 169 U.S. Energy Efficiency & Demand Response Industry 2007-2009**

| | 2007 | 2008 | 2009 |
|---|---|---|---|
| Energy Efficiency Appliances, Devices & Equipment | 37,761 | 41,056 | 40,922 |
| Smartgrid/DR equipment & systems | 1,107 | 2,413 | 4,846 |
| Energy Service Companies (ESCOs) | 3,173 | 3,378 | 3,676 |
| Energy Service Providers | 635 | 676 | 735 |
| Consulting engineering firms with EE/DR practices | 465 | 510 | 612 |
| Demand Response Services | 232 | 367 | 513 |
| **Total EE & DR Industry** | **43,373** | **48,400** | **51,303** |
| **Growth** | **9.2%** | **11.6%** | **6.0%** |

*Source: EBI Inc., from a market model derived from a variety of sources including American Council for an Energy-Efficient Economy, Energy Information Administration, Electric Power Research Institute, McKinsey, MIS, WBCSD, U.S. Department of Energy, Lawrence Berkeley National Laboratory and others.*

Because of these and other disincentives, the energy efficiency marketplace has been "largely confined to a relatively narrow band of services that are tailored to the needs of public sector, tax exempt, municipal customers," notes the March 2009 *New Business Models for Energy Efficiency* report by California Clean Energy Fund (CalCEF).

As CalCEF's report authors and experts pointed out, the technology needed to greatly expand energy efficiency already exists. What is needed to realize energy-efficiency's potential is financing, both public subsidies, as well as debt and equity capital. New business models are also needed, in large part to unlock the potential of equity and debt financing to fuel energy efficiency. "To capture the large volume of energy savings projected in market studies, and to meet the increasingly aggressive efficiency targets being put forth at the state and federal levels, a variety of new business solutions and financing options need to be developed and implemented to overcome key financial, market, policy, and technical barriers," notes the CalCEF report.

Innovative firms, utilities, local and state governments and other market participants are developing new financing strategies and business models that can ease the upfront costs and other objections that prevent many energy-users from major energy-efficiency upgrades. Companies like Metrus Energy look to use finance projects almost like an independent power producer does for natural gas, wind or PV projects. Communities in California and Massachusetts have begun to use tax-exempt municipal financing to fund installations of energy efficiency and renewable energy equipment in homes and businesses, with the loans being paid back as an assessment on property tax.

Some in the energy efficiency field say that what is really needed is not so much new business models but better modeling of the financial benefits of energy efficiency projects. "The incentives help, but it's also how you work at the problem," said Derrick Rebello, president of Quantum Energy Services and Technologies (QuEST), an energy services firm active with California's investor-owned utilities and communities. "It's slightly frustrating that we hear from facilitator operators that they really can't invest in anything that has more than a year payback, or at most two years. I argue that they're looking at the wrong metric. If they look at return on investment they'd see that their business makes all kinds of investments that have worse returns than energy efficiency."

**Figure 170 Select ENERGY STAR Appliance and Electronics Statistics, 2004**

| | Annual Product Sales (1,000 units) | Percent ENERGY STAR | Energy Saved (trillion Btu) | Dollars Saved (million $) |
|---|---|---|---|---|
| **Appliances** | | | | |
| Clothes Washers | 8,830 | 27% | 28.27 | 249 |
| Dishwashers | 6,950 | 78% | 15.81 | 139 |
| Refrigerators & Freezers | 10,910 | 33% | 12.78 | 104 |
| **Electronics** | | | | |
| TVs | 19,150 | 83% | 29.82 | 243 |
| DVD Players | 5,440 | 52% | 9.19 | 75 |
| **Home Office** | | | | |
| Printers | 19,790 | 99% | 31.06 | 253 |
| Monitors | 14,740 | 95% | 28.67 | 234 |
| Scanners | 4,730 | 75% | 10.97 | 89 |
| PCs | 23,155 | 74% | 10.61 | 87 |
| **Office Equipment** | | | | |
| Printers | 16,125 | 99% | 104.15 | 763 |
| Monitors | 20,020 | 95% | 192.04 | 1,406 |
| Scanners | 2,172 | 75% | 4.87 | 36 |
| PCs | 31,515 | 97% | 16.13 | 118 |
| **Total** | **183,527** | | **494** | **3,796** |

*Source: LBNL (2006).*

Of course, perceptions about the trajectory of energy prices have a major impact on how firms value energy saving devices and programs. The conservation initiatives launched in the late 1970s by President Jimmy Carter, California Governor Jerry Brown and other leaders weren't just dismantled by ideologically motivated Republicans: they were deflated as slumping energy prices sapped the motivation of people and businesses to become more efficient.

Oil and natural gas prices dropped precipitously in the recession, and it's worth noting that an April 2009 survey of 1,400 energy management executives conducted by Johnson Controls showed that 60% believe natural gas and electricity will rise over the next year; this is a drop from an 80% response rate to the same questions in 2007 and 2008, according to the company's summary of the research. But while pessimism about energy costs may have moderated a bit, energy managers have become even more certain that they'll face mandatory energy efficiency or carbon abatement regulations within the next two years. In 2008, 76% saw this prospect as likely; this year, 85% thought so.

Like every segment of the clean energy industry, EE&DR companies would benefit from clean energy legislation. Proposed measures in the Waxman Markey clean energy bill in the 111th Congress espoused energy efficiency targets, including national building codes, support for zero-net energy commercial buildings, and allocation of carbon emission allowances to states based on their energy performance, among other initiatives.

Today, in the absence of federal regulation, state and federal energy-efficiency mandates have gotten tighter, and public utility commissions are driving utilities to invest in energy efficiency. "We estimate utilities around the country will have to ramp up to about $10 billion per year in energy efficiency programs, by 2015," said Nadel of ACEEE. "As customers match that funding with $2 for every $1 [in incentives], we're guessing more than $30 billion per year will be invested in energy efficiency." And that is without any federal legislation. In short, the energy efficiency industry is virtually assured of a robust, growing future, with particular success going to those market participants who can be creative with financing and new business models. It's almost as if a new generation of low-hanging fruit has been created to ripen into business opportunity for the EE&DR industry.

### 11.1.2. California Energy Commission

Califonia Energy Commission says in its 2009 Integrated Energy Policy Report that because of the state's energy efficiency standards and efficiency and conservation programs, California's energy use per person has remained stable for more than 30 years while the national average has steadily increased. However, stabilizing per capita electricity use will not be enough to meet the carbon reduction goals of AB32. To meet those goals, the state must increase its efforts to achieve all cost-effective energy efficiency. CEC says that many of these efforts will be carried out by the investor-owned utilities and the publicly owned utilities, both of which are governed by legislative and regulatory mandates to identify and develop energy efficiency potential and to set annual savings goals.

California's building and appliance standards provide a significant share of energy savings from reduced energy demand. The 2008 Building Efficiency Standards took effect on January 1, 2010 and requires, on average, a 15 percent increase in energy efficiency savings compared with the 2005 Building Efficiency Standards. The 2009 Appliance Efficiency Regulations became effective statewide on August 9, 2009, and, as required by AB 1109, set new efficiency standards for general purpose lighting of a phased 50 percent increase in efficiency for residential general service lighting by 2018. The first phase took effect January 1, 2010.

Another issue associated with energy efficiency is how to incorporate the expected energy savings from meeting the state's long-term energy efficiency goals into the Energy Commission's electricity and natural gas demand forecast. Not all of the specific efforts and programs to achieve those goals are in place, since utility programs and efforts are only approved by the California Public Utilities Commission in three-year cycles.

CEC's 2009 Integrated Energy Policy Report made the following recommendations:

- The Energy Commission will adopt and enforce building and appliance standards that put California on the path to zero net energy residential buildings by 2020 and zero net energy commercial buildings by 2030.
- The Energy Commission and the California Public Utilities Commission should work together to develop and implement audit, labeling, and retrofit programs for existing buildings that achieve all cost-effective energy efficiency measures, maximize the benefit of existing utility programs, and expand the use of municipal and utility on-bill financing opportunities.
- The Energy Commission will use the 2009 adopted forecast as a starting point to estimate the incremental impacts from future efficiency programs and standards that are reasonably expected to occur, but for which program designs and funding are not yet committed. Staff is planning to use and possibly modify Itron's forecasting model, SESAT, for this new purpose, with Itron providing training for the model in early 2010.
- The Energy Commission, in cooperation with the California Public Utilities Commission, the investor owned utilities, and the publicly owned utilities, will devote sufficient resources to develop in-house capability to differentiate these future energy efficiency savings from energy efficiency savings that are already accounted for in the demand forecast.

### Resistance to On-Bill Financing is Eroding

Panelists at the ACEEE forum suggested several methods that have been proposed in papers by California Clean Energy Fund (CalCEF) and other institutions: On-bill financing (OBF) in which utility customers finance energy upgrades over a long period. Pilot OBF programs have proven successful in some states, but haven't become widespread due to utilities' reluctance to act as bankers and certain issues with public utility commissions.

"There are many design variables in existing on-bill financing programs," reported Lee Cooper, manager of energy efficiency emerging technologies for Pacific Gas & Electric Co., who researched such programs for PG&E which is considering OBF. "A lot of programs target very specific segments such as small commercial or residential.… There might also be policy objectives. If you have gas peaking issues in wintertime, you might incent folks to move into geosource heat pumps.… Generally speaking, ratepayer-funded programs are designed to support energy efficiency, while shareholder-funded programs tend to be designed to bring in revenue or retain customers while covering costs."

Cooper researched 21 of 35 utilities in North America with OBF programs. He found that 66% had default rates of less than 1%, with the rest experiencing up to 3% rates and one suffering defaults from 5% of borrowers. A common attribute of successful programs was that they charged interest rates of less than 3% and combined financing with rebates, said Cooper.

Before a utility enters into an OBF program, it needs to conduct a careful risk management analysis, according to Cooper. "The financing industry is very used to financing and default rates of 3%. In the utility world, we're used to much lower rates of default. [On the other hand] you need to be careful that you don't throttle back the risk so much that people who need the financing can't get it."

Community-based geographic aggregation is being practiced by a handful of cities nationwide which are using tax-exempt municipal financing to fund installations of energy efficiency and renewable energy devices in homes and businesses with loans that property owners pay back as an assessment on their property taxes.

"Municipal laws allow communities to finance improvements," said Stephen Compagni Portis, CEO of Renewable Funding, the firm that pioneered the concept and develops and manages municipal financing programs. "This is primarily used for infrastructure, new schools, parks, medical facilities. More recently it has been used widely for undergrounding utilities in particular neighborhoods where only [property owners in] that neighborhood pay the amortization on the bond because only that neighborhood gets the benefit."

Portis credited Renewable Funding's President Francisco DeVries with the brainstorm that led to the innovative financing mechanism, first deployed in the city of Berkeley, Calif.: "If you could do that in a neighborhood, why couldn't a single homeowner have the city issue a bond to finance a clean energy project?" After analysis by Berkeley's bond counsel and several major law firms, the project went ahead—first for PV installations and then for energy-efficiency upgrades. The model has been deployed in other communities in California, empowered by a recent state law; Towns in Massachusetts and Colorado also have such programs.

Portis pointed out that a key feature of this model's success is the fact that municipal liens have first positioned so even if the homeowner goes into default and experiences foreclosure, the city—and its bondholders—remain whole. "That is the power of a municipality who chooses to issue bonds associated with capital projects," said Portis. "Those laws have been tested for 100 years."

Energy service agreements that are akin to power purchase agreements in which a utility pledges to buy the output of a renewable power plant. Under this model, investors and lenders would build an energy efficiency project to own it, receiving payments from the customer at a contracted rate per kWh of avoided energy costs. This approach would extend to businesses the performance-based contracting method used by an energy service company (ESCO) that provide energy efficiency upgrades for government institutions. It's a new concept that has yet to be embraced by ESCOs or other firms, and it may face hurdles because third-party owned energy efficiency assets don't qualify for tax benefits.

Energy efficient mortgages value energy-efficiency features in a mortgage, thus spreading the additional costs over 15 to 30 years. These have been tried on limited bases but have lacked market acceptance due to poor marketing and complex structures, according to several panelists. Phil Angelides, former California state treasurer and chairman of the Apollo Alliance gave a rousing endorsement of the approach. "It's time to remake the mortgage markets in a way that incents energy conservation [by offering] lower interest rates for folks who buy or refinance buildings or homes if they do energy efficiency at the same time."

## 11.2. Investment Trends in EE&DR

Venture capital firms described the technology plays they're backing: energy-efficient cement manufacturing; electrochromatic "smart glass" that changes transparency to cut down on sunlight entering buildings on hot days; next-generation lighting that will outperform compact-fluorescent bulbs; microchips that operate with 30% less electricity than existing chips; and new air conditioning technology that wrests a 20% efficiency gain by tinkering with the phase change in coolants between gas and liquid.

With the global recession, however, venture capital and private equity investments in all industries have slowed dramatically, according to several panelists. But Dan Adler, president of the California Clean Energy Fund (CalCEF), predicted that when the investment climate improves, energy efficiency will present a favorable investment target due to the rapidly growing state and federal mandates that require utilities to fund energy efficiency measures. Not only that, but the recession has caused many venture and early-stage private equity investors to value energy efficiency more highly than they once did.

A nonprofit, CalCEF was founded in 2004 to channel investment to the state's clean energy economy. It was established out of the electricity crisis as part of the bankruptcy settlement negotiated between the California Public Utilities Commission (CPUC) and Pacific Gas and Electric Company (PG&E). Adler says that when CalCEF began probing the venture community about energy efficiency five years ago, their response wasn't exactly enthusiastic.

"Number one, we heard them say that there really wasn't a lot of IP [intellectual property] in the energy efficiency world," Adler said. "Number two, they said, 'even if we found something we liked, we'd have to deal with utilities and their constrained channels in the marketplace, and we need more flexibility in where we can sell products.'"

**Figure 171 Venture Capital Investment in EE, DR, and Smart Grid**

| Venture Capital Investment in EE, DR, and Smart Grid in the Second Quarter of 2009 | | | |
|---|---|---|---|
| **Company** | **Investment Amount** | **Investor Group** | **Company Description** |
| Tendril Neteorks | $30M Round C | VantagePoint Venture Partners, Good Energies, RRE Ventures, Vista Ventures | Residential smart grid software and wireless sensors |
| GreenRoad | $15M | DAG Ventures, Benchmark Capital, Virgin Green Fund, Amadeus Capital Partners, Balderton Capital | Driving behavior service provider |
| Zenergy (AIM) | $13.8M | Arranged by Panmure Gordon & Co and Mirabaud Securities | Suoerconductors as fault current limiters, preventing current surges on the grid. Recently announced contracts with NY's Con Ed. SC Power is the US subsidiary. |
| AlertMe (UK) | $12.8M Round B | Good Energies, Index Ventures, SET Venture Partners, VantagePoint Venture Partners | Zigbee-based web-enabled home energy management devices add-on to security systems |
| Metalysis (UK) | $8.2M | Environmental Technologies Fund,3i, Chord Capital, Seven Spires Investments, Cody Gate Ventures | Energy efficient production processes to create metallurgical grade tantalum and titanium powders |
| Ember | $8M | Chevron Technology Ventures, Stata Venture Partners, Polaris Venture Partners, GrandBanks Capital, RRE Ventures, Vulcan Capital, DFJ ePlanet Ventures, New Atlantic Ventures, et al. | The leading maker of ZigBee wireless mesh networking chipsets for communications between devices such as utility meters and thermostats |
| Powerit Solutions | $6M | Siemens Venture Capital, ArcelorMittal's Clean Technology Fund, @Ventures, Expansion Capital | Intelligent energy management and efficiency systems |
| Hexaformer (Sweden) | $4.6M Round B | Sustainable Technologies Fund, Innovations Kapital | Electric transformer cores |
| OutSmart Power Systems | $2M Seed | Bainco International Investors, Clean Energy Venture Group, Manifold Products | Hardware and software systems to monitor and manage energy usage, building occupancy and other activities in commercial buildings |
| Phoebus Energy | $1M | Galilaea Fund | Cost saving water heating SW technologies for medium and large water heating systems |
| EnergyHub | Undisclosed Round A | .406 Ventures, Physic Ventures | Home energy management solutions |

*Source: Greentech Media*

Adler recalls arguing for the value proposition of energy-efficiency plays with little success, until a year or so ago. In part what changed was the heightened profile of smart grid technologies and green building. And another part had to do with the credit crunch and recession and how a slumping economy changed investors' attitudes toward utilities, the gatekeepers for most energy-efficiency technology. "Now investors are looking for anyone with a balance sheet to make a deal," said Adler. Today when he attends events with investors and their partners, he hears a great deal of interest in utilities and their programs to certify equipment for rebate and incentive programs. Adler referred to New Energy Finance data on venture investing from 2000 through July 2009 to show that while not as robust as the leading venture investment target—PV and solar thermal power, which received more than $5 billion—a broadly categorized set of building energy efficiency companies landed $4.4 billion. Energy Efficiency Digital Energy (smart grid companies and DR or curtailment experts like now-public Enernoc and Comverge) was neck-and-neck with Energy Efficiency Green Buildings with $1.8 billion invested. NEF tallied $740 million in Energy Efficiency Supply Side such as making motors more efficient and $120 million invested in Industrial Energy Efficiency.

The pace of energy efficiency investing has increased in the past two years. According to Ernst & Young, in 2009 the number of financing rounds in the energy efficiency category—encompassing areas such as smart grid and residential and commercial energy management—grew by 11% to 61, making it the number one area of cleantech deal activity. The category's share of total financing in 2009 rose from 24% to 32%, while the share of rounds directed to the more capital intensive energy/electricity generation category fell from 30% to 18%.

While New Energy Finance counts $4.4 billion in energy efficiency venture investments since 2000, Cleantech Group tallies more than $1 billion invested in just the five quarters from Q4 2007 to the end of 2008. Although the largest deals are listed on Cleantech's top ten deals in energy efficiency, the majority of investments are relatively small even on the cleantech scale. The last seven quarters have seen an average of about 25 transactions and a total of near $1.4 billion or an average investment amount of about $8 million, according to Cleantech data.

Energy efficiency is also well represented in Scandinavian countries as evidenced from a report identifying the 50 leading cleantech companies in the Nordic market released in May 2009 by Cleantech Group and Cleantech Scandinavia. The authors evaluated 145 nominations from Sweden (48%), Denmark, Norway, Finland (19%, 17% and 14% respectively) and Iceland (1%), and 35 companies or 24% were in energy efficiency. Overall quality deal flow is expected by investors to increase with economic stimulus and climate change the principal drivers.

**Figure 172 Largest Energy Efficiency Venture Capital or Private Equity Deals: 2007-2009**

| Company | Country | Amount | Period | Industry1 | Industry2 | Industry3 |
|---|---|---|---|---|---|---|
| Luminus Devices, Inc. | USA | $72,000,000 | 1st Qtr 2008 | Energy Efficiency | Lighting | Solid State Lighting |
| Lattice Power (jiangXi) Corp. | China | $52,000,000 | 2nd Qtr 2007 | Energy Efficiency | Lighting | Solid State Lighting |
| Serious Materials, LLC | USA | $50,000,000 | 4th Qtr 2007 | Energy Efficiency | Buildings | Building Envelope & Insulation |
| Turbine Air Systems | USA | $47,000,000 | 2nd Qtr 2009 | Energy Efficiency | Buildings | HVAC |
| Aspen Aerogels, Inc. | USA | $37,000,000 | 2nd Qtr 2008 | Energy Efficiency | Buildings | Building Envelope & Insulation |
| Ubidyne GmbH | Germany | $34,000,000 | 2nd | Energy | Other | Appliances |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | Qtr 2008 | Efficiency | | |
| Ice Energy, Inc. | USA | $33,000,000 | 4th Qtr 2008 | Energy Efficiency | Buildings | HVAC |
| EPS Corporation | USA | $30,000,000 | 2nd Qtr 2009 | Energy Efficiency | Other | Monitoring, Metering & Control |
| Taishi Xinguang Tech Co., Ltd | China | $30,000,000 | 4th Qtr 2008 | Energy Efficiency | Lighting | Solid State Lighting |
| BridgeLux, Inc. (FKA eLite Optoelectronics) | USA | $30,000,000 | 2nd Qtr 2008 | Energy Efficiency | Lighting | Solid State Lighting |

*Source: Cleantech Group*

**Figure 173 U.S. Energy Efficiency Appliances, Devices & Equipment Sales in 2008 ($Mil)**

| | 2007 | 2008 |
|---|---|---|
| **Residential Sector** | | |
| Efficient appliances, electronics, office equipment and control systems | 7,531 | 8,134 |
| Efficient lighting (CFL, LED, linear fluorescent) | 1,084 | 1,194 |
| Efficient AC, space and water heating and heat pumps | 1,333 | 1,440 |
| Insulation, weatherization, shades, etc. (All Sectors) | 8,500 | 8,925 |
| **Commercial Sector** | | |
| Efficient appliances, electronics, office equipment and control systems | 8,017 | 8,659 |
| Efficient lighting (CFL, LED, linear fluorescent) | 1,626 | 1,791 |
| Efficient AC, space and water heating and heat pumps | 2,667 | 2,880 |
| **Industrial Sector** | | |
| Efficient process heating, cooling & systems | 2,037 | 2,200 |
| High-efficiency motors, drives and other equipment (non-HVAC) | 2,593 | 2,800 |
| High-efficiency Heating, Ventilation and Air Conditioning (HVAC) | 2,000 | 2,160 |
| Efficient lighting | 813 | 896 |
| **Total Energy Efficiency Appliances, Devices, Systems & Equipment** | **38,202** | **41,079** |

*Source: EBI Inc., from a market model derived from a variety of sources including American Council for an Energy-Efficient Economy, Energy Information Administration, Electric Power Research Institute, McKinsey, MIS, WBCSD, U.S. Department of Energy, Lawrence Berkeley National Laboratory and others.*

**Figure 174 Universe of Energy Efficiency Appliances, Devices & Equipment Companies (in $Mil)**

| | 2008 USA EE Sales |
|---|---|
| GE, Honeywell, Siemens and Johnson Controls | 12,040 |
| 30 Companies at $100-1,000 million | 5,880 |
| 100 Companies at $50-100 million | 6,200 |
| 2,200 Companies at $1-50 million | 16,940 |
| **Total USA EE Equipment & Systems Sales ($mil)** | **41,060** |

*Source: EBI Inc. market model*

## 11.3. Demand Response

Demand response is a strategy to shift patterns of energy usage in order to reduce electricity loads at times of peak demand. With demand response, utilities can increase overall grid reliability and meet growing peak demands without investing in new natural-gas peaking plants or paying high peak prices to independent power producers (IPPs). The approach also has the potential to mitigate carbon emissions by reducing overall energy consumption and by enabling the integration of more renewable energy into utility grids. In combination with smart grid technology, demand response (DR) can also support the dynamic shifting of discretionary loads (clothes washing, electric vehicle charging) to times when intermittent renewables like wind power are generating, and even to improve the efficiency of coal-fired power plants.

State and federal mandates are increasingly pushing many utilities to implement DR programs. And many are designing them on their own initiative to cope with growing peak loads in a cost-effective manner. Utility analysts and consultants contend that while growth in aggregate electricity consumption in North America is relatively flat, especially recently, due to the recession, peak loads continue to grow.

Utilities have offered differential pricing, with rates rising during times of peak demand, to commercial and industrial customers since the late 1970s. But such programs for residential customers have been rare until recently. One utility planning an aggressive demand-response program with pricing incentives is investor-owned electric utility Southern California Edison (SCE).

**Figure 175 Demand Response Services 2005-2009 ($thousands)**

| $thousand | 2009 | 2008 | 2007 | 2006 | 2005 |
|---|---|---|---|---|---|
| EnerNOC | 190,700 | 106,100 | 60,800 | 26,100 | 9,800 |
| Comverge | 98,800 | 77,200 | 55,200 | 33,900 | 23,400 |
| Others | 260,600 | 183,400 | 116,000 | 60,000 | 33,200 |
| Demand Response Services | 550,100 | 366,700 | 232,000 | 119,900 | 66,400 |

*Source:Public compnay data and EBI estimates*

SCE, which had a peak load of about 22,000 MW last year, aims to add an additional 1,000 MW of peak demand capacity by 2016 through a series of demand response programs that will be enabled by SCE's Edison SmartConnect program. Through the SmartConnect program, the utility will install 5 million digital smart meters (estimated to be complete by 2012). Residential users will have two new demand response options available to them. A Peak-Time Rebate program will kick into gear in advance of days that the utility is expecting high peak usage (usually driven by summer heat, but occasionally by outages or maintenance issues at power stations or on the transmission network). Customers can earn rebates of $0.75 per kWh by reducing their usage during peak hours the next day. All residential users will be automatically signed up, but participation will be voluntary. Customers can elect to receive optional emails, automated phone calls or text messages advising them of a scheduled event days.

"Then we're going to introduce a new Load Control program that will feature a communicating thermostat," said Brandi Anderson, manager of mass market demand response programs. "On a peak event day, if we call for a customer to reduce load, SCE will send a signal to their thermostat which would raise the temperature by four or six degrees or completely cycle it off, depending on which option the customer has chosen. In exchange, the customer can earn incentives of $1.25 per kilowatt-hour reduced." Eligible residential users will have the option to participate once their smart meter is installed and their communicating thermostat is operational. A key feature of the new program is that customers will be allowed to opt out of peak event days if they choose. Like the smart meters, the utility will initially pay for a basic smart thermostat and the installation. In the future, SCE anticipates that customers will be able to visit a retail store such as Home Depot to purchase an eligible thermostat and handle the installation on their own. SCE intends to offer customers a rebate if they choose this option.

Edison SmartConnect features two of the three main categories of demand-response programs: Load-control programs, where end-users provide capacity—in exchange for financial incentives—by giving control of energy-using equipment to a utility, a grid operator or a curtailment service provider who can dial down the load during peak demand periods; and dynamic pricing programs in which energy-users have the option to respond to peak prices by shifting usage to off-peak periods.

A third program is interruptible demand in which commercial and industrial energy-users exchange lower pricing for an agreement to let their power be shut off in emergencies. This type of program is what allowed the Electric Reliability Council of Texas to avoid broad outages when 1,400 MW of wind power suddenly dropped off its grid in February 2008.

## 11.4. Smart Grid

Demand response is closely tied to the evolution of what is known as the smart grid. Many in the electric power business would prefer the term "smarter grid," noting that the grid has been becoming progressively more intelligent for decades. But for better or worse, smart grid has become the established brand name for the packages of advanced metering equipment, wireless communications gear, software and systems that must be installed to allow greater communication and interaction between energy producers and users.

It's important, however, to distinguish between the transmission part of the grid—basically everything upstream from substations—and the distribution part of the grid—from the substations to the homes, businesses, institutions and other electricity consumers. "There is a great deal of technological advancement underway in the transmission part of the grid," said Craig Rizzo, smart grid practice manager for SAIC, a technology consulting and engineering firm deeply engaged in demand-response and the smart grid. "There are technologies such as dynamic line ratings and synchronous phasors that provide additional monitoring and measurement. These kinds of things will ultimately see more intelligent and sophisticated grid operations with significant efficiency benefits. But most of the smartgrid technology will be between the substation and the meters."

Automated meter infrastructure (AMI) is the first phase of smartgrid implementation, and makers of two-way smart meters such as Itron, Landis + Gyr and Elster are competing aggressively for contracts with utilities. As of January 1, 2009, more than 23 million smart meters had been scheduled for installation, according to the ZigBee Alliance, the non-profit developer of the dominant low-power communication standard for smart meters. Estimates of the ultimate rollout of smart AMI devices range from $40 million to $60 million through 2010.

AMI deployment in 2010 as expected got a major boost from the ARRA stimulus funding, as utilities raced to submit applications for some $4 billion in available funding by August 6 (for the U.S. Department of Energy's Smart Grid Investment Grant) and August 26 (for DOE's Smart Grid Development Program). Texas utility Oncor announced it would apply for $200 million to lower the cost for the Smart Texas SM AMI initiative; $58 million for telecommunications and network investments; and more than $58 million to expand its advanced distribution automation program. Kate Rowland, editor-in-chief of Energy Central's *Intelligent Utility*, noted that the SGIG solicitation seeks proposals that "support the two-way flow of both electric power and information between electric power companies and electricity consumers [including] the installation of smart meters which are able to measure, store, send and receive digital information concerning electricity use, costs, prices and time-of-use between power companies and customers for purposes that include but are not necessarily limited to dynamic pricing, demand response, load management, billing, remote connect/disconnect, outage detection and management, and tamper detection."

## Smart Homes, Businesses Next

In addition to automated meter infrastructure (AMI) manufacturers, the demand response and smart grid industry includes a diverse range of firms, as underscored by these recently enrolled members of the Demand Response and Smart Grid Coalition: software developer Oracle, smart-grid consultancy Enspiria Solutions, private-equity firm Energy Capital Partners, wireless communications firm CalAmp, automation controls maker KMC Controls, lighting control and window shading system maker Lutron, and networking and energy management product maker PCN Technology.

Appliance manufacturers are getting onboard, too. "Carrier Corporation offers a direct load control thermostat," said Louisa Freeman, managing director of Black & Veatch, a consulting engineering firm with a large utility practice. "There are some other companies coming out with room air conditioning units or central air conditioning units that have control technology embedded in the product itself. They're already enabled for that kind of future, to address not just energy efficiency but the capacity crisis that may be coming in some regions of the country."

Such innovation by manufacturers highlights a key point in the evolution of the smart grid: while AMI is focused on communicating between electricity users and distributors, in order to bring alive the full potential of demand-response, load sources within homes, buildings and factories must become networked as well. "The next step is from the meter to the loads in the home or from the meter to the equipment in the commercial industrial facility," said Roger Jenkins, operations manager for SAIC. "You really want to have communication pathways to measure specific aspects of demand in a home or facility and send signals to modify consumption. What people refer to as the home area network has been moving very quickly, and even further along are the control and communication pathways for commercial and industrial facilities."

Much remains to be seen about what products and technology make up the home area network (HAN) that will give consumers finely parsed data on their loads. At this point SCE intends to make hourly usage data available on its website for customers with smart meters so they can gain a better understanding of how much energy they are using at various times of the day. In addition, SCE intends to leverage HAN-enabled products to provide customers more specific data about household usage, as well as to respond automatically in periods of peak pricing and grid emergencies. "We're in the exploratory phase right now of understanding what types of products will be available to consumers," said Anderson. "We also need to better understand what types of information and features our customers want in these products so we can design appropriate programs to meet their needs."

### Curtailment Service Providers 'Immensely Valuable'

Key players in the growth of demand response are the companies that perform demand aggregation, commonly known as curtailment service providers. Comverge, EnerNOC and other firms in this market package equipment, software and services such as energy audits and modeling into user-friendly demand-response products, and market them to electricity users. Their expertise combines energy market savvy with long IT résumés and deep understanding of how homes, businesses, office buildings, industrial firms and institutions use energy.

"They provide an immensely valuable service," said Andy Ott, vice president, markets, for PJM Interconnection, North America's largest ISO (Independent System Operator) and a leader in incorporating demand-response resources onto the electric grid. "Because of their expertise in these markets, they act as translators so that the individual staff of a business, such as a building manager or the energy procurer for a restaurant chain, doesn't have to learn all the complex power market rules."

"Most of the commercial and industrial customers we talk to have never heard about demand response," said David Brewster, president of EnerNOC. "We educate the customers about this opportunity, we work with them to be more active participants in the electricity markets and we work with them to create a curtailment strategy." When Brewster refers to "customers," he's talking about the customers—electricity users—of his main customers—utilities, ISOs and other grid operators. "In the demand response industry, electricity users are the supply chain, they're the providers," said Brewster.

EnerNOC, Comverge and other curtailment firms essentially turn the electricity consumer into a supplier of electricity back to the utilities and grid operators. They sign up utility customers, design curtailment programs for them, install load control devices on their air conditioners and other equipment and sell the resulting demand-response product, usually as capacity, to utilities directly—known as a bilateral sale—or bid it into the forward capacity markets operated by PJM and other ISO New England. They share the resulting revenues with the providers based on a contracted arrangement. When the utilities need power during a peak event, the ISOs or other grid operators communicate directly with the curtailment service provider's control centers. "We'll send a signal to their operations center, and they'll in turn distribute that out to the end use customers they've contracted with," said Ott.

How big can demand response grow as an industry? The Electric Power Research Institute (EPRI), in its January 2009 Assessment of Achievable Potential from Energy Efficiency and Demand Response Programs in the U.S., estimated that between 44 and 66 GW of summer peak demand capacity can be met with demand-response resources by 2020. By 2030, the total could go as high as 101 GW. (The variation takes into account such factors as how well utility demand response programs are run.)

A June 2009 report issued by SBI entitled Smart Grid Technologies, Markets, Components and Trends Worldwide estimates the smart grid enabling technologies market at $6.4 billion in the United States in 2009 and $13.6 billion globally. U.S. growth is forecasted at almost twice the rate as the global market to pass $16 billion in 2014.

EBI estimates the U.S. Smart Grid and DR equipment & systems market at $5 billion in 2008 with meters accounting for about $1.5 billion, sensors close to $1 billion and communication, IT and infrastructure equipment about $2.5 billion. We expected these figures to double by 2010 as the ARRA and other government funding and financing programs augment the momentum already established by the backlog of orders in AMI.

**Figure 176 2008 U.S. Residential Energy Use per Household by Region**

| | Northeast | Midwest | South | West | U.S. |
|---|---|---|---|---|---|
| Space Heat | 6% | 7% | 7% | 7% | 7% |
| Air Conditioning | 9% | 12% | 22% | 13% | 17% |
| Furnace Fans | 3% | 3% | 1% | 1% | 1% |
| Water Heating | 5% | 6% | 10% | 6% | 8% |
| Refrigerators | 11% | 9% | 6% | 10% | 8% |
| Freezers | 2% | 2% | 1% | 2% | 2% |
| Dishwashers | 2% | 2% | 2% | 3% | 2% |
| Cooking | 2% | 2% | 2% | 2% | 2% |
| Clothes Washers | 1% | 1% | 1% | 1% | 1% |
| Clothes Dryers | 5% | 6% | 5% | 5% | 5% |
| Lighting | 19% | 16% | 12% | 19% | 15% |
| Personal Computers | 2% | 2% | 1% | 2% | 2% |
| Color TV | 11% | 8% | 6% | 9% | 8% |
| Other Uses | 22% | 24% | 23% | 21% | 23% |
| **Total (kWh per household)** | **8,793** | **11,927** | **16,101** | **9,454** | **12,407** |

*Source: 2008 Annual Energy Outlook Reference Case.*

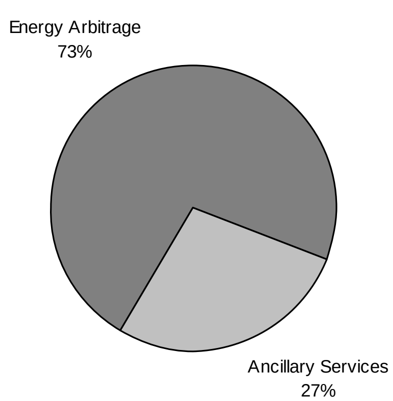
# 12. Energy Storage

## 12.1. Utility Scale Energy Storage Market

Utility planners and grid managers have long known that if they could store off-peak power to meet on-peak demands, they could ease their relentless quests to support ever-rising peak loads, relieve transmission congestion and transcend regional power shortages. But with a few exceptions, energy storage solutions have failed to deliver on their promises. “Typically with emerging technologies, concepts seem to outpace the technology,” said Richard Fioravanti, senior principal consultant for the consulting firm KEMA (Arnhem, The Netherlands), which analyzes technologies for utilities. “The technology has to catch up with the concepts at a price that’s competitive and economically viable. Until these technologies are commercialized in their proper price ranges, the ultimate use of electricity storage may still be an open question.”

Indeed, the development of batteries for utility-scale storage has lagged applications for consumer electronics and automobiles. “Most of the work for the last 20 years on batteries has been oriented to handheld devices, laptops, hybrid cars and other products, all with much higher values than commercial industrial stationary power,” said Harold Gotschall, an electricity storage expert with consulting firm Technology Insights (San Diego).

**Figure 177 U.S. Utility Energy Storage Industry in 2008 ($2 Bil)**




*Source: EBI Inc., derived from a variety of sources. Revenues come mostly from pumped hydro with minimal contribution from compressed air. Batteries & flywheels began contributing minimal revenues in Q4 2008. Ancilliary Services are up-regulation, down-regulation, non-spinning reserves and spinning reserves.*

However, advocates for the emerging energy storage industry say the corner to commercial viability is being turned. Advanced battery systems, flywheel energy systems and other technologies are now coming of age in terms of price points and technology, according to Brad Roberts, chairman of the Electricity Storage Assn. Roberts and other consultants and technology vendors said utility-scale storage technology has matured rapidly in the last few years. Demonstration projects have shown viability. Commercial projects and sales are becoming a reality. At the same time, the market drivers for energy storage have become more robust.

"Utility interest is expanding rapidly due to … the rising cost of conventional generation and delivery assets, increased load growth, the need to integrate large amounts of renewable resources, the need to address weak points in the power delivery system, and the simple fact that many new storage solutions are ready for wide use," wrote Dan Rastler, program manager for energy storage at the Electric Power Research Institute (EPRI) in Edison Electric Institute's September/October 2008 *Electric Perspectives*. Electricity storage systems and the power electronics to control them also go hand-in-hand with the evolution toward a "smartgrid" with advanced metering infrastructure, bi-directional electricity flows and more distributed generation. "Efficient storage opens up new possibilities for technology and the delivery system in the form of plug-in hybrid vehicles, for example, or advanced demand response," wrote Rastler.

"Storage, in effect, changes the electricity game," he noted, but in line with Fioravanti's perspective, "despite their game-changing potential, storage technologies remain largely underutilized. Developers and system integrators are addressing technical issues that limit their widespread implementation, including cost, longevity (both calendar life and cycle life), efficiency, and reliability."

**Storage Means More Clean Power, Lower Emissions From Fossil Units**

Utility-scale electricity storage is an important enabling technology to achieve two of the five major climate change mitigation strategies identified by the Intergovernmental Panel on Climate Change (IPCC): generating more power with clean renewable sources like wind and solar and using fossil fuels more efficiently and conservatively.

The developed world and some developing countries are making great strides in bringing more renewable power, especially wind, onto electricity grids. Wind energy is on track to meet at least 12% of electricity demand in the European Union by 2020. China wants 15% of its electricity to come from renewables by 2020, with wind expected to be the second largest source after hydropower. Renewable energy standards in U.S. states have grown wind power to the point where some utility grids now get 10% of their annual electricity production from wind.

**Figure 178 Commercial Energy Storage Costs**

| Technology | $/kw | $/kwh of storage cap | Storage hours | Total cap. cost $/kw* |
|---|---|---|---|---|
| **Compressed air energy storage** | | | | |
| Large (100-300 megawatts), below ground | 590-730 | 102 | 10 | 600-750 |
| Small (10-20 megawatts), above ground | 700-800 | 200-250 | 4 | 1,000-1,800 |
| **Pumped hydro** (1,000 megawatts) | 1,500-2,000 | 100-200 | 10 | 2,500-4,000 |
| **Battery** (10 megawatts) | | | | |
| Lead acid | 420-660 | 330-480 | 4 | 1,740-2,580 |
| Sodium sulfur (NAS) | 450-550 | 350-400 | 4 | 1,850-2,150 |
| Flow battery | 425-1,300 | 280-450 | 4 | 1,545-3,100 |
| **Flywheel** (10 megawatts) | 3,360-3,920 | 1,340-1,570 | 0.25 | 3,695-4,313 |
| **Superconducting magnetic storage** | 200-250 | 650,000-860,000 | 1 second | 350-489 |
| **Supercapacitors** | 250-350 | 20,000-30,000 | 10 seconds | 300-450 |

*Source: EPRI, *including power conditioning system and equipment necessary to provide power. Does not include replacement costs, site permitting, interest during construction, or substation costs.*

This is good from the perspective of reducing emissions, but for operating a grid, wind is challenging—and the more wind, the greater the challenge. As any sailor knows, the wind is not always reliable yet utility grids require reliable power that can be dispatched to meet load instantaneously. “Supplying electricity on a grid [is] not like supplying bread,” writes Phillip Schewe in his 2007 book *The Grid*. “If a baker is short a few loaves, he apologizes and tells the customer to return earlier tomorrow. A few loaves too many and the baker can make breadcrumbs with the leftover. But with electricity there is no leftover. It has to go somewhere all the time and can’t lie around unused … At all times, the generation must meet the load.”

U.S. utility grids are already experiencing problems from wind. Xcel Energy has seen wind power in Colorado increase or decrease by as much as 700 MW in an hour. In Texas, a drop in the wind on a cold weekday night in February 2008 led to the sudden loss of 1,400 MW of power. The grid operator, Electric Reliability Council of Texas (ERCOT), curtailed large customers through a demand response program quickly enough to prevent broader outages, but the event was a vivid symbol of the need for utilities and grid operators to gear up to manage wind’s intermittence. Utility planners and grid operators are increasingly looking to energy storage technologies for solutions.

Solar PV is not causing these types of problems yet; by its nature as a distributed resource, PV tends to show up on utility grids as reduced demand. But grid watchers say similar integration issues will emerge as PV increases substantially over its current very low levels of penetration. Energy analysts at the U.S. Department of Energy (DOE) National Renewable Energy Laboratory (NREL) expect PV to begin presenting significant grid management challenges in California as early as 2013. Grid managers at the California Independent System Operator (CAISO) confirm that future growth of PV puts it on their radar screen as a pending grid management issue, in part because the efficiency of PV decreases as modules heat up. “Due to the heating of the back of the panels, production can drop 10 to 20 percent in the middle of the afternoon [when demand is at its peak]” said David Hawkins, CAISO’s lead renewable power engineer.

Concentrating solar power plants that use the sun’s thermal energy, on the other hand, tend to follow the load curve; and therefore the anticipated gigawatts of new CSP capacity proposed for Southern California doesn’t concern CAISO from the grid management perspective. “As the load ramps up in the morning so do the concentrating solar power plants ramp up, and they do not degrade in the middle of afternoon like PV panels do,” said Hawkins. Additionally, some CSP designs incorporate thermal storage.

Energy storage systems can let grid operators incorporate greater amounts of these variable generation resources by storing electricity from these sources at off-peak times and dispatching it on-peak. If stored in great enough volumes, electricity from wind power could even displace some of the inefficient single-cycle gas turbines used for peaking power.

Other strategies to incorporate renewables are also needed and already being used to varying degrees as part of overall grid management practices. These include providing adequate reserve generation capacity and keeping resources like hydropower and gas turbines on automatic generation control to quickly adjust supply to meet demand. Some wind energy experts say these methods, along with more robust demand response programs and transmission buildouts to reach remote wind resources, will be enough to accommodate vast amounts of new wind capacity without energy storage. “Given an ideally integrated grid, this [energy storage] capacity would not be necessary because the pooling of resources across an electric system eliminates the need to provide costly backup capacity for individual resources,” write the authors of *20% Wind Energy by 2020*, a report by the U.S. Department of Energy’s Energy Efficiency and Renewable Energy division.

But the majority view appears to be that energy storage will be needed soon in areas with increasing wind energy penetration, and eventually in regions where PV grows to represent a significant amount of generation. Hawkins told CCBJ that the California’s existing 2,650 MW of wind power is dispersed across the vast state so that wind farms peak at different times, presenting a variability challenge that can be met with other resources capable of following the load curve such as gas-fired turbines and hydropower.

**Figure 179 Major Wind Storage Demonstration Projects**

| |
|---|
| • Large (300 MW) and small (15 MW) Compressed Air Energy Storage (CAES): EPRI, coming soon |
| • 34 MW NAS Battery Project, Rokkasho, Japan: direct wind support for wind developer, commissioned April 2008 |
| • 5 MW Beacon Flywheel Project, Tyngsboro, MA: NEPOOL/ISO-NE RC Program, (1 MW commissioned November 2008) |
| • 2 MW (3 MW Pulse) VRB Project, Sorne Hill, Ireland: direct wind support, under construction |
| • 1 MW NAS Battery Project, Xcel Energy, Luverne, MN: demo direct wind support for wind developer plus ancillary services, under construction |

*Source: Technology Insights*

"The future will look different, however," said Hawkins. With about 5,000 MW of new wind power pending in Southern California, the existing geographic diversity will be unbalanced, making energy storage an urgent issue for CAISO, the California Energy Commission and the state's investor-owned utilities. The same dynamics are in play, albeit on different schedules, in almost every region of the world where wind resources are growing rapidly. In Ohio, for example, legislators recognized the importance of energy storage to facilitate wind power penetration by designating storage systems as renewable energy resources for the purposes of state renewable energy targets and financing programs.

To build out new wind capacity without storage would require a large investment in new gas-fired generation as well as re-purposing many existing gas-fired generators, according to Gotschall of Technology Insights. "Introduction of wind power on a large scale will force some older thermal units to be retired, and it will force others into a more demanding duty cycle to accommodate the kinds of fluctuations introduced by wind while also taking them out of their primary revenue stream of baseload generation. That means that the price of those services they will be required to supply to accommodate wind will have to go up to cover their deployment costs."

**Figure 180 Global Energy Storage Industry**

| | 2007 | 2008 | 2009 | 2008 Growth | 2009 Growth |
|---|---|---|---|---|---|
| Utility Energy Storage | 5.99 | 6.55 | 7.19 | 9% | 10% |
| Fuel Cells | 0.36 | 0.56 | 1.54 | 56% | 177% |
| **Total Energy Storage Industry** | 6.35 | 7.11 | 8.73 | 12% | 23% |

*Source: EBI Inc. estimates derived from a variety of sources. Revenues in $ bil*

**Figure 181 U.S. Energy Storage Industry**

| | 2007 | 2008 | 2009 | 2008 Growth | 2009 Growth |
|---|---|---|---|---|---|
| Utility Energy Storage | 1.65 | 1.82 | 2.00 | 10% | 10% |
| Fuel Cells | 0.10 | 0.15 | 0.40 | 50% | 167% |
| **Total Energy Storage Industry** | 1.75 | 1.97 | 2.40 | 13% | 22% |

*Source: EBI Inc. estimates derived from a variety of sources. Revenues in $ bil*

**Figure 182 California Energy Storage Industry**

| | 2007 | 2008 | 2009 | 2008 Growth | 2009 Growth |
|---|---|---|---|---|---|
| Utility Energy Storage | 0.38 | 0.44 | 0.49 | 17% | 10% |
| Fuel Cells | 0.02 | 0.03 | 0.07 | 59% | 182% |
| **Total Energy Storage Industry** | 0.40 | 0.47 | 0.56 | 19% | 20% |

*Source: EBI Inc. estimates derived from a variety of sources. Revenues in $ bil*

**Figure 183 U.S. Energy Storage Industry as a Percentage of Global Total**

| | 2007 | 2008 | 2009 |
|---|---|---|---|
| Utility Energy Storage | 27.5% | 27.8% | 27.8% |
| Fuel Cells | 28.0% | 27.0% | 26.0% |
| **Total Energy Storage Industry** | **27.6%** | **27.7%** | **27.5%** |

*Source: Climate Change Business Journal, EBI Inc. estimates derived from a variety of sources*

**Figure 184 California Energy Storage Industry as a Percentage of USA Total**

| | 2007 | 2008 | 2009 |
|---|---|---|---|
| Utility Energy Storage | 23.0% | 24.4% | 24.5% |
| Fuel Cells | 16.0% | 17.0% | 18.0% |
| **Total Energy Storage Industry** | **22.6%** | **23.8%** | **23.4%** |

*Source: Climate Change Business Journal, EBI Inc. estimates derived from a variety of sources*

**Figure 185 U.S. and California Energy Storage Industry: Employment**

| | USA $bil in 2009 | USA 2009 Jobs | Calif. $bil in 2009 | Calif. 2009 Jobs | % of USA Jobs in Calif. |
|---|---|---|---|---|---|
| Utility Energy Storage | 2.00 | 5,000 | 0.49 | 1,230 | 24.5% |
| Fuel Cells | 0.40 | 4,000 | 0.07 | 720 | 18.0% |
| **Total Energy Storage Industry** | **2.40** | **9,000** | **0.56** | **1,950** | **21.7%** |

*Source: EBI Inc. estimates derived from a variety of sources. Revenues in $ bil*

## 12.2. Energy Storage Applications

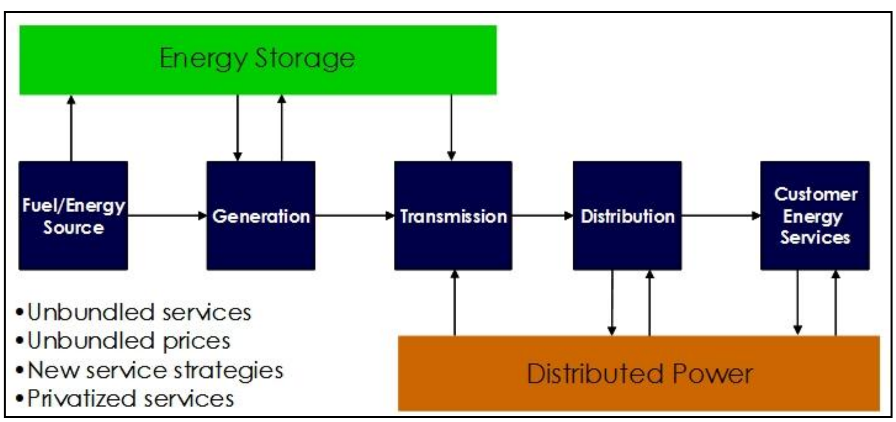
Advanced energy storage systems also offer utilities, independent power producers (IPPs), grid operators and investors a host of other economic values and potential revenue streams, many of which dovetail with the second climate change strategy mentioned above: making fossil fuel units operate more efficiently—thereby reducing greenhouse gas emissions—and even displacing existing and prospective fossil fuel generation capacity.

For utilities, a straightforward use of storage is to **defer investments in transmission capacity or substations in fast-growing areas**. American Electric Power (AEP) was the first U.S. utility to incorporate storage for this purpose. AEP has operated since June 2006 a 1.2-MW, 7.2-MWh sodium-sulfur (NAS) battery energy storages system at a West Virginia substation operated by AEP-owned Appalachian Power Company. "AEP is investing in additional NAS battery systems to achieve reliability improvements and deal with load growth in specific geographic areas as well as to support weak transmission locations," according to EEI's *Electric Perspectives*.

This setup also allows what is known as islanding to keep the power on to certain critical loads in the event of an outage. "If there is an outage, basically the automated control equipment will switch off some of the downline loads so the battery can sustain the critical loads for a prescribed period of time," said Gotschall. "This allows islanding for emergency lighting, traffic control or other critical loads."

One of the fattest economic targets is **creating arbitrage value out of the spread between off-peak and on-peak wholesale power prices**. The most advanced existing battery energy storage system in the world, the 150-plus-MW system in Tokyo using NGK's NAS batteries, generates substantial revenues by charging its batteries with inexpensive off-peak electricity then discharging electricity to the grid at Tokyo's very high on-peak rates. A large proposed compressed air energy storage (CAES) facility in Ohio is designed to similarly earn from the spread between off- and on-peak prices on the PJM Interconnection and Midwest Independent System Operator grids that serve much of the eastern and Midwestern United States. (The project proponents expect to make even more money by buying and selling electricity futures.)

**Figure 186 New Electricity Value Chain with Energy Storage as the "Sixth Dimension"**




*Source: http://www.energystoragecouncil.org/storage_valuechain.html*

Such projects can reduce greenhouse gas emissions from a given electricity grid due to the fact that baseload fossil generation units—primarily coal-fired power plants, the backbone of

U.S. electricity supply—operate most efficiently at specific high output levels. According to NREL, the efficiency of a typical coal unit decreases from 38% to between 28% and 31% at night when the units are pushed off their preferred operating point (POP) by low demand. As the efficiency of the units goes down, their emissions per kWh go up. Storage systems could provide an off-peak load that would allow these fossil units to keep operating at their POPs during times when they'd ordinarily have to throttle back to avert an oversupply situation on the grid. If the storage device is efficient enough then there would be a net reduction in emissions per kWh from a typical electrical generation mix. In regions heavily dependent on coal, the reductions would be even more dramatic.

Another major set of opportunities lies in **delivering the ancillary services needed to run a big electricity network**. These include spinning and non-spinning reserves (power plants operating in various states of readiness to supply reserve power in case another generating facility cuts service unexpectedly) and frequency regulation (power plants constantly adjusting their output to fine-tune electrical generation to match the changing usage of electrical appliances, industrial equipment and machines).

Beacon Power is one of many energy storage companies aiming at the frequency regulation market, and it reached a milestone in November when it connected a 1-MW flywheel energy system to the Independent System Operator-New England (ISO-NE) grid, with follow-on plans set to increase capacity to 5 MW by the middle of next year. Beacon estimates the current value of the regulation market at about $3 billion in the United States.

Regulation and other ancillary services are now provided by gas-fired plants, hydropower plants and in some states even coal-burning plants. Hydro is emission-free, but the fossil units emit carbon dioxide even though they're not producing useful energy, just moving up and down from a set point to regulate grid frequency within national electric system reliability standards (60 Hz). Energy storage advocates say they can provide this service emission-free and more effectively. "For every megawatt you can put in of fast-acting gas turbines [to provide ancillary services] you can put in a megawatt of emission-free lithium-ion batteries or flywheels," said Roberts of the Electricity Storage Assn. "If the plant costs are the same but one doesn't have a fuel cost, why wouldn't you do it?" Roberts answered his own question when he acknowledged that flywheels and batteries and some other storage systems are now coming of age this year at the right price points.

**Figure 187 Role of Energy Storage**

| Energy storage is one of the most critical components of the "new" electricity value chain. Storage can be used to: |
|---|
| **Make renewable energy economically viable:**<br>Enables renewables, solar or wind, to store energy generated during off-peak hours for use during peak hours |
| **Serve as an "electricity reserve" much like the national Petroleum Reserve:**<br>Critical as a safety net for future national emergencies |
| **Stabilize electricity markets:**<br>Eliminates the disruption of major pricing moves due to weather, natural disasters or national emergencies<br>Smoothes the wide swings between on-peak and off-peak prices |
| **Stabilize the transmission and distribution grid:**<br>Injected stored energy helps to stabilize the physical transfer and stability of electrons along the wire to support the integrity of the transmission infrastructure |

| |
|---|
| **Creates new energy market opportunities:**<br>Enables new markets for ancillary services |
| **Enabling more efficient use of existing generation assets:**<br>Reduces the need for cycling large coal-fired plants (peakers) and creates efficiencies along the grid,<br>Reduces dispatch costs incurred by generating assets |

*Source: http://www.energystoragecouncil.org/aboutenergystorage.htm*

## 12.3. Storage Technology Market Niches

What types of technologies can play and where is a subject of increasing public discussion among grid managers and energy policy specialists, as well as proprietary positioning by the emerging electricity storage technology suppliers. In simple terms, the market segments range from quick and short to big and long—from technologies that can deliver precise amounts of electricity very rapidly but for a short duration to systems that take longer to ramp up but can supply tens or hundreds of MW for many hours. CAISO's storage experts like to use the analogy of a sports car versus a minivan.

At a California Energy Commission workshop in July 2008, EPRI energy storage specialist Robert Schainker presented a simplified model of three "economically attractive regions" for energy storage technologies. At the sports car end of the spectrum are batteries and flywheels tasked with discharging for short durations up to two hours. On the minivan side are compressed air energy storage (CAES) and pumped storage hydropower (PSH) that can operate for a dozen hours or more. (Mentioned elsewhere by Schainker are supercapacitors and superconducting magnetic storage systems, devices that discharge electricity for seconds and can be used enhance power quality.)

Some solutions providers target their technology at one niche in the market spectrum: Beacon Power, for example, will use its flywheel energy systems exclusively to provide frequency regulation, the fine-tuning service that grid operators need to match electricity supply with instantaneous changes in demand. Maxwell Technologies is targeting its high-voltage capacitors at wind turbines to buffer the fluctuations in turbine output and to provide backup power to help with orderly shutdown at times when wind velocity exceeds operating standards.

Others are targeting multiple markets, looking to be the sports car, the minivan and many models in between. As a flow battery technology, Premium Power's storage system fits the responsive sports car mode, supplying frequency regulation and other ancillary services. But by deploying its 500 kW units in series at one site, Premium aims to compete with the minivans, saying it has fielded requests from utilities for systems that can supply 300 MW for 10 hours. By the same token, CAES and PSH can also compete with the sports cars to provide frequency regulation services.

What role a storage solution can play also depends on who owns it and what market rules its owner operates under. After PSH, the most widely deployed electricity storage system is the NAS battery developed by NGK Insulators and Tokyo Electric Power Co. In Japan, the NAS systems earn revenues through energy arbitrage, buying low off-peak power and selling expensive on-peak power. "A standard NAS installation with bi-directional power electronics is designed to deliver daily peak shaving cycles for 15 years, where a cycle supplies rated power for about 6 hours at 75% efficiency," according to a company statement.

But in the United States, regulatory issues pose some barriers to deployment of NAS or other storage systems for energy arbitrage or ancillary services by utilities. In the competitive electricity markets—those managed by the seven independent system operators, New England (ISO-NE), New York (NYISO), CAISO, PJM, MISO, the Southwest Power Pool (including

Oklahoma, Kansas and parts of adjacent states) and Texas (Electric Reliability Council of Texas; ERCOT)—investor-owned utilities have separated their unregulated power generation businesses from their regulated transmission and distribution (T&D) businesses. In these markets, public utility commissions require that energy and ancillary services be provided by unregulated entities like IPPs. This means that energy storage technologies like NAS batteries deployed by regulated T&D entities for grid support (improved reliability, deferral of transmission upgrades) are not currently able to use those devices to provide energy and ancillary services to the market.

The logic behind this regulatory framework is that the T&D companies in these markets receive a regulated rate of return based on the capital cost of assets admitted to their rate base. Allowing T&D companies already being compensated for the capital costs of their storage devices to compete for ancillary services or generation with IPPs limited to conventional financing would be unfair. But in practical terms, this arrangement means that storage assets owned by a T&D company can't produce the full spectrum of values that the technology makes possible. And if they don't have access to these potential revenue streams, their incentive to invest in storage will be limited to say the least.

According to Roberts, this conundrum is emblematic of the paradoxical status of storage devices in electricity grids. "Storage today doesn't have a home in a regulatory sense," said Roberts. "It doesn't get recognized appropriately." The ESA is on a mission to fix the problem. The Department of Energy is also concerned about these and other issues, and it has formed the Electricity Advisory Committee (EAC) to help formulate recommendations as to how to improve the grid's performance. The EAC's Energy Storage Subcommittee has just finished a report to Congress that makes recommendations on how storage can be recognized appropriately.

One way to liberate all the value in a battery system deployed at a substation to mitigate congestion and provide islanding during outages would be for an IPP to own the battery and use it most of the time for ancillary services, according to Gotschall. "But the IPP would have a contract with the distribution utility that in the event of an outage he'd discontinue ancillary services and back up the feeder." Gotschall says this is a simplified example that may be difficult to work out in practice because grid locations benefiting from storage tend to change over time. But it points to the need for new market rules and business models in the new architecture of electricity grids.

The ISOs, under pressure to facilitate the deployment of storage technologies on their grids, are grappling with many complex issues. For example, electric grids are set up to dispatch energy efficiently from generation sources to loads, but storage devices act as both generation and load. Batteries take power from the grid by charging; flywheels by increasing RPMs; CAES with compressors; and PSH with pumps. So RTOs will need new market rules for many types and uses of storage devices, along with new software and systems to signal storage devices to consume electricity when down regulation is needed (i.e., when system power exceeds load) and to manage bidding processes.

"We're doing a lot of thinking about how to handle this technology, how to integrate it into the market, how it should be bid and dispatched," said Hawkins of CAISO.

**Figure 188 U.S. Energy Storage Market 2005-2012**

| | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|
| Utility Energy Storage Market | 1,420 | 1,530 | 1,650 | 1,820 | 2,000 | 2,240 | 2,550 | 2,930 |
| Transportation Batteries | 7,370 | 10,320 | 12,900 | 14,190 | 15,610 | 17,170 | 18,890 | 19,900 |
| Fuel Cells | | | 100 | 150 | 400 | 800 | 1,200 | 1,800 |
| **Total Energy Storage** | **8,790** | **11,850** | **14,650** | **16,160** | **18,010** | **20,210** | **22,640** | **24,630** |

*Source: EBI Inc. derived from interviews with consultants and experts.*

### 12.3.1. Hydrogen

One technology that doesn't appear to be figuring prominently in the emerging utility-scale energy storage business is hydrogen fuel cells. Neither fuel cells nor the electrolysis technologies that can make hydrogen from clean PV or wind power are mentioned by the experts at EPRI as a viable technology for grid storage, nor have fuel cells or hydrogen gotten much attention in the technical papers presented at the U.S. Department of Energy's annual peer reviews meetings nor the bi-annual Electrical Energy Storage Applications and Technologies conference sponsored by DOE and the Electricity Storage Assn.

At least one notable hydrogen test was underway, however: Xcel Energy's Wind-to-Hydrogen Demonstration Project to analyze and compare hydrogen production from wind power and the electric grid. The project will pair a Northern Power Systems 100 kW turbine and a Bergey 10 kW turbine with a Titan HMXT Electrolyzer made by Teledyne and a HOGEN 40RE PEM electrolyzer to make hydrogen, then generate power either with a fuel cell or an internal combustion engine to meet peak demand. "This project will explore new synergies for hydrogen as an energy storage medium and a transportation fuel," noted Xcel in its 2007 resource plan. "Most importantly, the project aims to overcome the intermittent aspect of wind energy by enabling energy storage for later use when the wind isn't blowing or the demand for electricity is high."

According to Chris Kuehn, president of Teledyne Energy and Power Systems, the utility industry isn't exactly beating down the door for more electrolyzers. "The issues are the capital costs of the electrolysis unit, compression, storage, and fuel cell systems" said Kuehn. "We've done some projects with DOE on cost reduction. The thrust was to electrolyze at high pressure, 5,000 psi, to eliminate the compression step" to save costs. The process showed essentially that such enhancements would raise costs significantly, according to Kuehn.

"Eletrolyzer technology has been around for 100 years and it's a proven technology but it has gotten to the point where you can't improve costs without a serious paradigm shift," said Kuehn. "GE received DOE funding and was trying to make a system completely out of plastics, based on they're being in the plastics business. I understand they're trying to sell that technology to other people. … They didn't see the business case. I've got to say for the foreseeable future, we don't see something that will create that paradigm shift. It's still much cheaper to crack natural gas."

### 12.3.2. Vehicle to Grid

Any discussion of utility-scale energy storage inevitably must touch on the development of electric vehicles (including plug-in hybrid electric vehicles) and the potential to deploy car batteries as a "behind-the-meter" electricity storage source for utility grids.

Folks in the electricity storage technology business tend to fall into two camps on the question of how realistic this vision is. Those backing it sometimes act as if it's just around the corner while those selling competing stationary battery technologies generally disparage it as not viable. “People talk enthusiastically about PHEVs as a way of doing storage, but the major utilities I see say that’s not the case,” said an executive with one firm. “They want to provide energy to PHEVs, not buy it.”

Stephan Dolezalek, who runs the cleantech practice for VantagePoint Venture Partners, offered a more measured view. “First, we need to recognize that increasing our supply of renewable energy will require both utility-scale solutions like flow batteries and taking advantage of an increasingly electrified transport fleet. We will begin to see individual U.S.-based state and city programs over the next several years, but it is likely to take 10 years to implement a national vehicle-to-grid infrastructure in this country. On the other hand, I think we’ll see it much sooner than that in Europe and probably in China as well.” He noted that Better Place, a VantagePoint-backed company that positions itself as a “mobility operator” and aims to deploy a unique battery charging and battery-swapping model to alleviate the “range anxiety” associated with EVs, has secured commitments for projects in California, Israel, Australia, Denmark and most recently Hawaii.

Better Place’s project in Israel is the furthest ahead, with Denmark following closely behind. Danish utility Dong—looking for storage to deal with the highest wind energy penetration in the world—carmarker Renault-Nissan, lithium-ion battery maker NEC and Better Place plan to get 100,000 EVs on the road and hooked up to utility grids with bidirectional power controls for charging and discharging by 2011. “In Denmark there’s a huge tax on gasoline vehicles so any EV has a significant total cost of ownership preferential,” said Dolezalek.

Tax policies combined with high gasoline prices are driving interest in Better Place’s other developing markets, but in the United States, Dolezalek suggested that “either gasoline or carbon prices will need to rise and/or battery costs will have to further decline before it becomes abundantly clear to the American public that gasoline is not the way to go with regard to vehicle power. But interest among U.S. utilities is rising. They see it as a very attractive market opportunity and a number of them are ready to begin studying and piloting vehicle-to-grid programs.”

Emerging vehicle-to-grid technologies and markets will certainly be constrained by the economy. “We fully expect that the cleantech industry as a whole will see a slowdown and capital crunch through 2009 and into 2010,” said Dolezalek. “However, the Obama Administration and increasing numbers of political figures and pundits see cleantech as a significant part of how to grow this country out of the economic crisis. In the near term, that may mean energy retrofits, efficiency and wind projects, but within a year or two the focus will shift to solar, smart-grid, enhanced transmission and V-to-G implementations.”

“This is a transitional time for electric energy storage,” concluded EPRI’s Rastler. “A number of cost-effective systems and solutions exist while others will soon emerge. NAS and flow batteries are being adopted by electric utilities as a grid support asset. Advanced CAES system designs look attractive for bulk power energy storage, supporting renewable generation and reducing the sector’s carbon footprint.”

“Li-ion batteries applied in PHEV and utility distributed energy storage systems could enable a transformation to more distributed power systems and a convergence of electric power and transportation. Developments in flow batteries, advanced batteries, and ultra-capacitors also continue. The ability to store electricity will become increasingly important, but much remains to be done for the cause. Current technology and products need to be integrated within the activities leading to advanced ‘smart grids.’”

"Additional R&D, including research in basic materials science, is needed, especially in advanced batteries. Current technology and that in the R&D pipeline will give a big boost to improving the efficiency of the electric enterprise in the years to come."

**Figure 189 Energy Storage Applications**

| | Pumped Hydro | Compressed Air | Batteries | Flywheels | Capacitors |
|---|---|---|---|---|---|
| Up-Regulation | | | X | | |
| Down-Regulation | | | X | | |
| Non-Spinning Reserves | | | X | X | |
| Spinning Reserves | | | X | X | |
| Energy Arbitrage | X | X | | | |
| Transmission Upgrade Deferrals | | | | | |

*Source: EBI Inc.*

## 12.4. Investor Activity in Energy Storage

Energy storage is one of the more appealing areas of cleantech venture investing today, said Brian Fan, senior director of research at the Cleantech Group. The intermittency of principle renewable energy sources solar and wind is a major driver, as investors seek to hedge their bets. Most private equity and venture investors pursue a portfolio approach to energy investments and realize the future of their holdings in these other areas could be affected by the successful development of storage technologies. Likewise there is no dominant investor in the storage space given investors' desire for diversification, although General Electric (through GE Commercial Finance, GE Energy Financial Services, GE Capital or GE Equity), RockPort Ventures and Kleiner Perkins Caufield & Byers are among investors with multiple holdings in storage.

**Figure 190 Top 10 Investments in Energy Storage**

| Company | Description | Quarter | Region | Amount | Lead Investor |
|---|---|---|---|---|---|
| Bloom Energy (FKA Ion America) | Developer of a reversible solid-oxide fuel cell technology. | 3rd Qtr 2006 | West Coast | $103,000,000 | Kleiner Perkins Caufield & Byers |
| A123 Systems, Inc. | Developer of lithium-ion batteries utilizing nanophosphate electrode technology for improved discharge rates. | 2nd Qtr 2008 | Northeast | $102,100,000 | Undisclosed |
| A123 Systems, Inc. | | 4th Qtr 2008 | Northeast | $102,000,000 | GE Commercial |
| Boston Power, Inc. | Developer of lithium ion smart batteries with improved safety, lifetime, and sustainability. | 1st Qtr 2008 | Northeast | $45,000,000 | Gabriel Venture Partners |
| A123 Systems, Inc. | | 1st Qtr 2007 | Northeast | $40,000,000 | Alliance Capital |
| Infinite Power Solutions | Developer of thin-film energy storage devices for microelectronic applications. | 3rd Qtr 2006 | Rockies/Plains | $35,700,000 | Advanced Energy Technology |
| Beacon Power Corp. | Developer of multi-flywheel-based energy storage systems which provide sustainable | 2nd Qtr 2000 | Northeast | $32,325,900 | Beacon Partners |

| | | | | | |
|---|---|---|---|---|---|
| | frequency regulation. | | | | |
| ENER1, Inc. | Developer of light-weight compact lithium ion batteries for hybrid electric vehicles, and PEM fuel cells. | 4th Qtr 2007 | Southeast | $32,000,000 | Undisclosed |
| Lilliputian Systems, Inc. | Developer of a micro-fuel cell based power supply for handheld electronics. | 4th Qtr 2005 | Northeast | $30,200,000 | Atlas Venture Ltd. |
| Power Paper, Ltd. | Provider of micro-power source technology through thin energy cells that are adaptable to various products without metal casings. | 4th Qtr 2005 | Israel | $30,137,890 | Apax Partners Inc. |

*Source: Cleantech Group*

Fan agreed that certain investors have taken a stronger focus on storage and seem to be adopting a portfolio approach within the segment given the multiple technologies and applications. Fan observed that energy storage is well suited to the venture investor model as it possesses key characteristics not in all cleantech sectors: “Materials science matters, chemistry matters, IP matters, manufacturing matters,” he said.

Energy storage also has significantly more scope for technology improvement than solar and wind, for example, said Fan. “Wind power has a maximum efficiency of 59% and we are at about 51% in the best units today…. Solar is at about 15% for crystalline, and theoretical maximum efficiency is 25-30%.” Meanwhile battery performance is much lower compared to market ceilings. Measured in energy density, today’s battery technology has about 5% of the capacity of gasoline by the kilogram. Also, Fan said, improvements in batteries have only been incremental: “There have been no major breakthroughs.”

Nevertheless, investor money continues to flow into energy storage of all varieties. Cleantech Group reports that about $2.2 billion in investments have gone into 220 energy storage deals since 2003, or about 10% of total cleantech investing. Early activity during this period was largely in fuel cells, with more recent activity paced by battery companies. Cleantech’s database shows record energy storage investment in 2007, but continued high activity into 2008.

Lux Research reports that after several lean years, venture capital investment in energy storage technologies is soaring. In 2007, makers of batteries, capacitors, fuel cells, energy harvesting and related products raised total funding of $709 million, up 74% from 2006, according to a Lux report. The leaders in attracting VC are battery specialists, which raised more than $426 million in 2007, compared with $142 million the previous year, Lux says. Next are fuel cell makers, which drew $206 million in 2007, although that figure is down from $246 million in 2006. The chart exhibiting the 10-year history of VC investment shows fairly consistent interest in fuel cells in spite of the bumpy ride experienced by those companies, but more notably the dramatic emergence of batteries in 2007 in terms of dollars invested.

Lux did report, however, that investor returns have been harder to come by in storage. Only 17% of VC-backed energy storage companies have gone public since 1997, generating a modest 4.5 times average cash-on-cash return to investors. Venture-funded startups that were acquired during that period, which amount to 6% of the sector, fared much worse, yielding a miniscule 0.8 times return on investment. Of the remaining players, 69% are still in business, while 9% are inactive.

Other financial news of note:

• Ener1 bought an 83% interest in Enertech International, a Korean manufacturer of lithium-polymer batteries that were previously used to fabricate prototype battery packs for plug-in electric vehicles that Norway's Th!nk plans to introduce next year.

• Exide Technologies bought Mountain Power, a Canadian developer of large capacity lithium-ion batteries for the communication, utility, medical, military and industrial markets.

• A123 Systems filed a third amendment to the registration statement for its IPO, indicating the offering is likely to go forward in December.

• In utility applications, Beacon Power Corp. received provisional regulatory approval from ISO New England for the commercial use of a modular system that uses an array of high-speed flywheels to provide on-demand power for frequency regulation. And France's Saft Batteries and infrastructure giant ABB announced the joint development of a modular system that uses lithium-ion batteries to provide on-demand power for frequency regulation and other utility applications.

Alternative energy blogger John Peterson noted these and other trends amount to a tidal wave in energy storage. "The fundamental market drivers have developed far faster than I imagined and what I initially described as a rising tide is now looking more like an investment tsunami as a handful of micro-cap and small-cap companies gear up to compete for $50 to $70 billion of rapidly developing annual demand for large format energy storage systems," Peterson wrote.

The October 2008 $102-million investment in battery manufacturer A123 Systems lead by GE is testament to the potential of energy storage. As one of the world's leading power generation equipment providers and a clear leader in the clean energy industry with its Ecomagination platform, GE seems primed to be the eventual leader in energy storage technology and systems. In October 2008, GE reported that its revenues from energy efficient and environmentally advantageous products and services will surge 21% to $17 billion in 2008, while GE's annual investment in cleaner research and development will pass $1.4 billion. Energy blogger Garry Golden wrote that GE's investment in A123 indicates that "GE's executives must see clear growth ahead around demand for storage to support growth in wind and solar power generation, utility companies trying to build more robust 'smart grids', and to help the automobile industry as it moves the world's fleet away from liquid fuels and the combustion engine." For executives in the energy storage and the clean energy industry it would be hard to do much better than get an endorsement from GE, although one from President Obama and Warren Buffett may not be far behind.

## 12.5. Pumped Storage Hydro

When it comes to storing large amounts of electricity, nothing beats pumped storage hydropower (PSH). By far the leader in utility-scale energy storage, pumped hydro accounts for 22 GW of storage capacity spread across 150 facilities in 19 U.S. states, according to the Electric Power Research Institute (EPRI). Worldwide capacity is about 90 GW, and Japan is the top user with about 23 GW installed, followed by China (9 GW), Russia (5 GW), Italy and France (4.5 GW each), according to data from engineering and construction firm MWH. (Broomfield, Colo.).

**Figure 191 U.S. Pumped Hydro Storage Projects: License Applications Filed as of 8/08**

| Project Name | Permitee | Waterway | MW |
|---|---|---|---|
| Iowa Hill | SMUD | Upper American River, CA | 400 |
| Taum Sauk | Ameren UE | MO | 408 |

| | | | |
|---|---|---|---|
| Lake Elsinore | Elsinore Valley Mun Water District | CA | 500 |
| Eagle Mountain | Eagle Crest Energy, Company | CA | 1334 |
| Hook Canyon | Hook Canyon Energy, LLC | UT | 1120 |
| West Valley | Hot Springs Valley Irrigation Dist. | Moon Lake Dam, CA | 264 |
| Mineville | Moriah Hydro Corp. | Harmony Mines, NY | 189 |
| Bryant Mountain | United Power Corporation | Pope Reservoir, OR | 1175 |
| Phantom Canyon | H2OProviders, Inc. | Arkansas River, Co | 220 |
| Red Mountain Bar | Modesto Irrigation District | Tuolumne River, CA | 880 |
| San Vicente | San Diego County Water Authority | San Vicente River, CA | 570 |
| Sentinel Mountain | United Power Corporation | Crab Creek and Moses Lake, WA | 2000 |
| Mulqueeney Ranch | BPUS Generation Development | Mulqueeney Ranch, CA | 280 |
| Plateau Creek | UTE Water Consevancy District | Plateau Creek, CO | 2700 |
| Lake Powel Pipeline | Utah Board of Water Resources | Lake Powell, WA | 443 |
| Summer Lake | NT Hydro | Summer Lake, OR | 256 |
| Abert Rim | NT Hydro | Mule Lake, OR | na |
| Mt. Hope | Mt. Hope Waterpower Project, LP | Mt/ Hope, Mine Water, NJ | 850 |
| Loomis Creek | Loomis Creek Hydro, LLC | Loomis Creek, NV | 370 |
| Hoppie Canyon | Hoppie Creek Hydro, LLC | Hoppie Creek, NV | 380 |
| Division Canyon | Division Canyon Hydro, LLC | Division Canyon, NV | 500 |
| Thousand Springs | Thousand Springs Hydro, LLC | Thousand Springs, NV | 470 |
| Long Canyon | Utah Independent Power | Colorado River, UT | 800 |
| Kings River | PG&E | North Fork Kings River, CA | 5 |
| Mokelumne | PG&E | North Fork Kings River (380-1140 MW), CA | 760 |
| Bull Canyon | Utah Independent Power | Colorado River, UT | 1600 |
| Lorella | BPUS Generation Development | Groundwater Resources, OR | 1000 |
| KlamathCounty | Interie Energy Storage | Groundwater Resources, OR | 1000 |

*Source: MWH derived from Federal Energy Regulatory Commission (ferc.gov): Note: Total of projects in the short-term pipeline represent more than 20 GW, nearly the existing U.S. capacity of 22 GW; First group are Pending FERC License Applications as of 8/2008, Second group are Issued Preliminary FERC Permits as of 8/08, Last group are Pending Preliminary FERC Permits filed August 07-08.*

Pumped hydro plants use electricity during off-peak periods such as nights and weekends to pump water from one reservoir to a second reservoir at higher elevation. When power is needed during peak periods, water is released from the upper reservoir, flowing through turbines to generate electricity. There is, however, a slight efficiency penalty from the energy consumed by pumps, as it takes more energy to pump the water uphill than can be generated when flowing downhill. Even so, the difference in offpeak and peak rates and the demand for ancillary services such as frequency regulation helps make a market for PSH. "Offering 10 or more hours of energy storage, pumped hydro plants can absorb excess electricity produced during off-peak hours, provide frequency regulation, and help smooth the fluctuating output from other sources," according to EPRI's September/October 2008 Electric Perspectives.

Utilities and grid operators in places where renewable energy standards are prompting the development of large amounts of intermittent wind power are looking at PSH to firm wind's intermittent reliability and regulate its frequency and voltage variations. But building new PSH capacity is not easy lifting. "Pumped hydro is economical only on a large (1,000-2,000 MW) scale," according to EPRI. Suitable sites that are technically feasible are common, but these sites are sometimes located far from high-voltage transmissions lines and may have environmental permitting challenges. Another challenge is that permitting and construction timelines can be as long as a decade. “Pumped hydro is a terrific technology— especially if you already own some,” said EPRI storage expert Robert Schainker, as quoted in Electric Perspectives. “But the expense and long construction times of new pumped storage facilities are making the industry look to other alternatives.”

Other utility experts and consultants are more optimistic about the prospects for new PSH capacity, however. “There are signs that pumped storage is about to experience another surge of growth,” wrote Daniel Adamson, a partner in law firm Davis Wright Tremaine and former head of energy projects for the Federal Energy Regulatory Commission (FERC), in *The Energy Daily*. “Pumped storage provides an extraordinary ability to both follow load and store energy, characteristics that will become even more important than they are today as we move toward increased reliance on intermittent renewable power resources.”

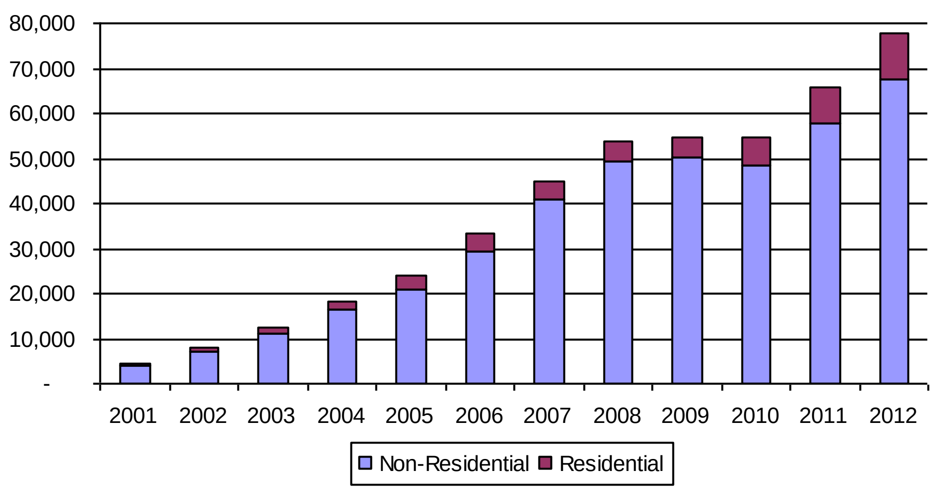
# 13. Green Buildings

In just a few years, the green building business has grown from a boutique market to the hottest segment of the building industry. In the United States, green building—also known as sustainable building or high performance building—has expanded from the coasts to the heartland, from a specialty practiced by a few to a competency that few designers and other building trades firms can thrive without. From a market made up of mission-driven public agencies and institutions it has grown into one in which corporations and developers are going green to meet the demands of customers, tenants, employees, legislators and shareholders.

"Up until about 18 months ago, we were constantly battling against the overwhelming myth that to build green would cost you a pound of flesh that you'd never get back," said Michelle Moore in 2008 as senior vice president for policy and public affairs for the U.S. Green Building Council (USGBC, Washington, D.C.), keeper of the Leadership in Energy and Environmental Design (LEED) rating systems. "But for the past 18 months we've seen a widespread acceptance of the business case for green building, an understanding that [LEED certification] will add to the bottom line in [operational] cost savings and higher valuations."

Virtually all of the more than 120 developers, designers, engineers and consultants interviewed or surveyed by EBI reported surging demand in the United States for green building design and features—and not just in green hotbeds such as Boston, Seattle and San Francisco. "Green building is huge in Houston," said Brian Malarkey of architecture firm Kirksey.

**Figure 192 U.S. Green Building Industry 2001-2012 ($mil)**




*Source: EBI Inc. derived from a variety of sources including USGBC, GBI, government sources and CCBJ and EBJ annual surveys and interviews of consultants, designers, architects, construction firms, non-profits and experts.*

"Of the private-sector projects [in development] that are over 50,000 square feet, about 75% are going for LEED certification." Malarkey said that among energy companies, the percentage is above 90%. "Of the 27 projects under construction right now [by energy companies], 25 are seeking LEED certification."

Without a doubt, the turmoil in real estate and credit markets has impacted the green building segment, but most observers believe it will be substantially better off than the development market overall. In single-family homes, the credit crunch and the decline in real estate values has definitely stalled green builders. “We’re not building any single-family homes because of the market conditions,” said Mark Fischer of The Grupe Company (Stockton, Calif.), until recently one of the most active green homebuilders in the United States. At the end of 2007 Grupe stopped work halfway through its planned 144-unit zero-energy community near Sacramento. For reasons discussed below, single-family housing is the least developed segment of green building in the United States. The larger segments such as commercial office, government and institutional markets like hospitals and universities may be slightly more buffered from the credit and financial markets.

USGBC reported no decline in the monthly volume of projects registered through September 2008. The first step in the LEED process, registration occurs well before projects break ground but months after they’ve reached the design phase. “There could be from three to nine months of development work before the first submittal is made,” said Goldsmith. In other words, projects registered in August 2008 had likely been planned as early as the fourth quarter of 2007. Therefore, a decline in the pipeline of proposed green construction projects may not have shown up yet. Additionally, many projects that get to the registration phase may be delayed or canceled as the developers find a lack of financing for new construction.

**Figure 193 U.S. Green Building Industry 2001-2012 ($mil)**

| | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|
| **Estimated % 'Green'** | | | | | | |
| Non-Residential | 1.2% | 2.2% | 3.6% | 5.0% | 6.0% | 7.50% |
| Residential | 0.1% | 0.2% | 0.3% | 0.4% | 0.5% | 0.6% |
| **Value Put in Place** | | | | | | |
| Non-Residential | 4,161 | 7,025 | 11,111 | 16,227 | 20,835 | 29,450 |
| Residential | 373 | 804 | 1,354 | 2,154 | 3,088 | 3,719 |
| **Total** | **4,533** | **7,829** | **12,465** | **18,381** | **23,922** | **33,169** |
| Green Building Growth | | 73% | 59% | 47% | 30% | 39% |
| | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** |
| **Estimated % 'Green'** | | | | | | |
| Non-Residential | 8.80% | 10.30% | 12.10% | 13.90% | 15.70% | 17.50% |
| Residential | 0.8% | 1.1% | 1.5% | 1.9% | 2.5% | 3.1% |
| **Value Put in Place** | | | | | | |
| Non-Residential | 40,712 | 49,330 | 50,417 | 48,650 | 57,698 | 67,528 |
| Residential | 3,997 | 4,369 | 4,469 | 5,802 | 8,015 | 10,436 |
| **Total** | 44,709 | 53,699 | 54,885 | 54,452 | 65,713 | 77,964 |
| Green Building Growth | 35% | 20% | 2% | -1% | 21% | 19% |

*Source: EBI Inc. derived from a variety of sources including USGBC, GBI, government sources and CCBJ and EBJ annual surveys and interviews of consultants, designers, architects, construction firms, non-profits and experts.*

“Green is sort of an overlay that can put a project in a more competitive position and can be a big advantage in permitting… but it doesn’t guarantee that a developer will get funding,” said Michael Wagner, editor of *Green Real Estate News*. “There definitely are [green] projects that are getting funded. It’s just much harder [than before]. Also lender requirements have changed so you typically need more equity to invest in a project and that can have a big effect on your returns."

**Figure 194 Total Put in Place ($Mil)**

| | | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|
| Total $mil Put in Place | | 721,285 | 759,900 | 862,952 | 964,752 | 1,012,486 |
| Growth (%) | | | 5% | 14% | 12% | 5% |
| Green Building % of Total | | 1.1% | 1.6% | 2.1% | 2.5% | 3.3% |
| | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
| Total $mil Put in Place | 962,285 | 876,133 | 714,571 | 655,352 | 688,120 | 722,526 |
| Growth (%) | -5% | -9% | -18% | -8% | 5% | 5% |
| Green Building % of Total | 4.6% | 6.1% | 7.7% | 8.3% | 9.5% | 10.8% |

*Source: FMI and EBI Inc.*

Doug Mass, president of engineering firm Cosentini Associates (a Tetra Tech company) that works on high-profile green projects worldwide, reported that his firm is "not doing any less that we would be in a robust market." But in the United States, he said some green projects have indeed been canceled or postponed. "What happens generally is that there is some seed money [from equity investors] to put a project through the schematic phase. But the banks are not going to give you a loan until they know what the hard costs are based on a design development level document. And right now, banks are saying 'we don't have the capital,' or 'capital is only available at a much higher rate.'"

**Figure 195 Components of Green Building**

| |
|---|
| Energy Efficiency and Renewable Energy |
| Water Efficiency |
| Environmentally Preferable Building Materials and Specifications |
| Waste Reduction |
| Toxics Reduction |
| Indoor Air Quality |
| Smart Growth and Sustainable Development |

*Source: http://www.epa.gov/greenbuilding/*

Like other design and engineering professionals who are working globally, Mass reported that demand for green buildings overseas has shown little sign of diminishing in the wake of credit problems emanating from the United States. "Overseas is a whole different world. Asia and the Middle East are showing very strong demand for green building," said Mass.

"So far we've seen some slowdown in the United States," agreed Mary Ann Lazarus, sustainable design director for leading green design firm HOK (St. Louis). "A couple of projects seem to have been put on hold." By contrast, HOK's international green building business is showing no signs of easing off the accelerator pedal. "We're doing a lot of work in the Middle East. Asia also has a strong demand for sustainably designed buildings."

**Figure 196 The Top 100 Green Design Firms (1-23)**

| Rank (2008) | Company, Location |
|---|---|
| 1 | HOK, St. Louis, Mo. |
| 2 | URS Corp., San Francisco, Calif. |
| 3 | Gensler, San Francisco, Calif. |
| 4 | HKS Inc., Dallas, Texas |
| 5 | Fluor Corp., Irving, Texas |
| 6 | Kimley-Horn and Associates Inc., Raleigh, N.C. |
| 7 | AECOM Technology Corp., Los Angeles, Calif. |
| 8 | Perkins+Will, Chicago, Ill. |
| 9 | Tetra Tech Inc., Pasadena, Calif. |
| 10 | Perkins Eastman, New York, N.Y. |
| 11 | Zimmer Gunsul Frasca Architects LLP, Portland, Ore. |
| 12 | Callison, Seattle, Wash. |
| 13 | SmithGroup Inc., Detroit, Mich. |
| 14 | Hammel Green and Abrahamson Inc., Minneapolis, Minn. |
| 15 | HDR, Omaha, Neb. |
| 16 | Flad Architects, Madison, Wis. |
| 17 | The Facility Group, Smyrna, Ga. |
| 18 | WSP Group, New York, N.Y. |
| 19 | KlingStubbins, Philadelphia, Pa. |
| 20 | Langan Eng'g and Enviromental Services, Elmwood Park, N.J. |

*Source: http://enr.construction.com/people/topLists/GreenDesign/topGreenDesign_1-50.asp, Engineering News - Record ENR.com, Top green design firms, 2008*

## 13.1. Green Building Industry Statistics & Review

**Figure 197 Global Green Buildings Energy Industry**

| | 2007 | 2008 | 2009 | 2008 Growth | 2009 Growth |
|---|---|---|---|---|---|
| Green Building Design and CM/PM | 7.45 | 8.33 | 7.97 | 12% | -4% |
| Green Building Materials | 91.07 | 101.84 | 97.38 | 12% | -4% |
| Green Building Construction | 67.06 | 74.99 | 71.70 | 12% | -4% |
| **Total Green Buildings Industry** | 165.59 | 185.17 | 177.05 | 12% | -4% |

*Source: EBI Inc. derived from a variety of sources including USGBC, GBI, government sources and CCBJ and EBJ annual surveys and interviews of consultants, designers, architects, construction firms, non-profits and experts. CM/PM is construction management and project management.*

**Figure 198 U.S. Green Buildings Energy Industry**

| | 2007 | 2008 | 2009 | 2008 Growth | 2009 Growth |
|---|---|---|---|---|---|
| Green Building Design and CM/PM | 2.01 | 2.42 | 2.47 | 20% | 2% |
| Green Building Materials | 24.59 | 29.53 | 30.19 | 20% | 2% |
| Green Building Construction | 18.11 | 21.75 | 22.23 | 20% | 2% |
| **Total Green Buildings Industry** | 44.71 | 53.70 | 54.89 | 20% | 2% |

*Source: EBI Inc. derived from a variety of sources including USGBC, GBI, government sources and CCBJ and EBJ annual surveys and interviews of consultants, designers, architects, construction firms, non-profits and experts.*

**Figure 199 California Green Buildings Energy Industry**

| | 2007 | 2008 | 2009 | 2008 Growth | 2009 Growth |
|---|---|---|---|---|---|
| Green Building Design and CM/PM | 0.36 | 0.43 | 0.42 | 19% | -2% |
| Green Building Materials | 4.43 | 5.26 | 5.13 | 19% | -2% |
| Green Building Construction | 3.26 | 3.87 | 3.78 | 19% | -2% |
| **Total Green Buildings Industry** | 8.05 | 9.56 | 9.33 | 19% | -2% |

*Source: EBI Inc. derived from a variety of sources including USGBC, GBI, government sources and CCBJ and EBJ annual surveys and interviews of consultants, designers, architects, construction firms, non-profits and experts.*

**Figure 200 U.S. Green Buildings Industry as a Percentage of Global Total**

| | 2007 | 2008 | 2009 |
|---|---|---|---|
| Green Building Design and CM/PM | 27% | 29% | 31% |
| Green Building Materials | 27% | 29% | 31% |
| Green Building Construction | 27% | 29% | 31% |
| **Total Green Buildings Industry** | 27% | 29% | 31% |

*Source: EBI Inc. derived from a variety of sources including USGBC, GBI, government sources and CCBJ and EBJ annual surveys and interviews of consultants, designers, architects, construction firms, non-profits and experts.*

**Figure 201 California Green Buildings Industry as a Percentage of U.S. Total**

| | 2007 | 2008 | 2009 |
|---|---|---|---|
| Green Building Design and CM/PM | 18.0% | 17.8% | 17.0% |
| Green Building Materials | 18.0% | 17.8% | 17.0% |
| Green Building Construction | 18.0% | 17.8% | 17.0% |
| **Total Green Buildings Industry** | 18.0% | 17.8% | 17.0% |

*Source: EBI Inc. derived from a variety of sources including USGBC, GBI, government sources and CCBJ and EBJ annual surveys and interviews of consultants, designers, architects, construction firms, non-profits and experts.*

**Figure 202 U.S. and California Green Buildings Industry: Employment**

| | USA $bil in 2009 | USA 2009 Jobs | Calif. $bil in 2009 | Calif. 2009 Jobs | % of USA Jobs in Calif. |
|---|---|---|---|---|---|
| Green Building Design and CM/PM | 2.47 | 18,300 | 0.42 | 3,420 | 18.7% |
| Green Building Materials | 30.19 | 83,900 | 5.13 | 14,250 | 17.0% |
| Green Building Construction | 22.23 | 177,800 | 3.78 | 30,230 | 17.0% |
| **Total Green Buildings Industry** | 54.89 | 280,000 | 9.33 | 47,900 | 17.1% |

*Source: EBI Inc. derived from a variety of sources including USGBC, GBI, government sources and CCBJ and EBJ annual surveys and interviews of consultants, designers, architects, construction firms, non-profits and experts.*

## 13.2. Trends and Market Drivers

Presuming that business credit becomes more readily available, EBI expects the U.S. green building segment to continue its growth although at reduced rates. EBI estimated the U.S. green building industry at $55 billion in 2009 in terms of value of green buildings put in place during the calendar year. Annual growth was 30-40% from 2004-2007, after 50-60% growth in 2001-2003 when EBI started estimating the value of green buildings based on certification data, total construction data, interviews and surveys of practitioners and experts. Annual growth is expected to be in the 8-20% range in 2011-2016, with 2009 and 2010 an recession-induced slice off growth. Overall U.S. construction data released by FMI indicates that after double-digit growth years in 2004 and 2005 and 4% growth in 2006 to top $1 trillion in value put in place, construction markets declined 3% in 2007 with FMI saying -7% for 2008, -14% for 2009, -5% for 2010 with recovery starting in 2011.

Executives across the spectrum of the green building industry said that in spite of the current conditions, green building market drivers are robust and will remain so for the long term. Combining EBI survey and interview research with analyses by other industry observers, we rank these six issues as the top market drivers for green building in the United States.

1. Rising energy costs, for natural gas and electricity in particular, appear to be the most significant drivers for green and energy-efficient design and features in new construction and retrofits. EBI survey respondents ranked energy costs as the top market driver, with 60% choosing it the "most important" factor and 36% ranking it as "very important." Reflecting the economic imperative to cut energy costs and related concerns about climate change, USGBC in its 2009 version of LEED will give significantly more weight to energy usage by increasing the

rating points for Energy and Atmosphere. Water Efficiency is also getting more prominence, with the logic that climate change is impacting water resources, and that water delivery consumes a lot of energy. For institutions such as K-12 schools, energy costs are draining budgets and creating urgency for school authorities to invest in green building retrofits, particularly in more efficient lighting and HVAC systems and improved daylighting. According to Brian Domke, senior project manager for Tetra Tech Architects & Engineers, "It's not uncommon to achieve anywhere from 20% to 40% decrease in annual energy costs."

2. Government incentives that reduce the initial costs of investing in energy-efficiency and green building measures, both for new buildings and renovations, are having a major impact in many markets. New Yorkers raved about rebates and incentives from the New York State Energy Research and Development Authority (NYSERDA) for commercial buildings, multi-family and single-family housing. "Developers, whether they're remodeling or building a new building, are being given substantial incentives to make buildings green and energy efficient," said green building consultant Steven Winter, president of Steven Winter Associates.

Nationwide, local governments and investor-owned utilities are in the lead with incentives. Cash payments are the most common form of incentive, according to a November 2007 report by Yudelson Associates for the National Assn. of Industrial and Office Properties Research Foundation. Additionally, many cities are offering developers expedited permit processing for green projects—a key advantage given developers' financing costs. Some cities are giving what are known as density bonuses—permission to build more densely than zoning ordinances allow—for green and energy efficient projects. In many cases, density is also a key factor in so-called Smart Growth planning strategies that aim to concentrate people, jobs and services within existing urban and suburban areas. "If you can allow a developer to get more condos, apartments or offices in less square footage of dirt, he makes more money and you get a more sustainable city," said Alan Whitson, president of the Corporate Realty Design and Management Institute (Portland, Ore.).

3. Demand from tenants, customers, shareholders and employees is increasingly a factor in developers' and corporations' decisions to adopt green building strategies. "It may be the most important driver of all," said Wagner of *Green Real Estate News*. "Companies are getting pressure from their shareholders and customers who are asking what they're doing for sustainability." Renting space in a green building helps provide at least a partial answer. Helen Kessler of Chicago-based HJKessler Associates, a green building consultancy, noted that "when a tenant says to a developer, I'd love to have my 80,000 square feet in your building, under one condition—you get LEED Gold certification—that's definitely a driver."

Wagner believes that in many U.S. cities where there are no LEED office buildings, "There are huge opportunities to be the first in the market." Ditto for owners of existing buildings who are looking at LEED for Existing Buildings. "There's mounting evidence that tenant retention is higher and turnover rate is much lower [in green buildings]," he said.

Demand for green buildings is also coming from employees and prospective employees. According to Malarkey of Kirksey, a key motivator for Houston-based energy companies to build green—aside from the public relations value—is staff recruitment. "It turns out that a lot of kids out of college are asking to work in LEED buildings, and the energy industry has to compete hard for new hires because there's a shortage of talent out there and not a lot of people want to get into the oil & gas business," he said.

But in spite of impressive growth, the green office building segment is still constrained by corporations' and developers' aversion to extra upfront costs and the fact that builders of speculative office developments for prospective tenants—as opposed to projects “built-to-suit” for owners—do not reap the operational savings from investments in energy and water efficiency because they generally sell their buildings within a few years. Additionally, common lease structures create a disincentive for these developers because savings accrue to tenants.

4. Policies and regulations are emerging that require projects above a certain size threshold to achieve LEED equivalence (actual certification is generally not required). “Los Angeles, San Francisco and Dallas over the past six months have all passed green building ordinances,” that require projects above 50,000 square feet to achieve ratings similar to LEED Certified, the minimal LEED rating, said Wagner. Nellie Reid, director of sustainable design for Gensler (San Francisco), an architecture and design firm, noted that the District of Columbia recently adopted energy performance labeling requirements for buildings similar to those in place in the United Kingdom. “You’re going to start seeing the Energy Star ratings posted on all buildings in Washington, D.C.,” she said.

In jurisdictions without such ordinances, designers and developers foresee them coming “down the track like a freight train,” said Winter. “First cities and jurisdictions are hoping and wishing that green practices will be pursued, so they provide incentives. The next thing they provide is regulation. I see green as becoming a de facto requirement.”

5. Sustainable materials, green building design features and equipment are improving in terms of performance, cost and availability. “There’s no question that availability of more good sustainable design materials has made it possible for creative designers to do good work and also do environmentally sensitive design,” said Bradford Perkins, president of Perkins Eastman, a New York design firm. “If you’d have asked me 10 years ago to specify a green roof on top of a sensitive area of a hospital, I would have said you were nuts. The technology just wasn’t there. Today building a green roof that actually performs is fairly routine.”

The reduction in cost premiums for green materials and features is as significant as the improvements in performance. Cost is the largest disincentive to green and energy efficient buildings, but premiums may not be as high as many expected. Median responses from EBI survey respondents indicated that cost premiums for LEED buildings were: 2.5% for Certified; 3% for Silver; 6% for Gold and 10% for Platinum rating. Yudelson’s report on incentives also surveyed developers, 41% of whom ranked cost as the top barrier to more green building. Many EBI sources say that the cost premiums are trending downward because of the volume of demand for once-obscure materials like low-VOC paints. “Because there has been so much uptake among market leaders, including governments building green, the price premiums for materials have really come down,” said Moore of USGBC.

6. Reducing water consumption, especially in regions like the Southwest. Water concerns are rising with climate change, so even water-rich areas like the northeast are installing more high-efficiency fixtures and water re-use systems both for conservation and cost savings. “In New York City over the last three years, water and sewer rates have gone up 36%, and a 15% increase is projected for 2009,” said Les Bluestone of green multifamily developer Blue Sea Development. (New York, N.Y.). “If you have a building that’s saving thousands of gallons of water through the use of efficient showerheads, that’s real money in your pocket.” Fifty-one percent of CCBJ survey respondents ranked reducing water consumption as “very important” and 28% ranked it as “important.”

**Figure 203 Footprint of Buildings**

**In the USA, buildings account for:**

- 65% of electricity consumption,
- 36% of energy use,
- 30% of greenhouse gas emissions,
- 30% of raw materials use,
- 30% of waste output, and
- 12% of potable water consumption.

*Source: US Green Building Council*

### 13.2.1. Up-Front Cost an Obstacle

Despite these robust market drivers, a larger issue constrains the growth of the green building industry—an issue that may well become much more significant in the economically difficult months or years ahead: Developers as well as corporate real estate and building managers find it problematic to increase the initial costs of a project for the promise of lower operating costs over a long term, especially when those first costs are financed with debt.

"Many of our clients are looking to get buildings that would qualify as LEED certified. They want the aspects of sustainable design and green building that can deliver environmental and economic benefits over the long term, but they're not necessarily prepared for the additional costs," said Perkins. "They are so driven by first costs that they can't make some decisions based on long-term thinking."

Whitson of the Corporate Realty Design and Management Institute described an exercise that he and his colleague lead in energy-efficiency seminars for corporate real estate managers. "We ask people 'How many of you would take a project to management that had a payback period of 13 years?' Nobody raises their hand." The presenters ask the question for a 12-year payback period, then 11 years, 10 years and so on. "When we get to five years, one or two people raise their hands. But most don't raise their hands until we get to three years or even two years."

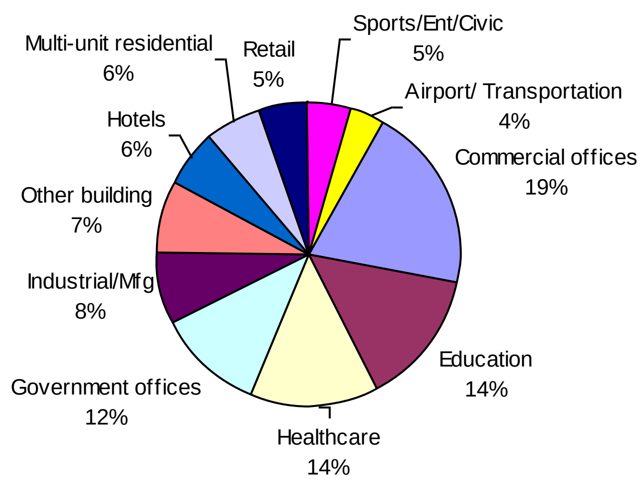
Whitson said such thinking ignores the value of a secure, long-term return on investment. "If you look at the number from a return on investment perspective, a 13-year payback is a 7.7% return," he said. "A 10-year payback is a 10% ROI.… Where can you invest your money and get 8-10% on it right now with virtually zero risk?" He cited a Department of Energy study which showed that corporate energy-efficiency projects have a lower beta—a measure of risk—than U.S. Treasury Bonds. But the culture of corporate management and the expectations of CEOs and investors make it difficult to justify major investments in energy-efficiency upgrades even when they promise secure, long-term cost savings.

"The problems in actually achieving and recognizing these savings can be subtle or mundane," said Daniel Kammen of the University of California Berkeley Energy & Resources Group. Kammen noted that in many cases the difficulty stems from the fact that one unit of a company must make the additional investments, while another unit will be credited for the savings. "If a company invests an extra 5% in an energy-efficiency feature that will save a lot of money over the life of a building, the company division that pays the upfront cost is not the division that operates the building and therefore registers the savings. The company is paying out in apples and getting back in oranges."

Kammen said the bifurcation in costs and benefits also occurs when investments in improved lighting and insulation improve workers' health and productivity and reduce the incidence of sick days—an outcome verified by studies, according to Kammen. "If one unit with a company makes the expenditures, e.g., capital projects, and the returns come to another through reduced company healthcare costs, this may never be recognized as savings and hence never show up as a cost advantage of the project."

Kammen pointed out that regulations imposing a cost on greenhouse gas emissions would help change corporate thinking, as would ways to integrate upfront capital costs with the operation and maintenance costs: "One way that is typically done is through a performance contract. A company that installs your new heating systems gets a certain level of payment for installation and the balance over time. If their system meets expectations, they get the rest of the money plus interest. If the product performs better, they get more. If it performs worse, they get less.... There are not that many performance contracts like that out there yet because companies aren't being pressured to cut their emissions," said Kammen. "A carbon price would make such an approach much more viable."

**Figure 204 Green Building Market in 2007**




*Source: : Engineering News Record, ENR.com*

**Figure 205 Construction Put In Place Estimated for The United States**

| Millions of Current Dollars, 3rd Quarter 2008 | $Mil |
|---|---|
| Single Family | 306,972 |
| Multi Family | 49,997 |
| Improvements* | 142,682 |
| **Residential** | **499,650** |
| Lodging | 28,728 |
| Office | 64,731 |
| Commercial | 88,777 |
| Health Care | 42,882 |
| Educational | 96,348 |

| | |
|---|---|
| Religious | 7,447 |
| Public Safety | 9,899 |
| Amusement and Recreation | 21,719 |
| Transportation | 32,420 |
| Communication | 27,040 |
| Manufacturing | 42,644 |
| **Total Nonresidential Buildings** | **462,635** |

*Source: FMI*

**Figure 206 Largest LEED-Certified Buildings**

| Owner/Project Name | Location | Gross Sq. Ft. |
|---|---|---|
| Johnson Diversey/Global Headquarters | Sturtevant, Wisc. | 2,316,996 |
| State of Illinois/McCormick Place West Expansion | Chicago, Ill. | 2,226,000 |
| State of California/Capitol Area East End Complex | Sacramento, Calif. | 1,728,702 |
| Silverstein Properties/7 World Trade Center | New York City, N.Y. | 1,682,000 |
| Nitze-Stagen & Co./Starbucks Center | Seattle, Wash. | 1,650,000 |
| Goldman Sachs/Goldman Sachs Tower | Jersey City, N.J. | 1,556,915 |
| General Motors/Lansing Assembly Plant | Lansing, Mich. | 1,500,000 |
| General Dynamics/Roosevelt C4 Facility | Scottsdale, Ariz. | 1,500,000 |
| Union Investment/111 South Wacker Drive | Chicago, Ill. | 1,400,000 |
| LaSalle Street Capital/Abn Amro Plaza | Chicago, Ill. | 1,375,058 |

*Source: State of Green Business 2008. Greenbiz.com. Original source: U.S. Green Building Council*

**Figure 207 Extra Costs to Go Green Vary by Region**

| Market | LEED Certification Level | | |
|---|---|---|---|
| | **Platinum** | **Gold** | **Silver** |
| San Francisco | 7.80% | 2.70% | 1.00% |
| Merced | 10.30% | 5.30% | 3.70% |
| Denver | 7.60% | 2.80% | 1.20% |
| Boston | 8.80% | 4.20% | 2.60% |
| Houston | 9.10% | 6.30% | 1.70% |

*Source: Does Green Pay Off? By Norm Miller, Jay Spivey and Andy Florance. Final Draft: July 12, 2008*

### Home Construction Market

Of all the segments of green building, single-family homes is by far the smallest. As of September 2008, USGBC had certified less than 90 single-family homes nationwide. “My sense is that the demand isn’t there yet,” said Wagner of *Green Real Estate News*. “If you look at the percentage of utility costs versus household income, [savings from water and energy efficiency] are still too small and the payback period is too long. Most homebuyers would rather put in a marble kitchen.”

In San Antonio, Texas, custom homebuilder has often received that kind of reaction when he recommends green building features like spray foam insulation—a $10,000 upgrade that can reduce air conditioning load by 45% in the South Texas climate—to his clients. “Green has to compete with the eye candy, the granite countertops, it really does,” said Lindsey. “Even with the current energy situation, there clearly has to be an education process about green building, at least here in Texas. A lot of people just don’t know about it or they think it means I’m a tree-hugging liberal.”

Even in the tree-hugging Pacific Northwest, green single-family homes are uncommon; about 150 had been LEED certified as of the end of September 2008, according to USGBC data. “I think it’s partly just from habit,” said Carolyn Forsyth, a senior associate with the design firm Ankrom Moisan Associated Architects (Portland, Ore.). “Homebuilders just do what they’re used to doing, and the faster they can do it the better.” Forsyth noted that LEED for Homes was only introduced last year, and before that “the single family home industry hadn’t had that kind of standard to work from.”

Sue Loomans, interim executive director of the Wisconsin Green Building Alliance told EBI that Wisconsin builders are having a difficult time convincing homeowners to make the investment [in green upgrades. “Home owning is a more temporary thing these days, with people not staying in their homes as long as they used to, and that gets in the way of making the case.”

But interest is definitely growing according to a number of sources, even in Texas. Brian Malarkey of Kirksey reported that 10,000 people attended the Houston USGBC chapter’s first Gulf Coast Green expo for homeowners last spring. “It was a very engaged and diverse crowd of the general public, not practitioners,” he said. “It really shows the interest building from the residential side.”

**Figure 208 Leading States for Green as of Second Quarter 2007**

| State | # Bldgs | Square Feet | % of Total |
|---|---|---|---|
| California | 219 | 51,952,382 | 26.50% |
| Texas | 91 | 27,942,442 | 14.20% |
| New York | 13 | 12,580,084 | 6.40% |
| Minnesota | 20 | 11,381,738 | 5.80% |
| Colorado | 39 | 11,244,380 | 5.70% |
| Virginia | 27 | 8,468,423 | 4.30% |
| Wash. DC | 24 | 7,803,610 | 4.00% |
| Washington | 17 | 7,649,214 | 3.90% |
| Florida | 28 | 7,209,186 | 3.70% |
| Illinois | 13 | 6,326,489 | 3.20% |

*Source: Does Green Pay Off? By Norm Miller, Jay Spivey and Andy Florance.*

For The Grupe Company, building green on its Carstens Crossing project near Sacramento proved to be a good marketing move—that is before the project was halted with the real estate market downturn. Senior Vice President of Construction Mark Fischer said that it was difficult to determine whether the green homes—for which features like PV panels, upgraded insulation, tankless water heaters and high-efficiency HVAC systems cost the builder an extra $18,000 per house—fetched a significant premium. But there was no question that LEED certification helped Grupe sell the homes faster than similar homes in the same market, especially when Grupe could advertise projected savings of $1,500 annually on energy. “The absorption rate exceeded the market by two to one,” said Fischer.

With the real estate downturn well underway in 2007, Fischer said the three- and four-bedroom homes of between 2,100 and 2,700 square feet sold for as much as 20% less than the asking prices of $450,000 to $550,000. But the faster pace of sales still gave the company an economic edge. “Let’s assume that I got same price [for a comparable home] that every other builder did… but mine cost $18,000 more. Because I sold mine so much faster, my holding costs were much less. I think we at least broke even.”

Now Grupe is looking for project opportunities in the more affluent Coastal areas of California such as Santa Cruz. “The more sophisticated and more affluent buyers seem to be looking for green homes more than the guy who is just struggling to get into a home,” said Fischer. Fischer figures the reason that few homebuilders have embraced green homes is the extra cost. But that thinking is quickly changing, and when the California housing market recovers, Fischer believes his firm will have a lot more competition. Some of the big public [homebuilding] companies are getting on board. Lennar is starting to do solar in a lot of their communities. In some communities they’re marrying it with energy-efficiency, and in others they’re not. Centex Homes is getting into it as well.”

**Figure 209 U.S. LEED Certified Projects, by Certification Type and Selected State (1)**

| | Platinum | Gold | Silver | Bronze | Certified (2) |
|---|---|---|---|---|---|
| Arizona | 1 | 7 | 4 | 1 | 21 |
| California | 12 | 37 | 31 | 0 | 120 |
| Colorado | 2 | 11 | 15 | 0 | 41 |
| Georgia | 2 | 10 | 19 | 0 | 41 |
| Illinois | 4 | 8 | 14 | 0 | 40 |
| Maryland | 1 | 6 | 5 | 0 | 20 |
| Massachusetts | 3 | 6 | 9 | 0 | 41 |
| Michigan | 0 | 13 | 11 | 0 | 34 |
| New Jersey | 0 | 7 | 7 | 0 | 21 |
| New York | 3 | 10 | 7 | 0 | 32 |
| Ohio | 0 | 4 | 8 | 0 | 22 |
| Oregon | 2 | 32 | 13 | 1 | 60 |
| Pennsylvania | 3 | 28 | 31 | 0 | 78 |
| Texas | 0 | 7 | 13 | 0 | 36 |
| Virginia | 0 | 4 | 9 | 0 | 23 |
| Washington | 1 | 20 | 23 | 0 | 70 |
| Wisconsin | 0 | 5 | 6 | 0 | 20 |
| **United States** | **43** | **266** | **293** | **3** | **933** |

*Source: EERE: Buildings Energy Data Book 2007. Note(s): 1) Project types include new construction, major renovations, existing building operations, interior design, homes, neighborhood* *development, development multi-building complexes, schools, and retail spaces. 2) Certified projects do not constitute the sum total of the other four categories, but rather designate an entirely separate category in and of itself. Original source(s): United States Green Building Council Web site, accessed Aug. 2007.*

According to Centex Homes' website, the firm is making a branded Centex Energy Advantage package standard in new homes beginning in January 2009. In addition to Energy Star appliances, R38 to R60 insulation and radiant barrier roof decking, the homes will have an energy monitor to let homeowners measure and control energy consumption, a capability that the National Assn. of Homebuilders says can empower homeowners to reduce their energy use by up to 15%.

For some green building designers, senior housing projects are becoming a major source of business. Ankrom Moisan's Forsyth said the firm's green portfolio has gotten a "turbo-boost" from client Pacific Retirement Services. "Ten years ago, you couldn't say the term green building to them… Now they're so into the concept of green building and sustainability that they're saying, 'Don't hold us to LEED, we want to go beyond.'" A PRS project in Portland, Ore.'s, South Waterfront "is going to be an easy Platinum," said Forsyth.

**Figure 210 Leading Metro Areas for Green in 2007**

| Metro Area | # Bldgs | Square Feet | % of Total |
|---|---:|---:|---:|
| Los Angeles | 100 | 26,167,038 | 13.30% |
| Houston | 46 | 21,101,378 | 10.80% |
| Washington DC | 61 | 19,796,646 | 10.10% |
| New York City | 11 | 12,328,784 | 6.30% |
| San Francisco | 30 | 11,862,367 | 6.00% |
| Minneapolist / St. Paul | 20 | 11,381,738 | 5.80% |
| Denver | 34 | 10,285,745 | 5.20% |
| Seattle/Puget Sound | 16 | 7,616,710 | 3.90% |
| Chicago | 13 | 6,326,489 | 3.20% |
| Dallas/Ft Worth | 20 | 6,058,892 | 3.10% |

*Source: Does Green Pay Off? By Norm Miller, Jay Spivey and Andy Florance. Draft date Nov. 19, 2007*

### Healthcare Sector

While healthcare facilities represented more than 13% of ENR's U.S. green building market in 2007, many green building specialists told EBI that hospitals are still somewhat resistant to green materials and methods. "The healthcare industry is still lagging," said Malarkey. "They have just not embraced green building as rapidly as the commercial market has. On the surface it has to do with materials and a perception that some of the products such as low-VOC paints aren't as good a quality."

"For hospitals there's definitely an additional regulatory layer that is not insignificant," added Forsyth. "There are a lot of eyes on hospitals, as there should be, questions about the cleanability and static generation for flooring and vector control for your air handling system." These requirements make it more difficult for hospitals to concentrate on green building and energy efficiency upgrades in their capital planning.

But with increasing energy costs, their incentive is growing. Forsyth and others see this as inevitably moving hospitals toward green. "We definitely see the healthcare market going green—sometimes through LEED, but there also is the Green Guide to Health Care certification that some clients opt for," said Myrrh Caplan, Skanska USA Building's national program manager for green construction.

In 2008, USGBC and the Green Guide to Healthcare agreed to merge their efforts into LEED for Healthcare. The USGBC news release on the joint venture pointed out that "studies have shown dramatic increases in the health, happiness, and productivity of people who live and work in green buildings, and hospitals are no exception."

**Figure 211 Number of LEED Projects by Project Type, 2005-2007**

| Owner Type | 2005 | 2006 | 2007 | Grand Total | % CAGR 2001-2006 |
|---|---|---|---|---|---|
| Multi-Use | 607 | 803 | 491 | 2,453 | 1 |
| Commercial Office | 284 | 388 | 288 | 1,299 | 48 |
| Higher Education | 63 | 54 | 32 | 284 | 18 |
| K-12 Education | 60 | 62 | 38 | 264 | 51 |
| Multi-Unit Residence | 55 | 49 | 43 | 222 | 48 |
| Unknown | 54 | 29 | 6 | 196 | 49 |
| Other | 48 | 58 | 22 | 180 | 53 |
| Public Order/Safety | 58 | 22 | 20 | 175 | 26 |
| Health Care | 34 | 36 | 22 | 128 | 48 |
| Industrial | 18 | 28 | 14 | 124 | 23 |
| Library | 22 | 14 | 15 | 112 | 9 |
| Retail | 15 | 32 | 33 | 103 | 61 |
| Interpretive Center | 15 | 9 | 3 | 94 | -11 |
| Laboratory | 15 | 9 | 3 | 75 | 2 |
| Assembly | 15 | 12 | 3 | 55 | 25 |
| Recreation | 8 | 8 | 3 | 45 | 22 |
| Financial & Commercial | 11 | 6 | 7 | 42 | 15 |
| Military Base | 6 | 12 | 6 | 37 | 86 |
| Hotel/Resort | 2 | 10 | 14 | 33 | 38 |
| Campus (corp./school) | 12 | 5 | 6 | 33 | 20 |
| Other | 23 | 43 | 19 | 148 | 37 |
| **Grand Total** | **1,425** | **1,689** | **1,088** | **6,102** | **51%** |

*Source: SBI Research: Green Building Materials in the U.S., November 2007. Original source: USGBC. CAGR means compound annual growth rate.*

## Commercial Office Development

Building green has become a key marketing issue for many commercial office developers. Yes, being able to boast of a LEED rating is a more significant advantage in towns and cities with large environmentalist constituencies, but even in such bastions of conservatism as Bakersfield, Calif.—the largest city on the top 10 most conservative list as ranked by the Bay Area Center for Voting Research—green building is catching on. While only one existing building is LEED-rated in the city, the Kern Schools Federal Credit Union Office, as of September six projects had registered for LEED certification, including a mixed-use office/retail development by Castle & Cooke (Honolulu).

In the commercial office building segment, build-to-suit developments initially led the way in terms of going green. First public agencies and later corporations contracted with developers to build green office buildings. Koll Development Co. (KDC), for example, built its first green project in 1999 for the Kansas City office of the U.S. Environmental Protection Agency. Today, 70% of KDC's build-to-suit projects are LEED certified or pursuing LEED certification, according to the company's website. In June, the developer and its client Chevron Corp. cut the ribbon on Chevron's new LEED gold rated 300,000-square-foot regional office building in Tammany Parish, the first LEED-certified office building in Louisiana, according to a Koll news release.

**Figure 212 Number of LEED Projects by Building Owner Type, 2005-2007**

| Project Type | 2005 | 2006 | 2007 | Grand Total | % CAGR 2001-2006 |
|---|---|---|---|---|---|
| For-profit Organization | 559 | 802 | 594 | 2,508 | 60 |
| Nonprofit Organization | 283 | 287 | 166 | 1,106 | 62 |
| Local Government | 219 | 198 | 130 | 959 | 37 |
| State Government | 149 | 105 | 59 | 528 | 31 |
| Other | 100 | 110 | 53 | 421 | 53 |
| Federal Government | 76 | 84 | 28 | 351 | 25 |
| Individual | 38 | 103 | 58 | 227 | 120 |
| Unknown | 1 | - | - | 2 | NA |
| **Grand Total** | **1,425** | **1,689** | **1,088** | **6,102** | **51%** |

*Source: SBI Research: Green Building Materials in the U.S., November 2007. CAGR means compound annual growth rate.*

But in the speculative office development business—in which developers build not for a client to own the property but for lease to prospective tenants—green building has been a tougher pill for developers to swallow. But surging demand from tenants has led speculative developers to see green features as a tonic for their marketing. "Five years ago if we had a speculative office developer for a client and we started talking to them about green building and going for a LEED rating, they didn't see the market demand.... Now they almost need that LEED rating to be competitive," said Nellie Reid, director of sustainable design for Gensler, a leading architecture and design firm. "Let's say they're building a new 300,000-square-foot multi-tenant office building in downtown Los Angeles. Many of their potential tenants have adopted their own corporate sustainability initiatives and they want to lease space in an energy-efficient building," said Reid. "They want to be able to extend their marketing and PR to the building they occupy."

But for many developers, going deep with green design on speculative office buildings is still a tough sell. "One of the big problems with speculative office buildings is that often the developer will hold onto the building for only three to five years," said Reid. "As soon as they get the first round of tenants in and signing 10-year leases, they want to turn around and sell the building."

With such a short period of ownership, operational savings from reduced energy and water consumption will accrue not to the developer but the buyer and tenants. "If you're going to recommend they spend a little more money on innovative water and energy systems, you need to show them they're going to get that money back within the time frame that they're still owning the building," said Reid. The best way to do that is to demonstrate that such features increase the value of the building, an argument that is increasingly being borne out in reality, according to Reid and others. "If a building uses 20 percent less energy than a code-compliant building, that can significantly increase the value [to a potential buyer]."

Recent analysis by the University of San Diego's Burnham-Moores Center for Real Estate found strong but not conclusive evidence that LEED ratings translated into higher values.

"We confirm that those buildings that do not reflect more efficient operating abilities as required by green buildings will become obsolete much faster," stated the study authors.

## 13.3. Regional Profile: Los Angeles

In the land of palm trees and 12-lane highways, a supercharged green building industry is thriving on robust demand and deep political support. Indeed, while somewhat behind Chicago, which boasts 49 LEED-rated buildings and Seattle with 45, the City of Los Angeles is one of the leading centers of environmentally sustainable building in the United States. As of October 2008, the U.S. Green Building Council (USGBC) had certified 21 completed green buildings within the Los Angeles City limits and at least 31 in other Los Angeles County cities, the largest concentrations being in Santa Monica, Pasadena and the college town of Claremont.

The pipeline of green projects in development in Los Angeles County is enormous: 268 new projects have been registered—the first step in seeking LEED certification—in Los Angeles and other incorporated cities in the county, according data searches on the USGBC website.

The Los Angeles area green building list includes some extraordinary landmark projects. Among the most noteworthy: the LEED Platinum Audubon Center at Debs Park, where structural rebar incorporated melted-down handguns, and carpeting was made from organic Mexican agave plants; the Natural Resources Defense Council's Platinum-rated Santa Monica office, with clerestories (glass panels that naturally light hallways and offices), a displacement ventilation system and rooftop PV panels; and the Gold-rated Elleven and Luma condo towers, the first major residential construction projects in the downtown area in 20 years, according to a news release from The South Group, a partnership of Gerding Edlen Development and Williams, Dame and Atkins Development.

Los Angeles-area green builders report that demand for commercial, retail, institutional and residential green projects is intense. "As of September 2008, 58 percent of our new construction projects in Southern California currently in design or construction phases are pursuing a LEED rating," said Nellie Reid, director of sustainable design for Gensler, a top green architectural firm. "Just two years ago, that figure was only 20 percent." In addition to market demand, business and political leaders have driven the green building agenda by lobbying to make Los Angeles and other Southern California cities not only green friendly but unfriendly to large developments that don't adopt green and energy-efficient design strategies.

Consider the Los Angeles Business Council (LABC). You might think such a group would focus on relieving the regulatory burdens on developers, but Renee Loveland, director of sustainable design for green developer Gerding Elden Development, credited members of the LABC with being instrumental in neutralizing potential opposition to a green building ordinance. "They really reached out to the development community, hosting forums and panel discussions to help them understand, for example, that a LEED silver building can be cost neutral," said Loveland.

When the green building ordinance reached the Los Angeles City Council, not a lot of convincing was needed. For one thing, like every jurisdiction in California, Los Angeles is under pressure to show how it will adjust its planning and building policies to comply with AB 32, California's landmark climate change bill that mandates state emissions be reduced to 1990 levels by 2020. Furthermore, in June 2008, the California Building Standards Commission adopted a green building code with new standards for energy efficiency, water usage, insulation and other features; the code will be voluntary until 2010, then is expected to become mandatory. "In California, lawmakers from the governor on down have really taken a strong stance on climate change, energy efficiency and renewable energy," said Loveland. "All these factors are influencing what happens at the local jurisdictions." Also, Los Angeles had already pledged to go beyond AB 32, cutting the city's carbon-dioxide emissions 35% below 1990 levels by 2030.

It was little surprise when the council voted to require green building design and features on private projects above a certain size. For both new construction and major renovations, projects larger than 50,000 square feet will have to meet LEED Certified criteria. Little surprise but big news. Los Angeles wasn't the first Southern California city to institute such a requirement: Pasadena, West Hollywood and Santa Monica already had passed similar measures. But given the size and scope of Los Angeles, second-largest U.S. city with nearly 4 million people, the ordinance generated excitement in green circles nationwide.

In similar fashion to most other green building ordinances, Los Angeles builders won't have to get their building LEED Certified but they will have to follow the LEED checklist and demonstrate to city planners that their buildings would qualify for a LEED Certified rating at minimum. Projects can choose the most appropriate LEED rating system, including New Construction, Existing Buildings, Commercial Interiors, Core & Shell or Homes. The city will audit one in seven submissions from developers to verify that what is proclaimed in the submittals are reflected in the actual plans. Certain historic structures are exempted.

Builders who go above the LEED Certified standard to achieve the equivalence of LEED Silver, Gold or Platinum will receive extra help. "They'll benefit from an expedited permitting process," said Reid. Such fast-tracking can add significantly to a project's return on investment.

According to published reports, city officials expect about 150 new and renovated buildings, equaling roughly 7.5 million square feet, to be covered by the ordinance annually.

Los Angeles is also updating its building codes and procedures to accommodate elements of green building like permeable pavement and green rooftops. On the South Park project, a $320 million, 1.5 million square-foot residential and commercial development, Gerding Edlen and its team built a bioswale water treatment planting area which treats stormwater from the city streets.

At the time the council passed its green building ordinance, some advocates argued for a lower size threshold or a requirement that projects meet the equivalence of LEED Silver, one step up from Certified. Council President Eric Garcetti promised to push in that direction, predicting "in a couple of years, every single building over 25,000 square feet will be covered" by the ordinance, according to the *Los Angeles Times*. Garcetti also spoke favorably of adopting LEED Silver as the standard.

## 13.4. CCBJ's Green Building Survey

This section presents results of EBI/CCBJ's Green Building Survey 2008. The survey took place during September and October 2008.

**Figure 213 Market drivers**

Please rate the importance of the following market drivers for the green building business in 2008: Please pick the option "Most Important" only once. However, you may pick multiple responses to "Very Important", "Important", "Not Very Important" and "Meaningless".

| | Most important (pick 1) | Very important | Important | Not very important | Meaningless |
|---|---|---|---|---|---|
| Energy costs | 60% | 36% | 4% | 0% | 0% |
| Current or impending regulations and policies | 9% | 45% | 30% | 11% | 4% |
| Rebates and incentives | 8% | 38% | 33% | 21% | 0% |
| A “Green” Image | 8% | 29% | 48% | 12% | 4% |
| Reducing water consumption | 2% | 49% | 28% | 19% | 2% |
| Reducing carbon footprints | 9% | 28% | 38% | 19% | 6% |
| Availability of more materials & services in GB supply chain | 2% | 41% | 37% | 15% | 6% |
| Using more recycled materials | 4% | 32% | 38% | 25% | 2% |
| Obtaining value from carbon offsets | 4% | 23% | 28% | 25% | 21% |

*Source: CCBJ's Green Building Survey 2008*

**Figure 214 United States share 2008**

Please estimate what percentage of new building construction in the United States is currently “green”:

| | # of responses | % of total |
|---|---|---|
| 0–2% | 4 | 7.7% |
| 2–4% | 8 | 15.4% |
| 4–6% | 9 | 17.3% |
| 6–8% | 6 | 11.5% |
| 8–10% | 12 | 23.1% |
| 10-12% | 6 | 11.5% |
| 12-15% | 3 | 5.8% |
| 15-20% | 3 | 5.8% |
| 20-30% | 1 | 1.9% |
| more than 30% | 0 | 0.0% |
| **Total** | **52** | **100.0%** |

*Source: CCBJ's Green Building Survey 2008*

**Figure 215 United States share 2020**

Please estimate what percentage of new building construction in the United States will be “green” in 2020:

| | # of responses | % of total |
|---|---|---|
| 0–5% | 2 | 3.8% |
| 5–10% | 1 | 1.9% |
| 10-12% | 2 | 3.8% |
| 12-15% | 2 | 3.8% |
| 15-20% | 4 | 7.7% |
| 20-25% | 5 | 9.6% |
| 25-30% | 7 | 13.5% |
| 30–40% | 3 | 5.8% |
| 40-50% | 5 | 9.6% |
| 50% or greater | 21 | 40.4% |
| **Total** | **52** | **100.0%** |

*Source: CCBJ's Green Building Survey 2008*

## Regions: Northern California and Pacific Northwest

**Figure 216 Northern California and Pacific Northwest 2008**

Please estimate what percentage of new building construction in Northern California and Pacific Northwest is currently “green”:

| | # of responses | % of total |
|---|---|---|
| 0–2% | 1 | 6.3% |
| 2–4% | 2 | 12.5% |
| 4–6% | 3 | 18.8% |
| 6–8% | 0 | 0.0% |
| 8–10% | 1 | 6.3% |
| more than 10% | 9 | 56.3% |
| **Total** | **16** | **100.0%** |

*Source: CCBJ's Green Building Survey 2008*

**Figure 217 Northern California and Pacific Northwest 2020**

| | # of responses | % of total |
|---|---|---|
| Less than 10% | 1 | 6.3% |
| 10–20% | 1 | 6.3% |
| 20–30% | 1 | 6.3% |
| 30–40% | 3 | 18.8% |
| 50% or greater | 10 | 62.5% |
| **Total** | **16** | **100.0%** |

*Source: CCBJ's Green Building Survey 2008*

**Figure 218 Northern California and Pacific Northwest 2030**

| | # of responses | % of total |
|---|---|---|
| Less than 25% | 1 | 6.3% |
| 25-50% | 0 | 0.0% |
| 50–75% | 3 | 18.8% |
| Greater than 75% | 12 | 75.0% |
| **Total** | **16** | **100.0%** |

*Source: CCBJ's Green Building Survey 2008*

## Regions: Southern California

**Figure 219 Southern California 2008**

Please estimate what percentage of new building construction in Southern California is currently “green”:

| | # of responses | % of total |
|---|---|---|
| 0–2% | 2 | 15.4% |
| 2–4% | 4 | 30.8% |
| 4–6% | 1 | 7.7% |
| 6–8% | 1 | 7.7% |
| 8–10% | 2 | 15.4% |
| more than 10% | 3 | 23.1% |
| **Total** | **13** | **100.0%** |

*Source: CCBJ's Green Building Survey 2008*

**Figure 220 Southern California 2020**

Please estimate what percentage of new building construction in Southern California will be “green” in 2020:

| | # of responses | % of total |
|---|---|---|
| Less than 10% | 1 | 7.7% |
| 10–20% | 3 | 23.1% |
| 20–30% | 5 | 38.5% |
| 30–40% | 1 | 7.7% |
| 50% or greater | 3 | 23.1% |
| **Total** | **13** | **100.0%** |

*Source: CCBJ's Green Building Survey 2008*

# 14. Transportation

The future of transportation is a trillion-dollar question. With more than $750 billion in vehicle sales and $500 billion in fuel sales in the United States, revenue shifts can indeed be seismic. With a variety of market drivers—climate change an increasingly important one—transportation looks to be one of the most lucrative and dynamic segments of the clean energy industry for some time.

## 14.1. Transportation Market Overview

With less than 5% of the world's population, the United States emitted 22-23% of greenhouse gases (GHGs) worldwide in 2008. Moving people and goods generated 27% of the U.S. carbon footprint in 2008, nearly 1,900 million metric tons of carbon dioxide-equivalent (CO2-e) emissions. Cutting transport GHGs over the next 10 to 40 years will be one of the most important challenges in mitigating climate change. It will also represent one of the largest emerging business segments of the clean energy industry, but one whose structure is in flux and whose leadership is up for grabs as companies and technologies battle it out in the marketplace for commitments from the investment community and for influence with policymakers.

**Figure 221 2008 U.S. Greenhouse Gas Emissions by Economic Sector (Tg CO2 Eq.)**

| | Tg CO2-e | % |
|---|---|---|
| Electric Power | 2,404 | 35% |
| Transportation | 1,886 | 27% |
| Industry | 1,343 | 19% |
| Agriculture | 504 | 7% |
| Commercial | 410 | 6% |
| Residential | 359 | 5% |
| Total | 6,907 | 100% |

*Source: U.S. Inventory of Greenhouse Gas Emissions and Sinks, U.S. EPA, April 2010; Total is 6,907 Tg CO2eq or teragrams (million metric tons) of CO2 equivalent or about 22% of the global total..*

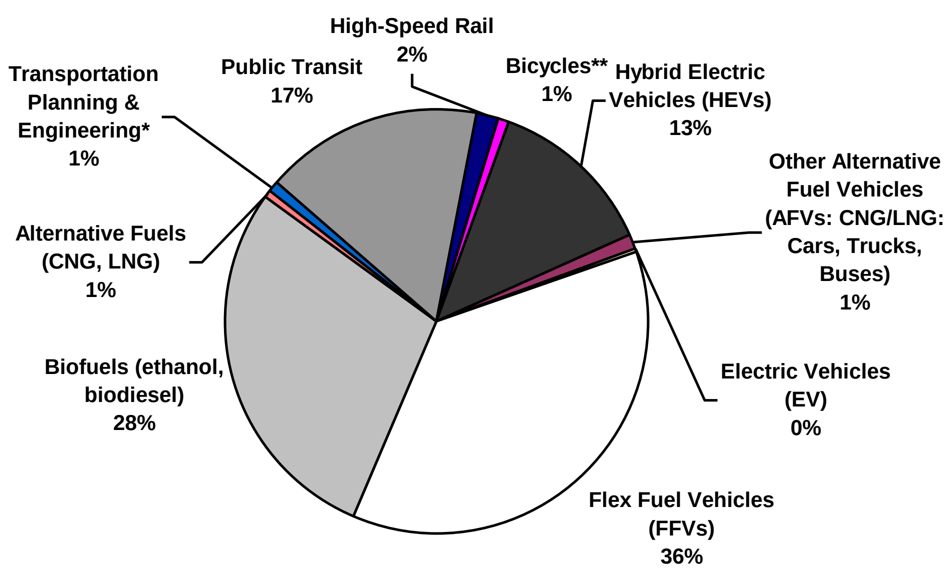
**Figure 222 2008 U.S. Transportation-Related Greenhouse Gas Emissions (Tg CO2 Eq.)**

| | Tg CO2-e | % |
|---|---|---|
| Passenger Cars | 634.5 | 34% |
| Light-Duty Trucks | 552.5 | 29% |
| Med-/Heavy-Duty Trucks/Buses | 413.5 | 22% |
| Aircraft | 157.3 | 8% |
| Ships & Boats | 38.8 | 2% |
| Rail | 50.7 | 3% |
| Pipelines & Lubricants | 43.7 | 2% |

*Source: U.S. Inventory of Greenhouse Gas Emissions and Sinks, U.S. EPA, April 2010; Total is 6,907 Tg CO2eq or teragrams (million metric tons) of CO2 equivalent or about 22% of the global total.*

In its simplest form the transportation business affected by climate change will come down to three areas: vehicles, fuels and new systems to effect mass transit in aircraft or rail like high-speed rail. Secondary markets, likely no less important, are the supply chain and infrastructure to support vehicles and fuels, and a variety of services designed to effect behavioral change. And advocates won't let us forget fringe markets like public transit and bicycles.

**Figure 223 Transportation Segments in the U.S. Clean energy industry**




*Source: Climate Change Business Journal, EBI Inc.: CCBJ model of the transportation industry derived from data from a variety of sources including DOE's Energy Information Administration, IHS Global Insight, hybridcars.com, NGV Gas Vehicle Report, National Sporting Goods Association, U.S. Census Bureau, American Public Transportation Association and International Union of Railways.*

Vehicles and fuels add up to well over 80% of EBI's estimated $71 billion in U.S. transportation business in the clean energy industry in 2009 (see chart). We count hybrid electric vehicles (HEVs), natural gas vehicles and flex fuel vehicles (FFVs) in the $35.5 billion alternative fuel vehicles (AFV) total. This total still represents less than 5% of U.S. annual light duty vehicle (LDV) sales of new and used vehicles: $750 billion per year on average the past decade. It is fair to say that 2009 total sales figures are an anomaly, but that the growing portion of AFVs to over 12% of new LDVs sold in 2009 is not.

Similarly $25 billion in wholesale biofuel sales in 2008 was still only 7% of wholesale gasoline sales of about $350 billion, but this represents a growing percentage from 1-4% of gasoline sold in 2000-2006.

**Figure 224 Biofuel as a % of Gasoline by Volume 2000-2010**

| | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|---|---|
| US Gasoline (million gallons) | 136,974 | 139,580 | 140,407 | 141,848 | 142,354 | 137,801 | 137,755 | 141,888 |
| US Biofuel (million gallons) | 2,814 | 3,437 | 4,022 | 5,101 | 6,997 | 9,946 | 11,050 | 11,952 |
| Biofuel as a % of Gasoline | 2.1% | 2.5% | 2.9% | 3.6% | 4.9% | 7.2% | 8.0% | 8.4% |

*Source: Adapted from Energy Information Administration*

Revenues generated by public transit systems admittedly are not largely driven by climate change, yet EBI feels compelled to include them in our transportation segment since they will increasingly be expected to play a role in reducing emissions. Data from American Public Transportation Association (APTA) indicates that passenger fares generated $12 billion in revenues in 2008, growing 6% over 2007. APTA also concludes that fares accounted for only 31% of the $38 billion in total income by transport authorities indicating the still high level of subsidization in public transit.

By the same token, although most FFV drivers fill up on conventional gasoline, the fact that the vehicles are capable of running on potentially lower-carbon biofuels merits their inclusion. Other small subsegments include specialty services within the $20-billion transportation planning & engineering business and bicycles. Surveys indicate 10% of bicycles are used predominantly for commuting in the United States so EBI counts 10% of the $6 billion in bicycle sales.

EBI estimates that sustainable transportation or smart growth revenues account for 2-3% of the transportation planning & engineering business—a market of about $400 million. Much like the green building business however, virtually all planning and development related to transportation will involve some shade of green and likely evolve to incorporate most of the traits that are still considered specialty add-ons today.

Overall the transportation segment of the clean energy industry grew 15% and 17% in 2007 and 2008, respectively, and 2009's 12% decline was largely an effect of the dominance of vehicle and fuel sales in the numbers and the overexposure of those industries to the recession. Growth is expected to return, although at a modest rate given the slow recovery in vehicle sales, and is forecasted at 10-12% annual growth from 2011-2012.

# 14.2. Transportation Statistics & Review

**Figure 225 U.S. Climate Change Transportation Business Segments: Revenues Generated**

| | 2007 | 2008 | 2009 | 2008g | 2009g |
|---|---|---|---|---|---|
| Hybrid Electric Vehicles (HEVs) | 10.98 | 9.97 | 9.03 | -9% | -9% |
| Alternative Fuel Vehicles (AFVs: CNG/LNG: Cars, Trucks, Buses) | 0.67 | 1.39 | 0.89 | 107% | -36% |
| Electric Vehicles (EV) | 0.17 | 0.17 | 0.17 | -2% | -1% |
| Flex Fuel Vehicles (FFVs) | 27.88 | 29.38 | 26.24 | 5% | -11% |
| Biofuels (ethanol, biodiesel) | 16.31 | 25.68 | 20.32 | 57% | -21% |
| Alternative Fuels (CNG, LNG) | 0.39 | 0.43 | 0.42 | 10% | -3% |
| Transportation Planning & Engineering* | 0.40 | 0.43 | 0.44 | 7% | 1% |
| Public Transit** | 11.15 | 11.86 | 12.04 | 6% | 2% |
| High-Speed Rail | 0.73 | 0.81 | 1.13 | 10% | 40% |
| Bicycles*** | 0.61 | 0.61 | 0.58 | 1% | -6% |
| Total | 69.29 | 80.74 | 71.24 | 17% | -12% |

*Source: Climate Change Business Journal, EBI Inc.: CCBJ model of the transportation industry derived from data from a variety of sources including DOE's Energy Information Administration, IHS Global Insight, hybridcars.com, NGV Gas Vehicle Report, National Sporting Goods Association, U.S. Census Bureau , American Public Transportation Association and International Union of Railways.*Transportation Planning & Engineering: projects driven to significant extent by GHG emissions reduction. **Public transit is measured in passengar fares collected as revenue (total costs are about $30 billion) ***Bicycles predominantly for commuting at 10% of total. AFVs include CNG, LNG, electric and hydrogen. CNG is compressed natural gas and LNG is liquified natural gas.*

**Figure 226 Global Climate Change Transportation Business Segments: Revenues Generated**

| | 2007 | 2008 | 2009 | 2008g | 2009g |
|---|---|---|---|---|---|
| Hybrid Electric Vehicles (HEVs) | 15.77 | 16.02 | 20.36 | 2% | 27% |
| Other Alternative Fuel Vehicles (AFVs: CNG/LNG: Cars, Trucks, Buses) | 38.06 | 44.15 | 49.44 | 16% | 12% |
| Electric Vehicles (EV) | 0.29 | 0.28 | 0.28 | -2% | -1% |
| Flex Fuel Vehicles (FFVs) | 39.82 | 41.98 | 37.48 | 5% | -11% |
| Biofuels (ethanol, biodiesel) | 38.48 | 58.50 | 46.65 | 52% | -20% |
| Alternative Fuels (CNG, LNG) | 19.63 | 21.54 | 20.92 | 10% | -3% |
| Transportation Planning & Engineering* | 1.01 | 1.08 | 1.18 | 7% | 9% |
| Public Transit** | 111.45 | 118.60 | 120.38 | 6% | 2% |
| High-Speed Rail | 73.20 | 80.52 | 88.57 | 10% | 10% |
| Bicycles*** | 12.12 | 12.24 | 11.54 | 1% | -6% |
| Total | 349.82 | 394.91 | 396.80 | 13% | 0.5% |

*Source: EBI Inc.: CCBJ model of the transportation industry derived from data from a variety of sources.*Transportation Planning & Engineering: projects driven to significant extent by GHG emissions reduction. **Public transit is measured in passengar fares collected as revenue (total costs are about $30 billion) ***Bicycles predominantly for commuting at 10% of total. AFVs include CNG, LNG, electric and hydrogen. CNG is compressed natural gas and LNG is liquified natural gas.*

**Figure 227 California Climate Change Transportation Business Segments: Revenues Generated**

| | 2007 | 2008 | 2009 | 2008g | 2009g |
|---|---|---|---|---|---|
| Hybrid Electric Vehicles (HEVs) | 3.82 | 3.06 | 1.89 | -20% | -38% |
| Other Alternative Fuel Vehicles (AFVs: CNG/LNG: Cars, Trucks, Buses) | 0.11 | 0.24 | 0.16 | 113% | -34% |
| Electric Vehicles (EV) | 0.07 | 0.07 | 0.08 | -2% | 13% |
| Flex Fuel Vehicles (FFVs) | 2.62 | 2.70 | 2.36 | 3% | -13% |
| Biofuels (ethanol, biodiesel) | 0.48 | 0.76 | 0.86 | 59% | 13% |
| Alternative Fuels (CNG, LNG) | 0.19 | 0.20 | 0.15 | 5% | -24% |
| Transportation Planning & Engineering* | 0.06 | 0.06 | 0.07 | 11% | 7% |
| Public Transit** | 0.80 | 0.84 | 0.84 | 6% | 0% |
| High-Speed Rail | 0.01 | 0.02 | 0.05 | 38% | 124% |
| Bicycles*** | 0.12 | 0.13 | 0.13 | 6% | -1% |
| Total | 8.28 | 8.09 | 6.59 | -2% | -19% |

*Source: EBI Inc.: CCBJ model of the transportation industry derived from data from a variety of sources.*Transportation Planning & Engineering: projects driven to significant extent by GHG emissions reduction. **Public transit is measured in passengar fares collected as revenue (total costs are about $30 billion) ***Bicycles predominantly for commuting at 10% of total. AFVs include CNG, LNG, electric and hydrogen. CNG is compressed natural gas and LNG is liquified natural gas.*

**Figure 228 California Climate Change Transportation Business Segments as a Percentage of U.S.**

| | 2007 | 2008 | 2009 |
|---|---|---|---|
| Hybrid Electric Vehicles (HEVs) | 34.8% | 30.6% | 21.0% |
| Other Alternative Fuel Vehicles (AFVs: CNG/LNG: Cars, Trucks, Buses) | 17.0% | 17.5% | 18.2% |
| Electric Vehicles (EV) | 42.0% | 42.0% | 48.0% |
| Flex Fuel Vehicles (FFVs) | 9.4% | 9.2% | 9.0% |
| Biofuels (ethanol, biodiesel) | 2.9% | 3.0% | 4.2% |
| Alternative Fuels (CNG, LNG) | 48.4% | 46.4% | 36.4% |
| Transportation Planning & Engineering* | 14.5% | 15.0% | 16.0% |
| Public Transit** | 7.2% | 7.1% | 7.0% |
| High-Speed Rail | 2.0% | 2.5% | 4.0% |
| Bicycles*** | 20.0% | 21.0% | 22.0% |
| Total | 12.0% | 10.0% | 9.2% |

*Source: EBI Inc.: CCBJ model of the transportation industry derived from data from a variety of sources.*Transportation Planning & Engineering: projects driven to significant extent by GHG emissions reduction. **Public transit is measured in passengar fares collected as revenue (total costs are about $30 billion) ***Bicycles predominantly for commuting at 10% of total. AFVs include CNG, LNG, electric and hydrogen. CNG is compressed natural gas and LNG is liquified natural gas.*

**Figure 229 U.S. Climate Change Transportation Business Segments as a Percentage of Global**

| | 2007 | 2008 | 2009 |
|---|---|---|---|
| Hybrid Electric Vehicles (HEVs) | 70% | 62% | 44% |
| Other Alternative Fuel Vehicles (AFVs: CNG/LNG: Cars, Trucks, Buses) | 2% | 3% | 2% |
| Electric Vehicles (EV) | 60% | 60% | 60% |
| Flex Fuel Vehicles (FFVs) | 70% | 70% | 70% |
| Biofuels (ethanol, biodiesel) | 42% | 44% | 44% |
| Alternative Fuels (CNG, LNG) | 2% | 2% | 2% |
| Transportation Planning & Engineering* | 40% | 40% | 37% |
| Public Transit** | 10% | 10% | 10% |
| High-Speed Rail | 1% | 1% | 1% |
| Bicycles*** | 5% | 5% | 5% |
| Total | **20%** | **20%** | **18%** |

*Source: EBI Inc.: CCBJ model of the transportation industry derived from data from a variety of sources.*Transportation Planning & Engineering: projects driven to significant extent by GHG emissions reduction. **Public transit is measured in passengar fares collected as revenue (total costs are about $30 billion) ***Bicycles predominantly for commuting at 10% of total. AFVs include CNG, LNG, electric and hydrogen. CNG is compressed natural gas and LNG is liquified natural gas.*

**Figure 230 U.S. Climate Change Transportation Business Segments as a Percentage of Global**

| | USA $bil in 2009 | USA 2009 Jobs | Calif. $bil in 2009 | Calif. 2009 Jobs | % of USA Jobs in Calif. |
|---|---|---|---|---|---|
| Hybrid Electric Vehicles (HEVs) | 9.03 | 39,200 | 1.89 | 3,290 | 8.4% |
| Other Alternative Fuel Vehicles (AFVs: CNG/LNG: Cars, Trucks, Buses) | 0.89 | 3,900 | 0.16 | 700 | 18.2% |
| Electric Vehicles (EV) | 0.17 | 700 | 0.08 | 350 | 48.0% |
| Flex Fuel Vehicles (FFVs) | 26.24 | 114,100 | 2.36 | 5,130 | 4.5% |
| Biofuels (ethanol, biodiesel) | 20.32 | 108,900 | 0.86 | 4,590 | 4.2% |
| Alternative Fuels (CNG, LNG) | 0.42 | 1,400 | 0.15 | 510 | 36.4% |
| Transportation Planning & Engineering* | 0.44 | 3,300 | 0.07 | 590 | 17.6% |
| Public Transit** | 12.04 | 129,700 | 0.84 | 9,080 | 7.0% |
| High-Speed Rail | 1.13 | 2,800 | 0.05 | 110 | 4.0% |
| Bicycles*** | 0.58 | 2,900 | 0.13 | 630 | 22.0% |
| Total | **71.24** | **406,900** | **6.59** | **24,980** | **6.1%** |

*Source EBI Inc.: CCBJ model of the transportation industry derived from data from a variety of sources.*Transportation Planning & Engineering: projects driven to significant extent by GHG emissions reduction. **Public transit is measured in passengar fares collected as revenue (total costs are about $30 billion) ***Bicycles predominantly for commuting at 10% of total. AFVs include CNG, LNG, electric and hydrogen. CNG is compressed natural gas and LNG is liquified natural gas.*

## 14.2.1. Drivers: Governments Weigh Transportation Policy Options

In the longer term, the shape of climate change transportation segments cannot be predicted with any reasonable degree of probability. Policymakers are weighing a huge range of options for impacting vehicles and fuels markets and modifying transportation behavior. In its April 2010 Report to Congress on Transportation's Role in Reducing U.S. Greenhouse Gas Emissions, the U.S. Department of Transportation (DOT) lays out scores of tactical pathways and estimates their GHG reduction potential by 2030 and 2050.

The agency offers up tactics ranging from relieving highway bottlenecks so vehicles can travel more often in the fuel-efficient sweet spot between 45-55 mph—a strategy for which neither benefits nor costs could be quantified—to 60% of the light-duty vehicle (LDV) fleet being fuel cell vehicles by 2050—which could cut transport emissions by 470 mmtCO2-e per year but might cost as much as $275 per metric ton of avoided CO2-e.

But how and when will any of these ideas actually get implemented? Which ones will fly politically and which will be ushered into obscurity? For many of the strategies, including some of the easiest and most cost effective, the political barriers may be insurmountable. A 55 mph national speed limit, for example, would cut as much as 2% of transport GHGs by 2030, and because of improved fuel economy, it would not only cost nothing but would deliver economic benefits equivalent to $320 per ton of avoided CO2-e, according to DOT. But such a proposal would obviously go nowhere politically and practically.

The likely political resistance to other GHG-saving measures will probably ensure that they won't see the light of day anytime soon either. For example, pricing strategies like congestion and cordon pricing (charging drivers the equivalent of tolls to travel during periods of peak congestion or into crowded downtowns) are viewed by the report authors and other experts as potent and cost-effective measures to reduce the all-important measure of vehicle miles traveled (VMT). American VMT hasn't historically been affected by gasoline prices that much. However, when gas prices went from $1.50/gallon in 2003 to more than $3.00/gallon in 2008 there was some impact on VMT.

**Figure 231 Comparison of Trends in Vehicle Miles of Travel and Gasoline Price**

| | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 |
|---|---|---|---|---|---|---|---|---|---|
| Change in VMT | 1% | 3% | 2% | 3% | 3% | 2% | 3% | 2.5% | 2.1% |
| Change in Gasoline Price | -15% | -1% | -2% | 1% | 3% | 8% | -1% | -15% | 11% |
| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
| Change in VMT | 2.5% | 1.8% | 2.1% | 1.2% | 2.5% | 1.0% | 0.7% | -0.4% | -1.8% |
| Change in Gasoline Price | 31% | -6% | -4% | 15% | 20% | 24% | 13% | 10% | 15% |

*Source: DOT's Federal Highway Administration and DOE's Energy Information Administration. VMT is Vehicle Miles of Travel*

Americans love the independence and convenience of a private light-duty vehicle (LDV), and proposals to make traveling in a passenger vehicle slower or more costly are probably doomed to failure. This love affair may be strained by sharp and sustained increases in the price of oil, but market data and studies show that people will sacrifice other expenditures rather than give up driving. “There’s one thing we know about consumer behavior, and that is that if you leave the choice to the individual, cars will dominate,” said Bob Lepore, director of transportation planning for $6-billion engineering construction firm AECOM.

But no one disagrees that transport GHG strategies must focus on developing low-carbon propulsion technologies for vehicles of all types, especially LDVs, the source of 63% of GHGs from transportation in 2008.

**Figure 232 How Americans Get To Work: Mode of Commuting, by Percentage**

| | 1980 | 1990 | 2000 | 2006 |
|---|---|---|---|---|
| Other | 9.5% | 8.1% | 7.4% | 8.5% |
| Public Transit | 6.4% | 5.3% | 4.7% | 4.8% |
| Carpool | 19.7% | 13.4% | 12.2% | 10.7% |
| Driving Alone | 64.4% | 73.2% | 75.7% | 76% |

*Source: U.S. Census Bureau and American Community Survey*

In the menu of options analyzed by DOT, several strategies stand out as approaches to behavioral modification that are picking up steam. One is bus rapid transit, or BRT. Another is ride-sharing, including carpooling and vanpooling.

Parsons Brinckerhoff helped set up the nonprofit 511 Rideshare, the San Francisco Bay Area’s carpooling and vanpooling program, which since 2005 has placed more than 38,000 people in carpools, vanpools and similar “alternative commute” modes. Ecology & Environment has developed a web-based ridesharing system it calls GreenRide that serves about 60 cities; the firm says the program has avoided about one million trips in its first 15 months.

Firms like Avego (Kinsale, Ireland) and Goose Networks (Seattle) are marketing web-enabled ride-matching and commute management programs. Avego sells a system that incentivizes drivers to pick up passengers along their route because passengers pay a per-mile fee to defray costs. Goose Networks sells software and services to organizations that want to measure and report the impact of their members commute activities.

There are many regional ridesharing and car/vanpooling websites and services such as San Luis Obispo County’s iRideshare.org, Rideshare.com which sells monthly vanpool commuting packages ($139 a month for a 50-mile roundtrip) in the Northeast and Zimride.com which is focused on college students. And many people use Facebook or Twitter to find and share rides.

**Who’ll Take the High Road**

As readers will find in this report, the road to a low-carbon transportation future is going to be long and complicated—and hopefully interesting and profitable for firms able to position themselves for the enormous challenge of downsizing America’s transportation carbon footprint.

While transforming a trillion-dollar business is no trivial task, the scale does provide numerous niches of scale to attract investors, government support and the best & brightest from science, technology and business. As climate change transportation companies significantly increase their share into the hundreds of billions as expected in the next couple of years, the momentum behind them and interest from the entrenched interests on the other side of the share chart will only increase. It promises to be a wild ride.

**Figure 233 U.S. Climate Change Transportation Business Segments: Revenues 2008-2013**

| | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|
| Hybrid Electric Vehicles (HEVs) | 9,973 | 9,027 | 9,154 | 11,765 | 14,812 | 18,357 |
| Other Alternative Fuel Vehicles | 1,394 | 890 | 1,260 | 1,318 | 1,379 | 1,442 |
| Electric Vehicles (EV) | 170 | 168 | 159 | 167 | 791 | 2,255 |
| Flex Fuel Vehicles (FFVs) | 29,384 | 26,237 | 28,502 | 29,129 | 29,770 | 30,425 |
| Biofuels (ethanol, biodiesel) | 25,680 | 20,322 | 21,746 | 24,967 | 29,590 | 32,253 |
| Alternative Fuels (CNG, LNG) | 431 | 418 | 444 | 470 | 498 | 528 |
| Transportation Planning & Engineering* | 432 | 470 | 527 | 595 | 669 | 748 |
| Public Transit | 11,860 | 12,038 | 12,471 | 12,945 | 13,463 | 14,028 |
| High-Speed Rail | 805 | 1,127 | 2,254 | 4,509 | 9,018 | 13,527 |
| Bicycles** | 612 | 577 | 631 | 684 | 741 | 801 |
| Total | 80,740 | 71,274 | 77,150 | 86,550 | 100,731 | 114,365 |
| Growth | 16.5% | -11.7% | 8.2% | 12.2% | 16.4% | 13.5% |

*Source: EBI Inc.: CCBJ model of the transportation industry derived from data from a variety of sources.*Transportation Planning & Engineering: projects driven to significant extent by GHG emissions reduction. **Bicycles predominantly for commuting at 10% of total. AFVs include CNG, LNG, electric and hydrogen. CNG is compressed natural gas and LNG is liquified natural gas. Units: $million in sales*

Notes on EBI's Forecast: Hybrid vehicles are forecasted to go from 3% to 5% of vehicle sales from 2010 to 2013. Electric vehicles to grow more than 10-fold from 2011 to 2013 as models hit the market, but with potential for much more growth. Planning & engineering services related to GHG mitigation should account for 2-3% of projects. High-speed rail will likely double in spending in start-up phase. Other segments are forecasted to grow at annual rates of 6-10%.

**Figure 234 U.S. Energy-Related Carbon Dioxide Emissions by End-Use Sector, 2003-2008**

| | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|
| Residential | 1,224.9 | 1,221.9 | 1,254.5 | 1,186.7 | 1,235.1 | 1,220.1 |
| Commercial | 1,026.1 | 1,043.3 | 1,059.6 | 1,034.9 | 1,070.3 | 1,075.1 |
| Industrial | 1,690.3 | 1,728.5 | 1,671.4 | 1,657.8 | 1,655.2 | 1,589.1 |
| Transportation | 1,897.4 | 1,958.9 | 1,988.7 | 2,014.3 | 2,025.7 | 1,930.1 |
| Total | 5,838.6 | 5,952.5 | 5,974.3 | 5,893.7 | 5,986.4 | 5,814.4 |
| Electricity Generation[a] | 2,298.8 | 2,331.3 | 2,396.8 | 2,343.5 | 2,409.1 | 2,359.1 |
| Transportation Percentage | 32.5% | 32.9% | 33.3% | 34.2% | 33.8% | 33.2% |

*Source: EIA. a: Electric power sector emissions are distributed across the end-use sectors. Emissions allocated to sectors are unadjusted. Adjustments are made to total emissions only. Notes: Data in this table are revised from the data contained in the previous EIA report, Emissions of Greenhouse Gases in the United States 2007,DOE/EIA-0573(2006) (Washington, DC, December 2008). Totals may not equal sum of components due to independent rounding. (Million Metric Tons Carbon Dioxide)*

**Figure 235 U.S. Carbon Dioxide Emissions from Transportation Sector, 2003-2008**

| | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|
| Petroleum | | | | | | |
| Motor Gasoline | 1159.9 | 1181.3 | 1184.2 | 1186.9 | 1187.4 | 1134.9 |
| LPG | 1.0 | 1.1 | 1.7 | 1.6 | 1.3 | 1.2 |
| Jet Fuel | 231.5 | 239.8 | 246.3 | 239.5 | 238.0 | 226.3 |
| Distillate Fuel | 414.5 | 433.9 | 444.4 | 469.2 | 472.3 | 445.7 |
| Residual Fuel | 45.0 | 58.3 | 66.0 | 71.4 | 78.3 | 74.1 |
| Lubricants[a] | 5.6 | 5.6 | 5.6 | 5.5 | 5.6 | 5.2 |
| Aviation Gas | 2.1 | 2.2 | 2.4 | 2.3 | 2.2 | 2.0 |
| Petroleum Subtotal | 1859.5 | 1922.2 | 1950.7 | 1976.4 | 1985.1 | 1889.4 |
| Coal | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Natural Gas | 33.4 | 32.0 | 33.1 | 33.2 | 35.4 | 35.9 |
| Electricity[b] | 4.5 | 4.7 | 4.9 | 4.7 | 5.2 | 4.9 |
| Total | 1897.4 | 1958.9 | 1988.7 | 2014.3 | 2025.7 | 1930.1 |

*Source: EIA. a: Includes emissions from nonfuel uses of fossil fuels. b: Share of total electric power sector carbon dioxide emissions weighted by sales to the transportation sector. Notes: Data in this table are revised from the data contained in the previous EIA report, Emissions of Greenhouse Gases in the United States 2007, DOE/EIA-0573(2006) (Washington, DC, December 2008). (Million Metric Tons Carbon Dioxide)*

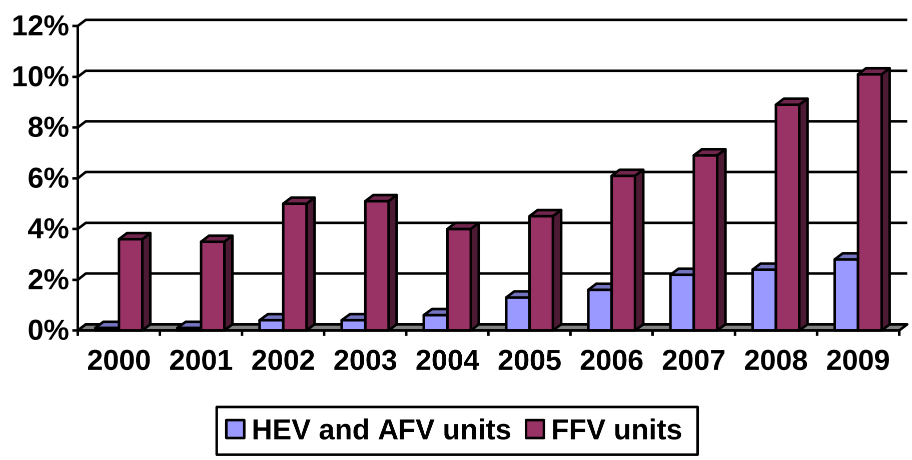
## 14.3. Vehicle Technology Types

There are multiple technology pathways toward low-carbon vehicle technology, from the rapidly maturing clean diesel and hybrid-electric vehicle (HEV) configurations to the emerging plug-in hybrid electric vehicle (PHEV) and battery electric vehicle (BEV) technology to the largely speculative hydrogen fuel cell vehicle (FCV) approach. There's also the natural gas vehicle (NGV) pathway, already established in many transit and other fleets but challenged by lack of fueling infrastructure for private LDVs. And there are flex-fuel vehicles that can run on up to 85% ethanol or 20% biodiesel as well as the probable emergence within five to 10 years of "drop-in" renewable biofuels that burn just like gasoline in an internal combustion engine. (It's important to point out that the lifecycle carbon footprints of biofuels—even advanced biofuels that will not use food crops—remains unsettled.)

Then there are incremental improvements to miles per gallon (MPG) and GHG emissions that can be achieved through the usage of turbocharging technology, by slimming down existing models and by selling smaller, lighter and more fuel efficient models with smaller engines.

Century-old auto manufacturers and well-capitalized start-ups are placing their bets on which technologies they think will offer the best combination of affordability, performance and overall market appeal. They're also balancing currently viable technology which can help them meet near-term fuel efficiency standards—such as the 2016 corporate average vehicle efficiency standard of 35.5 mpg in the United States and the European Union requirement for fleet average emissions of 130 g/km of CO2 or less by 2012—with R&D into BEVs, FCVs and other technologies that can hit the much stricter targets anticipated for 2020 and beyond. "Nobody knows what will be the winner, and nobody knows if there will be a single winner," said Jim Cannon whose Energy Futures firm has been following alternative vehicle technology and alternative fuels since 1979. "We had a single winner 100 years ago... we could have a transportation system in the future with multiple dominant technologies."

**Figure 236 Alternative Fuel Vehicles Sales as a % of All Light Duty Vehicles**




*Source: Energy Information Administration*

**Figure 237 Alternative Fuel Vehicles Sales Units Compared to All Light Duty Vehicles**

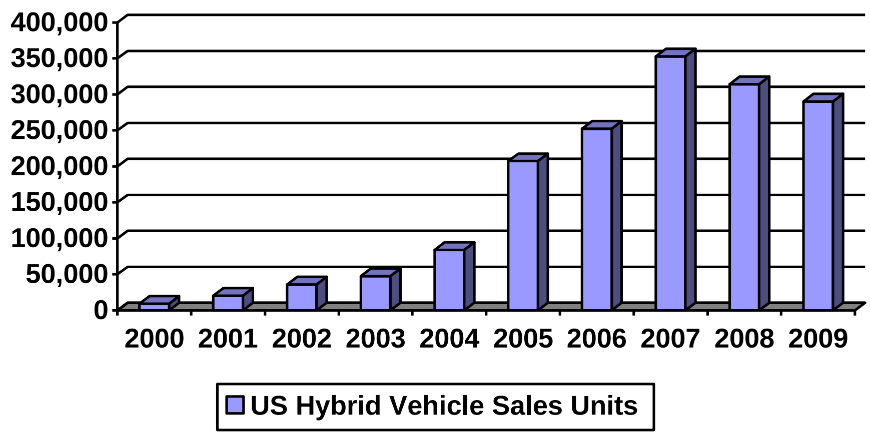
| | 2000 | 2001 | 2002 | 2003 | 2004 |
|---|---|---|---|---|---|
| FFV units | 600,832 | 581,774 | 834,976 | 859,261 | 674,678 |
| HEV and AFV units | 16,127 | 18,196 | 60,582 | 66,159 | 94,318 |
| US All LDV Vehicle Sales Units | 16,699,812 | 16,783,311 | 16,867,228 | 16,951,564 | 17,036,322 |
| | **2005** | **2006** | **2007** | **2008** | **2009** |
| FFV units | 743,948 | 1,011,399 | 1,115,069 | 1,175,345 | 1,049,478 |
| HEV and AFV units | 213,067 | 258,611 | 358,509 | 321,960 | 295,654 |
| US All LDV Vehicle Sales Units | 16,709,067 | 16,566,098 | 16,151,945 | 13,260,747 | 10,429,014 |

*Source: Energy Information Administration, AFVs include CNG, LNG, electric and hydrogen, but does not include FFV or flex fuel vehicles of which more than 1 million have been put on the road in each year from 2006-2008.*

Cannon sees a technology shoot-out looming within the next couple years between HEVs and PHEVs. HEV sales have grown steadily since first introduced by Honda then Toyota more than 10 years ago. HEVs commanded a record high 2.8% of the U.S. auto market in 2009 (the sales total of 290,300 vehicles was an 8% decline from 2008, but only a third of the 22% decline suffered by the market as a whole). Studies show that PHEVs capable of going even 20 miles in all-electric mode (before the gasoline engine kicks in to recharge batteries and/or power the electric motor) will have significantly better GHG profiles than HEVs. Several automakers plan to launch PHEV models soon, most notably General Motors whose 2011 Chevy Volt started sales in November 2010. Well-capitalized California companies Fisker with a luxury and sedan PHEV and Tesla with an EV Roadster and EV family car will also have a say.

Achieving an acceptable price point will be an even tougher challenge. Aftermarket PHEV conversions are currently available at widely varying prices. In Berkeley, Calif., 3prongpower will convert a Toyota Prius to a PHEV for prices ranging from $4,000 for a system capable of 10-mile all-electric range to over $12,000 for a 40-mile version. (Some states offer conversion incentives: Colorado grants a tax credit for 85% of costs up to $6,000; Florida received $500,000 in federal stimulus funds to provide rebates of $5,000 for 100 PHEV conversions.)

**Figure 238 U.S. Hybrid Vehicle Sales in Units 2000-2009**




*Source: hybridcars.com, Hybrid Market Dashboard*

**Figure 239 June 2010 U.S. Hybrid Car Sales Numbers**

| Model | Units | vs. prev. month | vs. June 2009 | CYTD | vs. CYTD 2009 |
|---|---|---|---|---|---|
| Toyota Prius | 10,998 | -23% | -15% | 66,039 | 19% |
| Ford Fusion | 2,010 | -19% | -2% | 10,008 | 85% |
| Honda Insight | 1,491 | -22% | -2830% | 10,257 | 36% |
| Lexus RX450h | 1,304 | -4% | 147% | 7,045 | 22% |
| Ford Escape | 1,260 | -3% | -3% | 6,121 | -15% |
| Toyota Camry | 1,097 | -25% | -47% | 7,634 | -41% |
| Toyota Highlander | 611 | -11% | -44% | 3,445 | -46% |
| Lexus HS 250h | 603 | -56% | n/a | 6,492 | n/a |
| Honda Civic | 595 | -17% | -62% | 3,111 | -75% |
| Altima | 479 | -59% | -28% | 4,048 | 28% |
| Mercedes ML450 | 212 | 17% | n/a | 636 | n/a |
| Chevy Tahoe | 168 | -30% | -34% | 913 | -43% |
| GMC Yukon | 132 | -32% | -5% | 746 | -16% |
| BMW X6 | 128 | 967% | n/a | 225 | n/a |
| Mercury Mariner | 100 | 24% | -9% | 504 | -29% |
| Mercury Milan | 93 | 22% | -50% | 517 | -2% |
| Chevy Silverado | 82 | -73% | -2% | 717 | 127% |
| Cadillac Escalade | 68 | -48% | -56% | 634 | -38% |
| Mercedes S400 | 63 | -38% | n/a | 524 | n/a |
| Mazda Tribute | 55 | 10% | -36% | 318 | -38% |
| GMC Sierra | 38 | 0% | -3% | 246 | 84% |
| Chevy Malibu | 36 | -12% | -93% | 359 | -86% |
| Lexus GS450h | 22 | -42% | -19% | 179 | -14% |
| Saturn Vue | 14 | 367% | -94% | 47 | -97% |
| BMW ActiveHybrid 7 | 11 | n/a | n/a | 18 | n/a |
| Saturn Aura | 5 | n/a | -91% | 38 | -80% |
| Lexus LS600hL | 4 | -50% | -87% | 52 | -67% |

| | | | | | |
|---|---|---|---|---|---|
| All hybrids | 21,679 | -23% | -18% | 130,911 | 3% |
| All vehicles | 983,738 | -11% | 14% | 5,614,023 | 17% |

*Source: hybridcars.com, Hybrid Market Dashboard*

**Figure 240 Selected Electric Vehicle Manufacturers in 2010**

**AeroVironment, California**
Alkè, Italy
**Aptera Motors, California**
Arcimoto, Eugene, Oregon
Brammo, Ashland, Oregon,
Changfeng Automobile, China
Citroën, France
De Dion-Bouton, France
Electric Car Corporation, England
Fiat, Italy
Fiat Industrial, Italy
**Fisker Automotive, California**
Ford Motor Company
General Motors
Green Propulsion, Belgium
Irisbus, Italy
Iveco, Italy
Karmann, Germany
Li-ion Motors, Nevada
Lightning Car Company, England
Lotus Cars, England
Magna International, Canada
Mitsubishi, Japan
Micro-Vett, Italy
Nissan Motors
Peugeot
PSA Peugeot Citroën

Shelby SuperCars, Washington
**Tesla Motors, California**
Think, Norway
Venturi Automobiles, France
Wheego Electric Cars, Georgia
**ZAP, California**
ZENN Motor Company, Canada

**Figure 241 U.S. Onroad Alternative Fuel Vehicles Made Available 2000-2008**

| Fuel Type/Configuration | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|---|---|
| E85 Flex Fuel Vehicle | 600,832 | 581,774 | 834,976 | 859,261 | 674,678 | 743,948 | 1,011,399 | 1,115,069 | 1,175,345 |
| Compressed Natural Gas (CNG) | 9,501 | 11,121 | 8,988 | 6,122 | 7,752 | 3,304 | 3,128 | 2,487 | 4,440 |
| Dedicated [2] | 3,997 | 5,506 | 5,397 | 3,397 | 4,398 | 2,276 | 2,066 | 2,480 | 4,401 |
| Nondedicated | 5,504 | 5,615 | 3,591 | 2,725 | 3,354 | 1,028 | 1,062 | 7 | 39 |
| Electric | 6,215 | 6,682 | 15,484 | 12,395 | 2,200 | 2,281 | 2,715 | 3,152 | 2,802 |
| Liquefied Petroleum Gas (LPG) | 4,435 | 3,201 | 1,667 | 2,111 | 2,150 | 700 | 473 | 356 | 695 |
| Dedicated | 1,056 | 633 | 532 | 287 | 164 | 241 | 277 | 179 | 376 |
| Nondedicated | 3,379 | 2,568 | 1,135 | 1,824 | 1,986 | 459 | 196 | 177 | 319 |
| Liquefied Natural Gas (LNG) | 411 | 393 | 147 | 111 | 136 | 68 | 92 | 26 | 384 |
| Hydrogen | 0 | 0 | 2 | 6 | 31 | 74 | 40 | 63 | 63 |
| TOTAL | 621,394 | 603,171 | 861,264 | 880,006 | 686,947 | 750,375 | 1,017,847 | 1,121,153 | 1,183,729 |

*Source: Energy Information Administration, Form EIA-886, "Annual Survey of Alternative Fuel Vehicle Suppliers and Users," as reported in "Alternatives to Traditional Transportation Fuels" 1998-2008 reports (Table 14 or S1, depending on year of report.) Notes:[1]"Made Available" means the sale or lease of a new AFV, or conversion of an existing vehicle to enable it to use an alternative fuel.[2]Dedicated vehicles and nonhybrid electric vehicles are designed to operate exclusively on one alternative fuel. Nondedicated vehicles and hybrid electric vehicles are configured to operate on more than one fuel, usually an alternative fuel and gasoline or diesel fuel.*

**Figure 242 NGV Global Vehicle Data**

11.4 Million Natural Gas Vehicles in 2010

| | | |
|---|---|---|
| Pakistan | 2,250,100 | 20% |
| Argentina | 1,826,845 | 16% |
| Iran | 1,820,000 | 16% |
| Brazil | 1,631,173 | 14% |
| India | 700,000 | 6% |
| Italy | 676,850 | 6% |

| | | |
|---|---|---|
| China | 500,000 | 4% |
| Colombia | 304,823 | 3% |
| Ukraine | 200,019 | 2% |
| RoW | 1,488,887 | 13% |
| Total | 11,398,697 | |

*Source: NGV Gas Vehicle Report, May 2010; Note USA is 100,000 or <1%*

### 14.3.1. Natural Gas Vehicles

While there is a lot of momentum building around electrification of LDVs to mitigate GHGs, another camp advocates for natural gas vehicles (NGVs) as well—most famously T. Boone Pickens, the "Texas oilman" whose Pickens Plan called for sharp increases in wind energy and energy efficiency for electricity supply and shifting from petroleum to natural gas for LDVs.

Pickens and groups like NGV America point to the widespread use of NGVs as transit buses (27% of new buses ordered in 2008 will run on gas, according to NGVA), garbage trucks (many using gas from their own landfill) and other fleet service vehicles, and they say that moving LDVs to a natural gas platform would have cost-effective, near-term benefits for GHG mitigation, not to mention increasing domestic energy independence.

Many gas utilities agree, and a representative of Southern California Gas Company and San Diego Gas & Electric, the two utilities owned by Sempra Energy, asked the California Energy Commission to advance both electricity and natural gas as vehicle fuels.

William Zobel, Sempra's head of clean transportation and alternative fuels, stated that gas production data indicates that increased demand from NGVs would not jeopardize supplies for electricity generation, heating and other uses. "Data from the International Energy Agency shows that unconventional gas production is on the rise and has unlocked new resources," said Zobel. He also spoke about the potential to draw on landfill gas, which he called biomethane. "Biomethane is one of the lowest carbon transportation fuels available today."

Cannon of Energy Futures agrees with the studies cited by NGVA that shifting from gasoline to natural gas would cut GHGs per mile by 20% to 30%. And he agrees the approach is less costly than electrification. "The advantages of compressed and liquefied natural gas are that while you have to modify the engines and add fuel storage you don't have to develop a whole new drive train," as BEVs and PHEVs require. Cannon say that the inefficiency of internal combustion engines would prevent this approach from delivering maximum GHG reductions, and some would therefore say this consigns NGVs to being a transitional technology. Duvall says that because of the greater efficiency of electric motors, charging an electric vehicle with electricity from a gas-burning combined cycle power plant yields lower GHG emissions per mile than burning gas in an internal combustion NGV—even accounting for transmission and distribution losses and the efficiency penalty from battery charging. "Internal combustion engines peak at about 30% efficiency, and in practice it's much lower because of idling and other factors," said Duvall.

As Cannon noted, there's no reason there has to be only one winner in the race for low-carbon vehicle propulsion. Natural gas vehicles and electric vehicles could certainly co-exist in the market. But for Cannon, the key advantage of the electric route is that it charts a course for what he thinks will ultimately be the core technology of the future. "I believe and I think most transportation people believe we need to go to an electric transportation system," said Cannon. "Electric power is so much more efficient and flexible. You can get it from the grid, from your home PV system or perhaps one day onboard from a fuel cell."

Despite his disappointment with the EV1, Cannon, age 60, believes the United States will make a transition to electric vehicles "possibly within my lifetime," he said. "Internal combustion engines mechanically powering wheels will not deliver the 50-80% reduction in greenhouse gases from transportation that we need in this century." Transitional technology indeed, but most experts agree there are billions to be made in all types of vehicles and fuels, but only for a finite amount of time.

**Figure 243 Top U.S. Transportation Engineering Design Firms in 2008**

| Top U.S. Transportation Engineering Design Firms in 2008 | | |
|---|---|---|
| Company | Total Revs | Transportation |
| AECOM | 5,216 | 1,617 |
| Jacobs | 5,501 | 1,320 |
| URS Corp. | 5,206 | 1,302 |
| Parsons Brinckerhoff | 1,572 | 896 |
| HNTB Cos. | 858 | 712 |
| Louis Berger | 971 | 699 |
| CH2M HILL | 3,731 | 560 |
| HDR | 1,280 | 499 |
| Parsons | 1,339 | 415 |
| The PBSJ Corp. | 594 | 351 |
| STV Group | 289 | 240 |
| Kimley-Horn | 459 | 229 |
| TranSystems | 226 | 226 |

*Source: ENR, The 2009 Top 500 Design Firms, $million*

## 14.4. Venture Investment

Venture capital investment activity in transportation companies has been on a steady rise, reaching 36 deals and almost $1 billion invested in the first six months of 2010, according to transactions compiled by Cleantech Group.

In addition U.S. government funds are leveraging venture-backed leaders. Prominent examples include Fisker Automotive's $530 million DOE loan for the development and production of two lines of plug-in hybrid electric vehicles, Tesla Motor's $465 million loan from DOE's same Advanced Technology Vehicles Manufacturing Loan Program, and battery company A123 Systems' $250 million in stimulus funds. A123 raised more than $200 million in five rounds of private investment from November 2005 to April 2009 before going public in September 2009 and raising $378 million from its IPO. Fisker closed a $190 million round in May 2010 bringing its total of private capital raised to at least $340 million and is using part of its DOE loan to buy a former GM plant in Delaware. Tesla has raised a total of $320 million since 2004 with Daimler coming aboard as a $50-million equity investor in 2009. Tesla plans its IPO before the end of June 2010 to raise another $170 million with a $50 million private placement from Toyota to follow that includes the purchase of Toyota's former Fremont, Calif. plant.

Other companies in the nine-figure club include electric infrastructure firm Better Place which raised $350 million in a Series B in Q1 2010, Coda Automotive that closed a $58 million Series C round bringing its total $125 million and Norwegian company Think Global.

**Figure 244 Global Transportation Venture Capital Investment 2005-2010**

| Deal Period | Sum of Amount | Deals: Count of Amount |
|---|---|---|
| 1Q05 | 6,815,354 | 5 |
| 2Q05 | 32,404,314 | 12 |
| 3Q05 | 46,307,818 | 15 |
| 4Q05 | 89,558,939 | 13 |
| 1Q06 | 115,507,123 | 11 |
| 2Q06 | 100,804,910 | 7 |
| 3Q06 | 72,689,397 | 9 |
| 4Q06 | 85,055,000 | 15 |
| 1Q07 | 163,239,000 | 14 |
| 2Q07 | 114,601,000 | 11 |
| 3Q07 | 114,191,000 | 13 |
| 4Q07 | 361,675,000 | 13 |
| 1Q08 | 200,260,000 | 17 |
| 2Q08 | 190,410,926 | 15 |
| 3Q08 | 167,970,000 | 14 |
| 4Q08 | 115,700,000 | 10 |
| 1Q09 | 176,850,000 | 19 |
| 2Q09 | 384,850,000 | 15 |
| 3Q09 | 232,137,000 | 15 |
| 4Q09 | 110,353,000 | 19 |
| 1Q10 | 728,880,000 | 24 |
| 2Q10 | 215,450,000 | 12 |
| 2005-2010 Total | 4,764,728,139 | 309 |

*Source: Cleantech Group, Transportation includes: advanced batteries, electric and hybrid vehicles, and fueling infrastructure.*

### 14.4.1. California Venture Investment summary 2009-2010

Prominent transportation venture investments as reported by Cleantech Group.

**Q2 2010**

BIOFUELS - $302 million in 13 deals

**Amyris Biotechnologies**, a California-based developer of technology for the production of renewable fuels and chemicals, closed the final tranche of a $61 million Series C round and also raised a further $47.8 million from Temasek Holdings; Virent Energy Systems, a Wisconsin-based developer of a catalytic bio-refinery platform, raised $46 million from Shell and Cargill Ventures; and Kior, a Texas-based developer of a catalytic cracking technology for turning biomass into bio-crude, raised $40 million.

**Q1 2010**

TRANSPORTATION - $704 million in 27 deals

Deals included: California-based electric vehicle infrastructure company **Better Place** which raised $350 million in a Series B round led by HSBC and also including Morgan Stanley Investment Management, Lazard Asset Management, Israel Corp., VantagePoint Venture Partners, Ofer Hi-Tech Holdings, Morgan Stanley Principal Investments, and Maniv Energy Capital; **Fisker Automotive**, a California-based developer of plug-in hybrid cars, which raised $140 million from investors including Kleiner Perkins Caufield & Byers and lithium-ion battery company A123 Systems; and **Coda Automotive**, a California-based electric car and battery company, which raised $30 million from investors including Aeris Capital.

**Q3 2009**

TRANSPORTATION (including Vehicles, Advanced Batteries & Biofuels) - $383 million

Deals included: **Tesla Motors**, the California-based electric car manufacturer, which raised $82.5 million in funding from a group of investors led by London-based Fjord Capital Management; Think Global, the Norwegian electric car manufacturer, which officially announced a $46 million round; and **Amyris Biotechnologies**, the California-based developer of a synthetic platform to create renewable fuels and chemicals, which secured $24.8 million as part of an ongoing $62 million Series C funding round.

**Q2 2009**

The leading sector in the quarter was transportation—specifically, vehicles, biofuels and advanced batteries—reflecting attention on the automotive sector and significant government stimulus. Meanwhile, solar saw its lowest level of investment in over three years, with only $114 million invested, down from a high of $1.2 billion invested in 3Q08, as most investors, whose portfolios contain significant solar holdings, did not increase their exposure. The largest transactions in each technology sector were:

VEHICLES - $236 million

Deals included San Diego startup **V-Vehicle**'s raise of $100 million to date from Kleiner Perkins Caufield & Byers and T. Boone Pickens to build a fuel-efficient car in Louisiana, California EV manufacturer **Fisker Automotive**, which raised $85 million from Eco-Drive

Partners and Kleiner Perkins to fund development and manufacturing of its Karma plug-in hybrid, Norwegian EV startup Think Global which raised $39 million, and Israel's ETV Motors which raised $12 million from Quercus Trust to develop an electric powertrain.

BIOFUELS - $206 million

Deals included agri.capital, a European developer of biogas plants, which raised $82 million from TCW Group and others and renewable oil producer Solazyme, which raised $57 million from Braemar Energy Ventures, Lightspeed Venture Partners and new investor VantagePoint Venture Partners.

ADVANCED BATTERIES - $165 million

Deals included lithium-ion battery startup A123, which raised a $100 million round led by GE and others, and Deeya Energy, which raised $30 million from Technology Partners and others to develop its redox flow batteries.

**Q1 2009**

BIOFUELS - $96 million

Deals included BioMCN, which has developed a process to convert crude glycerine, a byproduct of biodiesel, into methanol. It raised $46 million from Waterland Private Equity. Cellulosic ethanol company ZeaChem raised a $34 million round led by Globespan Partners and Prairie Gold Venture Partners.

ADVANCED BATTERIES - $94 million

Deals included lithium-ion startup Boston Power, which raised a $55 million round led by Swedish investor Foundation Asset Management. Boston Power's Sonata batteries were chosen by HP for nearly 70% of its consumer line of notebooks. UK-based Nexeon raised over $14 million from Invesco Perpetual and others for its silicon anode technology for lithium-ion batteries, while Swiss startup ReVolt Technology raised over $13 million for its Zinc-air battery technology for consumer electronics devices

ELECTRIC VEHICLES - $78 million

Deals included Dutch transmission manufacturer Fallbrook Technologies, which raised $25 million from NGEN Partners and Robeco. Scuderi Group raised $20 million for its split cycle internal combustion engine, PHEV manufacturer Bright Automotive raised $11 million from White Pines Partners and Duke Energy, and Smith Electric Vehicles, which manufactures electric trucks and vans, raised $10 million.

# 15. Carbon Markets

## 15.1. Context for 2011: Stage Set for AB32

As a result of the November 2010 U.S. elections, supporters of climate change mitigation will have virtually no chance of enacting federal legislation to cap greenhouse gases in the 112th Congress, with a wide range of observers and analysts saying cap and trade is off the table until at least 2013. In addition, Republican governors and state legislators opposed to climate change legislation swept into capitals in many states that were previously committed to greenhouse gas (GHG) mitigation. New Mexico's Environmental Improvement Board approved final rules for a cap-and-trade program on the same day the state's voters elected climate change skeptic Susana Martinez as governor. In Wisconsin, a member state in the Midwest Greenhouse Gas Regional Accord with aggressive renewable energy standards, Republican Governor-elect Scott Walker campaigned against climate change and renewable energy policies.

On the pro-climate side, 61% of California voters rejected a measure that would have postponed implementation of the state's Global Warming Solutions Act (aka AB32) indefinitely. On Dec. 17, California's Air Resources Board gave final approval to a sweeping economy-wide cap and trade program, the capstone of an epic rulemaking process that will also see scores of complementary measures such as fuel efficiency standards and smart growth planning requirements for local governments implemented under various state laws and regulatory authorities. With the survival of AB32, British Columbia, Ontario and Quebec will likely join California in 2012 or 2013 in a carbon trading system created under the Western Climate Initiative. New Mexico was the only other U.S. state on track for 2012 trading, but its participation is up in the air in 2011.

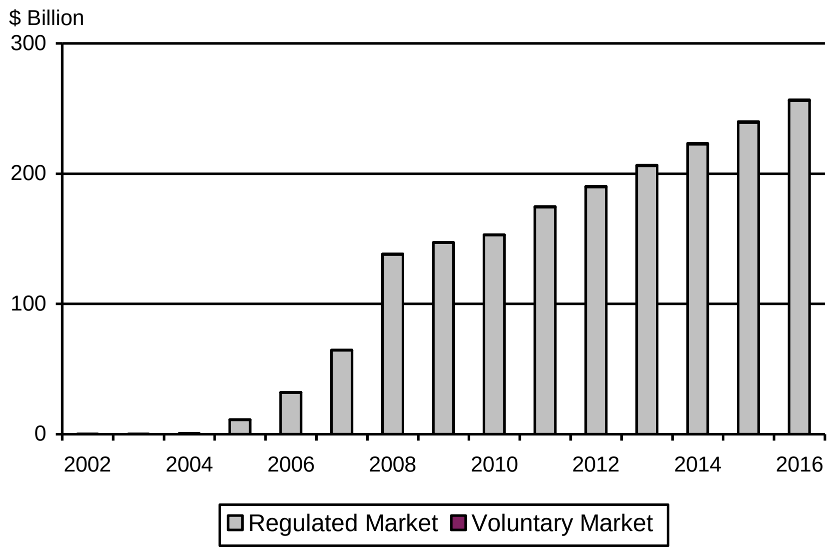
In the Northeast, support appears to be solid for the Regional Greenhouse Gas Initiative (RGGI), in spite of changes in state leadership and continuing objections to climate change policies from New Jersey Governor Chris Christie. Analysts suggest that this may be in part because the program is returning vital revenues to states—some of which are spending it to fill budget holes rather than using the money for energy efficiency as promised in the RGGI agreements. Also, RGGI to date has had a low profile. Due to lower power demand in the recession and fuel switching in response to cheap natural gas, RGGI allowances have been priced so low that there has been little if any impact on electricity prices.

### 15.1.1. Recent Carbon Markets in Brief

Estimated at about $120-130 billion, the global carbon market roughly doubled in 2008. Plummeting European prices in the first quarter of 2009 spurred fresh debate about cap-and-trade, but the political consensus remains strong in Europe, where Phase 3 will significantly boost value of carbon credits in the future.

After building up a powerful head of steam in 2007 and 2008, the global carbon market melted down with the world economy in the first quarter of 2009. By mid-February 2009, prices for European Union Allowances (EUAs) had fallen to under $11 per ton—a drop of more than 70% since the summer of 2008 when prices were as high as $40. Through March and April, prices ranged from $13 to $17, but projections for the year saw no major increase and even further flattening. Late 2009 saw prices range between $15-20.

**Figure 245 Global Carbon Market: Regulated vs. Voluntary**




*Source: EBI Inc. Carbon market model derived from a variety of sources and aggregated from annual figures on price and value by World Bank, Carbon Finance and Point Carbon.*

In 2009 the poor economic climate, which hit production levels and short-term cash flows, put an extra pressure on many industrial emitters to cash in EUAs – rather than bank them in case of future shortages – and depressed prices to as low as less than $10/ton. (dollar vs. euro) By the end of the year 2009, Point Carbon estimated that while the volume trades was up 10-15%, prices were down 30-40%.

The voluntary carbon market, largely centered in North America, also lost ground in early 2009 although not as dramatically. Prices of offsets traded on the Chicago Climate Exchange (CCX) dropped from a summer 2008 peak of just under $7 to between $1.50 and $2. According to New Carbon Finance, average prices for over-the-counter (OTC) carbon offset transactions fell from a summer 2008 peak of $8.40 per ton to $5.20 by February 2009.

The value of carbon emissions trading globally reached $120 billion in 2010, according to Bloomberg New Energy Finance (BNEF), a 5% rise year-on-year, despite a 10% drop in traded volume.

The sharp drop in prices in 2009 unnerved many market participants, especially investors. Some called on the European Commission (EC) to intervene and set a price floor. But according to news reports at the time, Artur Runge-Metzger, the EC's chief climate change negotiator, stated that the EU Emissions Trading Scheme (ETS) law doesn't allow such intervention or the setting of a floor price. "That is something we leave to market forces, otherwise we will not have a market," he said.

The price shock also provided carbon tax proponents and other critics with fuel for their arguments against the EU's cap-and-trade system—and proposed and emerging cap-and-trade systems in the United States and Australia. But analysts say that the decline in prices for this relatively new commodity was a natural response to the global recession which hit Europe hard. "Using the current situation as an example of why cap-and-trade doesn't work is not a good argument," said Jurgen Weiss, managing director of advisory services for Point Carbon. "Volatility is a phenomenon of essentially all commodity markets.… The 2009 decline in prices was a sign that the European cap-and-trade system functions as intended. The EU goal for lowering emissions in the sectors included in the EU ETS translates into an overall cap on emissions. The fact that emissions are now lower due to the recession makes it easier to achieve that cap, and as a result, the price paid to achieve that goal is and should be lower." Additionally, many owners of EUAs and other carbon instruments sold their holdings as part of larger strategies to monetize assets in the recession.

### 15.1.2. EU ETS Heading to Phase 3

Indeed, the EU ETS, the backbone of the global carbon market, shows all signs of supporting strong and enduring values.

The carbon market will grow 15% to €107 billion ($139 billion) in 2011, according to analysts at Bloomberg New Energy Finance. Utilities will drive this growth, as they acquire more allowances in anticipation of Phase III of the EU Emissions Trading Scheme, when they will have to buy all their allowances at auction. "With the advent of auctioning in the European scheme we are likely to see even higher traded volumes and prices in Europe in 2011 and these may increase further in future years," said Guy Turner, director of carbon market research at BNEF.

The European Commission's directive for Phase 3, approved by the EU's parliament and council in December 2008, will expand and toughen the standards for regulated emitters in a number of ways when it takes effect January 1, 2013. The more stringent regulations will create value well before 2013 as emitters seek to hedge their exposure in advance of the actual compliance period.

Specific rules for implementing Phase 3 are still in development, but the broad outlines are clear. Emissions caps will decline annually until 2020, when a 21% reduction over 2005 emissions will be in place. Many more permits will be auctioned as opposed to given freely to emitters. According to the European Commission (EC), Phase 2 saw auctions of less than 4% of available permits, while Phase 3 will see increasing proportions of permits auctioned; over the eight-year period, the EC estimates more than half of the available emission permits will be auctioned. Additionally, individual nations will no longer set their own allocation plans.

As the final rules emerge, the exact number of installations may decline as some small emitters are dropped. At the same time there are some new gases other than carbon dioxide which are going to be covered, and that will bring in some new installations under the scheme. According to the EC's summary, Phase 3 will "include other sectors [not before regulated such as] CO2 emissions from petrochemicals, ammonia and aluminum [as well as] N2O emissions from the production of nitric, adipic and glyocalic acid production and per fluorocarbons from the aluminum sector."

In separate legislation, the EU also will bring aviation under the ETS a year earlier than Phase 3, in January 2012. Airline operators will obtain some allowances for free, but it is estimated that 15 percent are going to be auctioned.

Weiss of Point Carbon also points to the benefits of the longer-term compliance period in Phase 3—eight years as opposed to five in Phase 2. "The compliance period [in Phase 2] is relatively short. The cap has been set through 2012. As a consequence, lower emissions in 2009 and 2010 also significantly lower the amount of further reductions needed to reach the 2012 cap. A longer compliance period would, at least in theory, reduce the price volatility resulting from relatively short-term fluctuations of emissions such as the ones caused by a temporary recession."

It's worth mentioning that while political leaders in Europe may be solidly behind the EU ETS, the public may have more diverse opinions. The carbon market may be particularly vulnerable in the longer term to arguments that it is not yielding quantifiable reductions in GHG emissions. There has always been a certain chorus of criticism of emissions trading as a strategy for climate-change mitigation, and such criticism appears to be increasing of late.

**Figure 246 Global Carbon Market ($mil)**

| | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|
| Regulated Market | 350 | 700 | 11,051 | 32,022 | 64,313 | 138,013 | 146,982 | 152,861 | 169,676 |
| Voluntary Market | 10 | 20 | 206 | 161 | 368 | 545 | 406 | 422 | 456 |
| **Total** | **360** | **720** | **11,256** | **32,182** | **64,681** | **138,558** | **147,388** | **153,283** | **170,132** |
| | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** | **2018** | **2019** | **2020** |
| Regulated Market | 184,947 | 200,667 | 216,721 | 232,975 | 249,283 | 266,733 | 284,871 | 303,672 | 323,107 |
| Voluntary Market | 497 | 541 | 590 | 643 | 701 | 750 | 803 | 859 | 919 |
| **Total** | **185,443** | **201,209** | **217,311** | **233,618** | **249,984** | **267,483** | **285,673** | **304,531** | **324,026** |

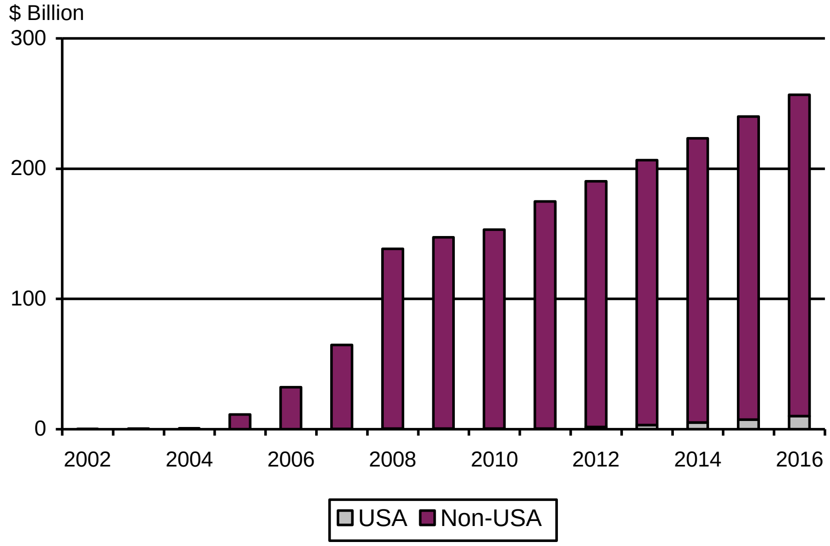
*Source:EBI Inc. derived from a variety of sources including Point Carbon, World Bank, CantorCO2e, Natsource, IETA, New Carbon Finance, Trexler C&ES, IDEAcarbon and CCBJ's survey of voluntary offset providers*

In December 2008, The Economist held an online debate about the topic; 55% of more than 160 readers commenting agreed with the statement: "carbon offsets undermine the effort to tackle climate change."

"Three points counted strongly against offsets," wrote The Economist's Emma Duncan. "The first was additionality. Many people struggled with the notion that it is possible to build a system on the basis of an unknown counter-factual: what would have happened without a market for offsets." "The second big objection to offsets was about innovation," wrote Duncan. "The more low-cost offsets rich-country companies can buy, the less incentive they have to develop the technologies necessary to moving the world on to a low-carbon path. And without those technologies, cutting emissions would mean politically unacceptable cuts in growth.… The third problem which some people have is a moral one. There is a sense that offsets let rich countries off the hook—that, somewhat like papal indulgences, they let the wealthy buy their way to redemption instead of changing their behavior."

As a careful reading of these comments reveal, the core of The Economist's criticism is focused on CERs (more or less equivalent currency to the EUA) that are obtained by European emitters who fund emissions-reductions projects in developing countries through the Clean Development Mechanism (CDM). The CDM executive board had been under increasing pressure to improve the quality of the projects it registers, and is making some headway.

**Figure 247 Global Carbon Market: U.S. vs. Non-U.S.**




*Source: EBI Inc. Carbon market model derived from a variety of sources*

**Figure 248 Global Carbon Market**

| | 2007 | 2008 | 2009 | 2008 Growth | 2009 Growth |
|---|---|---|---|---|---|
| **Carbon Market** | 64.68 | 138.56 | 147.39 | 114% | 6% |

*Source: EBI Inc. estimates derived from a variety of sources. Revenues in $ bil*

**Figure 249 U.S. Carbon Market**

| | 2007 | 2008 | 2009 | 2008 Growth | 2009 Growth |
|---|---|---|---|---|---|
| **Carbon Market** | 0.18 | 0.44 | 0.57 | 138% | 30% |

*Source: EBI Inc. estimates derived from a variety of sources. Revenues in $ bil*

**Figure 250 California Carbon Market**

| | 2007 | 2008 | 2009 | 2008 Growth | 2009 Growth |
|---|---|---|---|---|---|
| **Carbon Market** | 0.02 | 0.04 | 0.06 | 138% | 30% |

*Source: EBI Inc. estimates derived from a variety of sources. Revenues in $ bil*

**Figure 251 U.S. and California Carbon Market: Employment**

| | USA $bil in 2009 | USA 2009 Jobs | Calif. $bil in 2009 | Calif. 2009 Jobs | % of USA Jobs in Calif. |
|---|---|---|---|---|---|
| **Carbon Market** | 0.57 | 4,400 | 0.06 | 530 | 12.0% |

*Source: EBI Inc. estimates derived from a variety of sources. Revenues in $ bil*

## 15.2. U.S. Climate Policy

Of course, the big gorilla of any future carbon market will be the United States, the most notable developed country to spurn the Kyoto Protocol. As mentioned in the introduction to this overview edition, the election of Barack Obama as president and the growth of Democratic majorities in both houses of Congress in 2008 heralded a profound change in U.S. policy direction, but even then passage of a mandatory carbon cap-and-trade package in the United States was anything but a done deal. This is even truer after the mid-term election tipped power back towards the Republican party.

Whenever, and if ever it occurs, federal replacement of regional and state programs could be tricky. A major issue is what to do about the revenue stream that Regional Greenhouse Gas Initiative is generating now, and that the other regional programs like California plan to generate. States are looking to use these funds for beneficial projects.

Other scenarios raise separate but related problems, according to carbon market analysts. The co-existence of a federal program with the regional programs might be politically acceptable but may yield little environmental benefit. Pure preemption of the regional programs by the federal program could render state allowances worthless. The states may ultimately require incentives to give up their programs, and some integration of state and federal allowances may be part of the solution.

### 15.2.1. California Climate Change Policy

With endorsement from 61% of the state's voters, California will start a cap and trade system in 2012 that, along with a raft of complementary measures for energy efficiency, renewable energy, smart growth and other strategies, aims to cut state emissions 15% by 2020. Some analysts see the California carbon market reaching $10 billion in 2016. Canada's three largest provinces are likely to join within two years. Forestry offset protocols remain controversial while local governments are just beginning to tackle their GHG reduction challenges.

Observers says the defeat of Proposition 23 in California on November 2, 2010 was one of the most significant victories in the short history of climate change policy in North America. Legislation to cap greenhouse gases (GHGs) may be dead in the U.S. Congress, the parties to the United Nations Framework Convention on Climate Change may have all but given up extending the Kyoto Protocol, but 61% of voters in the USA's most populous state voted to enter the uncharted territory of an economy-wide cap and trade system—while suffering with 12.4% unemployment.

On top of so many defeats domestically and internationally for climate change policy, a loss in the California election would have had "a catastrophic impact, not just in California but for all North American regional initiatives, for federal policy and for the international climate negotiations," said Emilie Mazzacurati, head North American analyst for Point Carbon prior to the election.

Six weeks after the election secured the future of California's 2006 Global Warming Solutions Act, also known as AB32, the California Air Resources Board (ARB) gave final approval to a cap and trade system that will cover, starting January 2012, about 600 power plants, oil refineries and other facilities (owned by about 360 firms) that each emit more than 25,000 metric tons of CO2-equivalent (CO2e) annually. (Gases with higher global warming potential (GWP) than CO2 are classified accordingly; for example, one ton of methane equals about 20 tons CO2e because of the higher GWP of methane.)

Electricity imports from coal power plants in Utah and Wyoming will also be covered. In 2015, fuel suppliers with emissions above the 25,000 mtCO2e threshold will come under the cap—with their emissions measured by the emission factors of the fuel they sell in the state (i.e., 8.8 kg CO2 per gallon of gasoline combusted).

"To ensure a gradual transition, ARB will provide significant free allowances to all industrial sources during the initial period (2012-2014). Companies that need additional allowances to cover their emissions can purchase them at regular quarterly auctions ARB will conduct, or buy them on the market," wrote ARB in its news release announcing the board's decision. "Electric utilities will also be given allowances and they will be required to sell those allowances and dedicate the revenue generated for the benefit of their ratepayers and to help achieve AB 32 goals," stated the ARB news release.

Eight percent of an emitter's compliance can be met with offset credits from projects in one of four sectors where ARB has finalized protocols: "forestry management, urban forestry, dairy methane digesters, and the destruction of existing banks of ozone-depleting substances in the U.S. (mostly in the form of refrigerants)." Steve Cliff, lead ARB staff person for the cap and trade program, underscored that the program sets an overall cap for the state, not individual emitters. The incentive to reduce emissions is created by the cost of procuring adequate allowances.

"Let's say you run a facility that is about 10 percent short of what you need," said Cliff. "You can go into the secondary market and acquire offsets or buy allowances from ARB in the quarterly auctions.... The price that you're willing to pay is related to what you think the marginal charge would be for you to reduce the emissions at your facility," he said. "If you determine that putting on a new widget or insulating your boiler and pipes is going to cost you the equivalent of $12 per ton [to cut emissions] and the going price is $15, you're going to do the renovation," said Cliff.

Cliff pointed out that ARB staff has generated "compliance pathway" spreadsheets detailing cost scenarios for different energy efficiency and conservation measures for all covered industries. "We've looked at the entire economy," he said. "There are lots of opportunities for reductions, for making industrial processes more efficient."

**Allowance Allocation Based on 90% of Typical Carbon Intensity**

Rather than base allowance allocations on a facility's historic emissions, ARB has designed an efficiency-based benchmark that considers the typical carbon intensity of industrial processes, and then compensates those facilities that are the most efficient.

"We look at the amount of emissions per unit of production of any particular product," said Cliff. "Let's say cement is one ton CO2 per ton of cement, which is approximately the current intensity. We know that some plants are operating at 0.9 tons CO2 per ton of cement, so we're going to set the benchmark at 0.9, about 90% of the current average intensity."

"If I'm producing cement right at the average intensity, I'm going to be a little bit short and will have to acquire allowances or credits," said Cliff. "If I'm more efficient because I've made improvements, I'll have excess allowances to sell."

The covered emitters will report their production along with their emissions every year. “If your output increases, you get more allowances,” said Cliff. “In that way, we allow those who are already producing in the state to grow in the state and receive more allowances. It removes any incentive for a company to move its production out of state.”

On the surface, the California emissions cap isn’t as stringent as the one sought by President Obama and expressed in the 2009 Waxman-Markey climate bill. As mandated in the California legislation, ARB’s plan aims to ratchet state emissions down to 1990 levels by 2020. ARB put the 1990 level at 427 mtCO2e, and ARB estimates that cutting emissions to this level by 2020 will be equivalent to a 15% reduction from 2010 levels. By contrast, Waxman-Markey and Obama’s declarations targeted reductions in the range of 17% below 2005 levels by 2020.

Cliff observes however thatcomparisons between Waxman-Markey target and California’s are not straightforward. “The California targets are comparable to federal proposals such as Waxman-Markey, although it’s tough to directly compare the targets as a percentage reduction from a base year since California has already made significant reductions from energy efficiency and renewable electricity generation.”

Point Carbon reckons the California carbon market will be a large one: $1.7 billion in 2012, its first year, and close to $10 billion by 2016. “California alone would constitute the largest carbon market in the US, overtaking the Regional Greenhouse Gas Initiative (RGGI), and the second largest carbon market in the world after the [European Union Emissions Trading Scheme],” said Point Carbon in a statement released after the ARB vote.

The future market for California allowances and credits is highly sensitive to broader energy markets, economic growth and other factors—not to mention the availability and price of offset credits. The California think tank Next 10 commissioned research that yielded ranges of estimates quite broad, and quite different from Point Carbon’s: from $2.5 billion to $7.5 billion in 2012 and from $7.3 billion to $21.9 billion by 2020.

All analysts agree that the market will escalate significantly as the statewide cap declines starting at 2% annually from 2012 through 2014 then increasing to 3% annually after 2015. “The California market will start gradually and at moderate prices but we expect market size and value to pick up quickly after 2015 when oil companies join and targets become more ambitious,” said Veronique Bugnion, global head of trading analytics at Point Carbon in a news release. “The California Air Resources Board ensured the market would be comfortably supplied with credits from existing forestry and agricultural projects in 2012-2014, but with an aggressive target in 2020. The stakes are high and players will have to get their ducks in a row quickly.”

**Western Climate Initiative**

With the possible exception of New Mexico—where a GHG cap and trade program approved by the state’s Environmental Improvement Board is under a cloud after Governor-elect Susana Martinez declared her intention to overturn it—California is the only U.S. state in the Western Climate Initiative that has carried out its commitment to create a GHG cap. But California may be joined by up to three Canadian provinces: British Columbia, Ontario and Quebec as early as 2012.

All three have passed GHG reduction targets and are moving toward cap and trade systems. (Manitoba has also declared its intent to enact and cap and start carbon trading within WCI but its policymaking lags the other three). The three provinces have codified their reduction commitments in WCI agreements, and if they succeed in finalizing their cap and trade regulations, trading allowances and offsets with California emitters could begin in January 2012.

“Any compliance instrument in their system would be fully fungible with ours,” said Cliff. A future ARB rulemaking will be needed to make the formal linkages, and as provincial authorities finalize their programs, ARB staff will bring to the air board final agreements to enter emissions trading with those jurisdictions, according to Cliff.

**AB32 the Big Star in a Constellation of Climate Change Policy**

The cap and trade program is the major regulatory component of AB32, California's Global Warming Solutions Act, but it's by no means the entire package. The ARB has developed 69 complementary measures to help the state achieve its GHG reduction goals. These include policies for building energy efficiency, low carbon fuels, renewable power and sustainable urban planning already enacted by the legislature or other regulatory bodies like the California Public Utilities Commission.

Most of the measures are voluntary or incentive-based. There are lots of "partnerships" and technical assistance efforts, such as working with shipping companies to "develop and implement" programs to reduce emissions from goods movement. There are online "toolkits" to help businesses and local governments calculate their carbon footprints and identify opportunities to reduce emissions.

But there are also new mandatory regulations that will affect, and are already affecting, businesses, institutions and local governments.

There's a suite of regulations for refrigerants and other industrial gases with high global warming potential (GWP). A Stationary Equipment Refrigerant Management Program (through which ARB aims to achieve 4 million mtCO2e annual reductions by 2020) will require businesses with refrigerant capacity of more than 50 pounds to tighten up their leak detection and recordkeeping and to fix any leaks within 14 days of detection. The regulation also covers those who install, service, or dispose appliances using high-GWP refrigerant or who sell, distribute or reclaim the refrigerants. Businesses using only ammonia or $CO_2$ are not subject to the rule.

Other regulations impact ports, landfill operators, water utilities, local governments and businesses of many types. Some branch out into other regulatory territories like solid waste, water and energy. For example, ARB looks to work with the state's Integrated Waste Management Board to require commercial recycling by 2020, a strategy that can cut 5 million mtCO2e annually by 2020 in ARB's estimate.

Sorting out who's impacted, how and when—and helping them comply—has already driven business for environmental consulting firms. Consulting firms were also called upon to help entities with emissions above 25,000 mtCO2e verify and report their emissions, as required by AB32 since 2008.

Research by EBI indicates a U.S. climate change consulting market for core services of $780 million in 2009 with almost 20% or about $150 million in California. Of the $224-billion total U.S. clean energy industry, California accounts for over 10% or $27 billion with significantly higher proportions in solar and geothermal energy, electric vehicles and specialty services like consulting; and lower proportions in wind, nuclear and biofuels.

In its early phase of implementation AB32 proved frustrating to some environmental consultants and their clients because rules hadn't been worked out, yet many public and private project applicants and their consultants found they had to account for GHG impacts and develop mitigation strategies. This was driven in large part by the legal strategy of former Attorney General and now Governor Jerry Brown.

In 2007, soon after he was elected attorney general, Brown filed suit against San Bernardino County for failing to evaluate and mitigate the GHG impacts of its new long-term general plan for growth and development (known as a comprehensive plan in most other states). Brown's view was that after AB32 passed in 2006, California's Environmental Quality Act

(CEQA) required such analyses and mitigation, even though analyzing GHG impacts hadn't previously been a requirement under CEQA.

San Bernardino settled with Brown, agreeing to evaluate how land-use and planning decisions affected the community's GHG profile and to develop emission-reduction targets and strategies to meet them. With this settlement in his back pocket, Brown continued to send letters to local governments telling them AB32 required them to consider climate change before issuing permits for large public and private projects and in their own general plans. Environmental stakeholder groups also submitted similar comments, and in some cases filed suits.

One target of Brown and litigants like Earthjustice was the City of Richmond and its CEQA review of a major modification to the Chevron oil refinery complex. In June 2009, a superior court judge struck down the city's Environmental Impact Report for the project in part because the city planned to let Chevron delay its creation of a GHG mitigation plan for a year—despite the fact that the EIR required Chevron to offset any GHG emission increases and provided a list of possible methods for inclusion in the plan.

Staff for the city's environmental consulting firm ESA (San Francisco) said that in the 2006-2007 timeframe in which they developed the EIR, "there wasn't any regulatory guidance regarding what needed to be in a greenhouse gas control plan [to satisfy AB32]," said Tim Morgan, project manager. "The guidance came later but unfortunately was used by the court as the standard for the earlier work." Morgan said the plan to give Chevron up to a year to develop a detailed GHG offset strategy included "an open process with an independent reviewer appointed by the city." In December 2010, a Chevron spokesman wasn't available to comment on the company's intentions for the modification to the Richmond refinery, which processes more than 200,000 barrels of oil daily and is the single largest stationary source of GHG emissions in California, according to ARB data.

**Land Use Planning a Climate Change Issue for Local Government**

With this background, climate change analyses and mitigation plans for major projects and general plans have become essentially mandatory for local governments in California. "They're not a formal requirement yet, but our ex-attorney general and future governor has had pretty good success getting local governments to do them," said Joe O'Bannon, director of air quality and climate change for environmental consulting firm Chambers Group (Santa Ana, Calif.).

O'Bannon says that local governments lack consistent standards or methodologies for doing GHG assessments. "Now climate action plans are all over the map. Five different jurisdictions will do them five different ways," he said.

Many use methodologies provided by ICLEI—Local Governments for Sustainability (formerly the International Council for Local Environmental Initiatives), according to O'Bannon. "ICLEI has proprietary software to help you generate emissions estimates and estimate your reduction potential based on certain known things you can do at the local level like change your fleet to electric vehicles," he said. O'Bannon is a former director of criteria emissions inventories for the Kern County Air Pollution District, and as such he has a dim view of the ICLEI methodology, which he describes as "a black-box inventory and overly general."

O'Bannon said that he recently worked with an innovative planning staffperson at the City of Irvine to devise a parcel-based GHG inventory. The GHG inventory project didn't become the showcase that he had hoped because of budget and time pressures—and the fact that local utilities wouldn't share detailed usage data. So the city produced what O'Bannon called "an enhanced ICLEI" with modifications that "made it much more useable and representative."

For its Climate Action Plan, Irvine worked with Constructive Technologies Group (Irvine) to design a plan with more meat than usual, according to O'Bannon. According to CTG's website, the plan "is based on quantitative analysis, linked to real world data, and designed for implementation. [It] goes beyond simply stating goals to providing rational GHG reduction targets within a comprehensive regulatory framework."

**SB375 Drives Sustainable City Plans With a Focus on Transportation**

As noted above, some of the complementary measures that ARB expects to deliver GHG emission reductions are already codified in state laws and regulations. A key policy is SB375, passed in 2008, which directs ARB to set GHG reduction targets for passenger vehicles in each of California's 18 metropolitan planning regions.

ARB issued draft targets in June, including 5-10% reductions in the state's largest population centers: Southern California (including San Diego, a separate MPO), San Francisco Bay Area and Sacramento area. Now MPOs are preparing their "sustainable communities strategies" to demonstrate how their regions will achieve the reductions through "integrated land use, housing and transportation planning," states ARB's website. As of mid-December, only the San Diego Association of Governments had completed its SCS, according to O'Bannon.

O'Bannon singled out for praise one element of SB375: the potential to exempt transit-oriented development from the full Environmental Impact Report that would usually be required under the California Environmental Quality Act (CEQA), "That has become a great carrot for developers," he said.

**Debate Over What Qualifies for Forestry Offsets Settled**

AB32's forestry offset protocol was a focus of controversy at the air board's December 16, 2010 hearing. After many years in which the pre-compliance California carbon market—under protocols of the California Climate Action Registry—allowed only selectively-harvested forests to qualify for offset projects, the air board adopted its staff recommendations and made even-aged forestry (i.e., periodic clearcutting) an eligible management style.

"The debate has split environmental groups, with the Nature Conservancy backing [the position of timber companies and offset certifiers] that the protocol does not encourage clearcutting," wrote Debra Kahn of ClimateWire. But a spokesman for the Center for Biological Diversity said allowing clearcutting "increase[s] the possibilities for gaming and for the development of nonadditional credits."

Board Chair Mary Nichols responded that "the board's only concern should be whether carbon dioxide emissions would be reduced under the protocol," paraphrased Kahn. "'I was and am extremely sympathetic to the views of people who live in and around the forest and don't like the practice of clearcutting at all, but I think we at this moment are not in a position to craft changes to the protocol that would accomplish our goal in a way that has credibility from the forestry perspective,'" said Nichols.

According to ARB's Steve Cliff, the agency hasn't evaluated any other offset project types or protocols beyond the approved four: forestry management, urban forestry, dairy methane digesters, and the destruction of existing banks of ozone-depleting substances in the United States.

Cliff said the agency will stay mum on that score until and unless it's ready to announce that a new type of project protocol is under serious consideration. Given that California is now the only compliance-driven carbon market in North America (outside of Alberta's quirky internal market;), any advance signals of such deliberations "could really affect the market," said Cliff.

The priority that ARB gives to evaluating new project types will hinge in part on how well the supply of offsets in coming years is balanced with demand. “What we’ll probably do next year is to have a workshop to solicit ideas [on additional offset protocols],” said Cliff.

As noted above, the cap and trade regulation is designed so that California can link with carbon markets in other states or provinces within the Western Climate Initiative, with British Columbia, Ontario and Quebec being the near-term prospects for trading partners. “Efforts are also underway to link the WCI with other regional climate programs, such as the Midwest Greenhouse Gas Reduction Accord and the Regional Greenhouse Gas Initiative which covers the power generation emissions of 10 northeastern states,” stated ARB.

ARB’s cap and trade plan includes the possibility for broader international trade in offsets. “A Memorandum of Understanding has already been signed with Chiapas, Mexico, and Acre, Brazil, at the Governor’s Global Climate Summit 3 to establish these offset programs,” stated ARB in a news release.

ARB’s decision also exempted biomass power plants from emission caps, “under the theory that excess wood should at least be used to generate electricity rather than being burned outright,” wrote Kahn. “Representatives of the biomass industry said the provision wouldn’t lead to additional trees being felled for fuel. ‘There is no facility in California that uses anything other than wood waste from forest projects,’ said California Biomass Energy Alliance spokeswoman Julee Malinowski-Ball.”

If California is indeed to lead U.S. carbon trading in the second decade of the 21st century, at least it appears to have done its homework.

### 15.2.2. Northeast States: Lessons from the Regional Greenhouse Gas Initiative

While the interstate cap and trade program in the Northeast under the Regional Greenhouse Gas Initiative has been largely successful, the region’s leaders have no plans to extend coverage beyond the power sector, according to a range of analysts and stakeholders interviewed by EBI. Instead, state policymakers are focusing on achieving additional reductions through renewable energy—including the possibility of importing more hydroelectricity from Quebec—energy efficiency and a new region-wide fuel economy initiative.

“In the Northeast, we’ve seen policymakers ratchet up energy efficiency, renewable energy and other strategies,” said Liz Hicks, director of sustainable market strategies for energy consulting firm KEMA. “Even New York, which has a state plan with very significant carbon reductions, [aims to achieve those] with a certain percentage of renewable energy and a certain percentage of energy efficiency.”

Massachusetts enacted in 2008 aggressive greenhouse gas (GHG) reduction goals—at least 10%—and as much as 25%—below 1990 levels by 2020. Still, the administration of Governor Deval Patrick isn’t contemplating a cap on sectors beyond electricity generation.

“The principal approach they’re taking is to foster new markets and encourage economic development by investing more in energy efficiency and dramatically ramping up renewable energy deployment, including local and imported renewable energy, both land-based and offshore,” said Sue Reid of the NGO Conservation Law Foundation. “I don’t expect to see a comprehensive cap and trade system across all sectors”

**Political Changes May Affect RGGI**

The November 2010 elections brought new governors to some RGGI states, but the implications for RGGI’s future aren’t clear yet—and won’t be until governors appoint their representatives for RGGI's program review process, which could revise the program rules for the three-year control period to begin January 1, 2012.

"Connecticut is moving to a new governor who is extremely supportive of good climate policy," said Seth Kaplan, also with Conservation Law Foundation (CLF). Kaplan noted that Governor-elect Dan Malloy, a Democrat, won a Climate Change Leadership award in 2008 when he was mayor of Stamford.

"RGGI is a vital source of revenue for energy efficiency projects and programs. The tangible effect of RGGI has been that there are people working who would not otherwise be working."

Governor-elect Malloy supports the regional effort to create a low-carbon fuel standard (see below), but he hasn't given any indication that he wants to extend GHG caps to industries beyond the power sector. And at least one veteran air quality consultant doesn't see the political space for such a move. "The new Democratic governor and legislature [in Connecticut] would have a tough time arguing for putting a new tax on the small amount of manufacturing that's left in this state," said Gale Hofnagle, air quality practice leader for TRC Solutions (Lowell, Mass.).

Maine's Governor-elect Paul LePage, a Tea Party Republican, made statements during the campaign indicating he is a climate change skeptic, and he has criticized plans for sharply increasing wind power because of the technology's higher costs as compared to natural gas and hydropower.

But LePage hasn't mentioned abandoning RGGI and the associated caps on fossil fuel power generators in the state. Given that RGGI is largely noncontroversial—and a source of revenue for the state—there may be no immediate danger from that quarter. Governor Chris Christie of New Jersey has expressed similar views on the science of climate change, but hasn't challenged RGGI's cap and trade regime.

RGGI has raised and distributed \$777.5 million to its 10 member states since 2008. While states are supposed to spend the money on energy efficiency programs, New Jersey, New Hampshire and New York have recently used RGGI revenues to help balance their budgets. This angered some RGGI followers who think it's important that auction revenues be dedicated to energy efficiency. But other observers say that using RGGI money to plug budget holes doesn't diminish the program's value to states.

"States using RGGI money for purposes other than reducing emissions is not a big threat, though we would prefer they use their funds for activities that reduce emissions and benefit energy consumers" " said Jessica Shipley, solutions fellow at the Pew Center on Global Climate Change. "We see that as a sign of the poor economic times and not as a sign that RGGI is failing in any way. RGGI continues to have well-functioning auctions, including the 10th auction in December 2010," said Shipley.

One of the reasons RGGI hasn't drawn more opposition from conservative leaders in the Northeast is because it hasn't visibly raised energy prices. "The RGGI program is completely silent to the voting public," said TRC's Hofnagle. "There hasn't been a murmur of opposition, and most people don't really know it's going on."

"Nobody's utility bill has gone up because the allowance prices are so low," said Kaplan. "It would be a fool's errand to try to figure out what percentage of someone's electric bill is attributable to RGGI since the impact is vanishingly small. Just as the state officials and modelers predicted, the RGGI price impacts are getting lost in the noise of everything else that affects electricity prices, particularly fuel costs."

Indeed, allowance prices have stayed so low—\$1.86 per short ton, the regulated price floor, in the current control period—due to the fact that, like the first phases of the European

Union Emission Trading System, RGGI allocated far more allowances than the regulated entities needed.

Emissions fell 33% from 2005 to 2009 in the RGGI states, resulting in an allowance market with no appreciable scarcity. Indeed, the RGGI allowance market is so long that in its last two auctions, September and December 2010, only 75% and 57% of the allowances offered were purchased.

A RGGI draft white paper attributed the drop in emissions to three factors: "1) lower electricity load (due to weather, energy efficiency programs and customer-sited generation and the economy); 2) fuel-switching from petroleum and coal to natural gas (due to relatively low natural gas prices); and 3) changes in available capacity mix (due to increased nuclear capacity availability and uprates; reduced available coal capacity; increased wind capacity; and increased use of hydro capacity)."

Even at those low auction prices, RGGI did drive some fuel switching, according to the white paper. "The effective price gap between natural gas and coal prices decreased slightly more within the RGGI region [than nationally], due to the requirement to purchase CO2 allowances and the fact that a unit of electricity generated by coal requires nearly twice the CO2 allowances compared to natural gas."

Point Carbon's head North American carbon analyst Emilie Mazzacurati told EBI that the large price spread between RGGI and pre-compliance offsets being traded in California—which have been in the range of $10 to $12 per metric ton with a $10 price floor—was due to differences in the region's power mix.

"It was cheaper to reduce emissions in RGGI because generators had the ability to switch from coal or oil to natural gas power plants more easily than in California which has a lot of renewable energy and less opportunities to reduce emissions," said Mazzacurati.

## 15.3. Guide to Understanding Carbon Markets

Entering the world of carbon markets means familiarizing yourself with a bewildering array of terms and acronyms, particularly with regard to credits and offsets and the regulatory or voluntary schemes under which these carbon "instruments" or "assets" are traded. We use "credit" as a generic term to stand for the carbon units traded on the regulatory markets, and "offset" to stand for the units exchanged on the voluntary markets. Specific markets have their own specialized terms, as shown below. Regardless of whether you're talking about allowances, credits or offsets, the generally accepted unit is one ton of carbon dioxide equivalent (tCO2e) per instrument. The Chicago Climate Exchange (CCX) is an exception; each Carbon Financial Instruments (CFI) unit equals 100 tCO2e trade (prices are still expressed in dollars per tCO2e). The two basic types of markets are regulatory, like the European Union's Emissions Trading System (EU ETS) or other emerging national cap-and-trade markets designed to meet Kyoto Protocol obligations, and voluntary markets, which encompass any transaction designed to help an entity reduce its carbon footprint for other reasons.

Another dichotomy to be aware of is the distinction between allowance-based transactions and project-based transactions. Under the EU ETS, for example, the governments of the EU nations are in the process of allocating annual allowances to more than 11,500 facilities in several regulated industries. As in any cap-and-trade scheme, a company that is able to reduce its greenhouse gas (GHG) emissions to a level below its cap—i.e., its annual allocation of allowances—effectively generates a credit for each unused allowance and can sell those credits to regulated entities that are unable to keep their GHG emissions within their cap. These are allowance-based transactions and are exclusively creatures of the regulated carbon markets.

Regulated entities, either in the EU ETS or national schemes, that must purchase credits to meet their obligations have the option to purchase a limited number of these credits from projects undertaken under the Kyoto Protocol's Clean Development Mechanism (CDM) and Joint Implementation (JI) provisions. The CDM Executive Board has developed numerous methodologies for verifying emissions reductions and the associated credits, methodologies that are being emulated by providers of offsets for the voluntary markets. Project-based transactions can take place in both regulatory markets and voluntary markets. In fact, voluntary markets essentially comprise project-based activity.

COMMONLY USED ACRONYMS:

AAU = Assigned Amount Units. The allowances (one allowance = 1 tCO2e) issued to Annex I parties to the Kyoto Protocol, corresponding to the quantity of GHGs that these parties may emit in accordance with treaty obligations.

CER = Certified Emission Reduction. The carbon unit (1 tCO2e) generated for trade by projects designed to meet Kyoto Protocol obligations through CDM project-based transactions between entities in Annex I nations (industrialized countries) and entities in developing nations.

CFI = Carbon Financial Instrument. The CCX unit of trade (100 tCO2e).

ERPA = Emission Reductions Purchase Agreement. Any agreement involving the purchase and sale of emission-reduction credits or offsets.

ERU = European Allowance Unit. The carbon unit (1 tCO2e) generated for trade by projects designed to meet Kyoto Protocol obligations through JI project-based transactions between Annex I nations.

EUA = European Union Allowances. Allowance (1 tCO2e) used under EU ETS.

NGAC = New South Wales Greenhouse Abatement Certificate. The unit (1 tCO2e) of trade used in the New South Wales Greenhouse Gas Abatement Scheme in Australia, which has been operational since January 1, 2003.

VER = Verified Emission Reduction, or Voluntary Emission Reduction. The generally accepted terms for the unit of trade for offsets on voluntary markets.

## 15.4. Carbon Market Companies

Asked how his firm makes sense of the kaleidoscope of players and their roles in the global carbon market, Craig Ebert, executive vice president of leading climate change consulting firm ICF International (Fairfax, Va.), acknowledged that imposing order on the chaos can be challenging. "The market is indeed rather fractured. There are several key types of market players on the demand and supply sides of the voluntary market, each with different motivations and roles." On the supply side of the market, Ebert identified six major classes of market participant. "Some players may play more than one role," he stressed. Hundreds of such companies exist, and perhaps thousands (including lots of tiny "bit" players), with a few dozen at the top, as in any industry.

• Project developers "oversee all aspects of identifying and completing carbon offset projects. They seek out project opportunities, ensure projects are carried out to any applicable standards, arrange financing, and seek buyers for the generated offsets directly in the retail market or through brokers, exchanges, or aggregators."

• Aggregators "pool carbon offsets across multiple projects to sell them on to retail or other secondary buyers. By aggregating across projects, it is possible to reduce the risk of delivery across a more diverse portfolio. Aggregators include both companies and NGOs."

• Brokers "serve as intermediaries in offset transactions, typically for business-to-business deals."

• Exchanges "offer a platform for trading offsets in an open marketplace."

• Registries "record carbon emissions or emission reductions in a central and standardized carbon registry."

• Verifiers "audit offset projects to verify that they have been completed, meet necessary standards, and have calculated the achieved emissions reductions correctly."

*On the demand side of the market, Ebert identified four principal types of player*:

• Companies "may sponsor specific projects, participate directly on exchanges, or pay into offset schemes through project developers, aggregators, or brokers."

• Governments "have similar options for participating in the offset market, though there may be additional requirements regulating spending of public monies."

• NGOs "have also taken an interest in the offset market, with a similar path to market as companies and governments."

• Consumers "generally cannot participate on exchanges or through brokers, but rely on a packaged retail offset product supplied by a developer or aggregator."

According to Evolution Markets, there has been some consolidation in the population of brokers, aggregators, and others along the value chain of facilitating offset deals: "We've seen some brokers and trading partners go away, because banks are more conservative." Evolution Markets added, "there are some brokers that are broker/dealers, buying for their own position, and that sometimes runs contrary to the interests of customers."

The brokers that didn't make it are the ones that didn't add value, and "as the times get tight, the chaff gets shaken off, and we're seeing that right now," Evolution Markets noted. "There's a core of knowledgeable individuals and groups that are doing just fine, and can see where things are going. They are bullish and are focused on being prepared." The continued interest in the U.S. market by European financial traders is evidence of the general long-term outlook.

Summing up the impact of the current economic turmoil, Evolution Markets said that "the central thing to understand is that people will be tentative with money right now, but that doesn't mean that they aren't bullish about their expectations for a carbon program. You can be bullish about the program, even though you haven't got the money to spend right now. It's not an if, it's a when. In the mean time, we have RGGI in place, California kicking in, and other programs coming. The question is, where to put the price on the tons. They'll take a look at what's happening overseas as an indicator."

CarbonNeutral's Braun is comparably positive despite acknowledging that there is cause for concern. "I don't have my head in the sand. The economy is frightening, and not just from my parochial business position. But if I had to identify a segment that's going to gain attention and importance in the new economy, carbon management has to be on that list. I'm personally energized by a segment that has business value and will continue to do so over the years. The question is, how long will this turnaround take?" Whether it's a year or two or more, the core survivors that continue to build their core competency in carbon markets, in addition to their client relationships, will be well served by the thinning out period.

## 15.5. Forestry Offsets

With approximately 751 million acres of forests, 442 million acres of cropland and 587 million acres of range and grassland, the United States has vast market potential as a global supplier of agricultural and forestry-based carbon offsets.

Aldyen Donnelly of Canada's **Greenhouse Emissions Management Consortium** has studied the U.S. agriculture and forestry sectors as likely suppliers of offsets to GEMCO members—energy companies with large emission profiles, such as Saskpower, a Saskatchewan utility with 3,200 megawatts (MW) capacity in coal, natural gas and hydro power, and TransCanada, a gas pipeline operator and electricity generator. Donnelly estimates that with the right price signals from a greenhouse gas regulatory scheme, the United States could generate 350 million tons of ag and forestry credits annually. David Miller, director of research & commodity services for the Iowa Farm Bureau Federation, the largest aggregator of ag-based carbon offsets in the United States, has a somewhat lower maximum forecast: 200 million tons annually.

In the current voluntary market, such large quantities and revenues seem almost a fantasy. In its first four years, the **Chicago Climate Exchange** (CCX) had booked by December 2007 sales of just 626,000 tons worth of forestry offsets from three projects, three in the United States, one in Brazil and one in Costa Rica. Few large forestry transactions have been executed in the over-the-counter market. Buyer confidence is hampered by the fact that the actual forestry offset commodity is not standardized, and potential purchasers must either perform extensive due diligence to assure they're buying valid offsets or trust the claims of sellers and aggregators. "Demand is low right now because people are reluctant to buy. They're not confident in the market," said Joel Levin, vice president of business development for the California Climate Action Registry, an NGO established by the California legislature to register greenhouse gas emissions and offset projects.

Landowners are also reluctant to supply forest carbon sequestration services given the current prices—$2 to $3 per ton in the fourth quarter of 2007—for carbon offsets on the CCX. "When you consider that a good, well-managed, growing forest may only [sequester] a ton or a ton and half a year [per acre], you're looking at $4 to $6," revenue per acre, or $1.6 to $2.4 per hectare, said Neil Sampson, a consultant to forest landowners and the Regional Greenhouse Gas Initiative in the Northeast United States. "Half of that goes into costs [for project design and verification]."

The market for agriculture-based offsets—in which farmers sequester additional soil carbon by shifting to conservation tillage methods (thereby retaining more soil carbon than they would under business as usual tillage methods) or capture methane emissions from animal feeding operations—is slightly more mature. By December 2007, CCX had booked 9.16 million tons worth of offset trades in these categories, of which 8.74 million tons were soil carbon projects.

But the voluntary market for ag and forestry offsets in the United States is entering a growth phase. Major emitters are purchasing or making plans to purchase growing quantities of offsets—including those generated by ag and forestry projects. Many are doing so to prepare to meet their likely requirements under the Regional Greenhouse Gas Initiative (RGGI), California's AB32 greenhouse gas cap legislation, or a future U.S. federal greenhouse gas cap.

**Some recent examples:**

• The nonprofit Climate Trust and environmental consultancy M.J. Bradley & Associates have solicited bids for up to 9.5 million tons of offsets, including ag methane and forestry projects (along with energy efficiency, landfill gas and SF6 projects). The final buyers are five investor-owned utilities and electricity and natural gas suppliers that, combined, have more than $60 billion in annual revenues. Four operate in the Northeast—Conectiv Energy Supply, Dominion Resources Services, NRG Energy and Public Service Enterprise Group.—where they will be subject to caps imposed by the Regional Greenhouse Gas Initiative (RGGI). The Climate Trust's RFP states that some of these entities are "especially interested" in forestry management projects within RGGI's boundaries. (The fifth buyer, Entergy Corp., operates in Arkansas, Texas, Louisiana and Mississippi.)

• In California, the large investor-owned utility Pacific Gas & Electric Co. has embarked on a major effort to purchase offsets, and it is only considering ag and forestry offsets. "The goal of the program is to invest in 2 million tons by the end of 2009," said Robert Parkhurst, ClimateSmart manager for PG&E. The utility focused on ag and forestry because those are the only two offset project protocols issued thus far by CCAR. It expects to pay an average price of $9.71 per ton, a price set by reviewing carbon market data provided by Ecosystem Marketplace and other sources. The program is funded by customers who opt to pay $.0025 per kWh and $.065 per thermo of natural gas to offset their carbon emissions.

### Standards, Protocols Firming Up in California

In California and elsewhere, standards and protocols for ag and forestry offsets are firming up, giving buyers more confidence. RGGI has adopted protocols for ag methane offsets and is in the process of developing them for forestry offsets. CCX has adopted protocols for several types of forest-offset projects. But California is clearly way ahead of the pack. Established by the state legislature in 2002, California Climate Action Registry (CCAR) at first developed protocols focused only on registering emissions, not quantifying reductions achieved through offset projects. Forestry and ag methane are its first offset protocols, but the registry is working on additional project protocols for landfill methane, urban forestry, natural gas transmission and distribution, truck stop electrification and fleet energy efficiency.

Levin of CCAR says the rigor of the registry's protocols and certification programs have inspired confidence, and he predicts that other large emitters will soon join PG&E in using project protocols to verify and quantify offset values. "When we have our [offset] registry operational and there are tons in it, people will have confidence in the fact that the projects are real and additional," said Levin. "They'll know [the offset tons] will not have been double counted because we'll be assigning a serial number to every ton. We're assuming that this is going to drive the market. There are a lot of people sitting on the sidelines that will become a lot more interested in it."

Levin and others have noted that PG&E's per ton price is about double the peak prices for carbon traded on CCX. They consider this a tacit acknowledgement of the lower risks and greater standardization offered by a CCAR-registered offset. "I think CCX has played a valuable role [but] CCX emerged in a voluntary arena," said Wayburn of **Pacific Forest Trust**. The San Francisco-based nonprofit has completed two high-profile forestry deals to offset the travel-generated carbon emissions of California Governor Arnold Schwarzenegger and a U.S. House of Representatives delegation led by Speaker Nancy Pelosi. "The California system was developed in anticipation of a regulatory framework emerging. To get these voluntary carbon emission reductions to work in a future regulated market, which I think we all can see happening, the voluntary projects have to be constructed with the same rigor as they would under a regulated system. That's what California has been doing."

Just as California has done with air quality laws, the CCAR offset protocols have become something of a benchmark for other states. Sean Clark, director of Offset Programs for The Climate Trust, told EBI that future offset proposal requests will advise bidders to use CCAR protocols.

But soon, California's ag and forestry protocols—not to mention its protocols for other offsets—may become incorporated into protocols to be developed by the newest and largest North American climate registry. The Climate Registry is a consortium of 39 U.S. states—all but Arkansas, Indiana, Kentucky, Louisiana, Nebraska, South Dakota, North Dakota, Texas and West

Virginia—the Canadian provinces of British Columbia, Manitoba, Quebec and Saskatchewan, the Mexican states of Sonora and Tamaulipas, and several American Indian tribes. The registry, incorporated in March 2007, is drafting registration protocols and expects to begin registering emissions inventories in January 2008. This will be followed by development of offset protocols, although the timing of those is not clear.

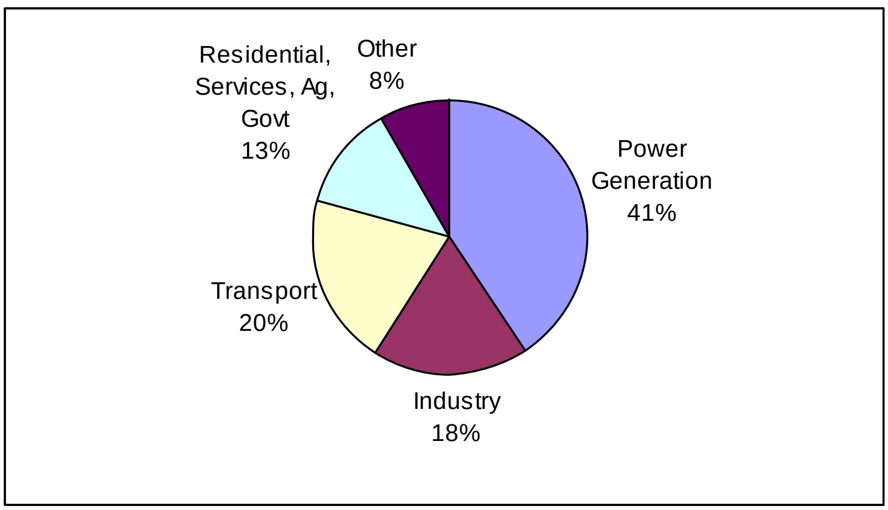
CCAR heavily supported the formation of The Climate Registry after it became apparent that regional efforts envisioned by the RGGI states and others could create more confusion and uncertainty in the offset market. A registry with national scope can develop one set of protocols and accounting standards and be a model for the federal registry that will likely emerge from legislation to impose emission caps on large emitters. "Since the California registry has been in business, we've always recognized that there is a limit to how far one state can go," said Levin.

## 15.6. Emissions Data

The pie chart below illustrates the source of CO2 emissions by major sector, indicating both the dominant role of power generation but also the likelihood that no group of major emitters can be left out of a regulatory equation. Europe's carbon trading system covers just the largest stationary emitters in power and industry, but it and other programs are busy with the details of adding transport, aviation, structures and even citizens in the future.

Keeping the engine of the global economy going will remain paramount for policymakers, but keeping people moving and their built environments hospitable contributes as much or more carbon to the atmosphere. Solutions will most likely be incremental improvements in power generation, transport and buildings, but each major sector has its revolutionary concepts and innovative projects that indicate the transition to a low-carbon future won't be strictly evolutionary.

**Figure 252 Global CO2 Emissions (% of total)**




*Source: International Energy Agency*

**Figure 253 Global CO2 Emissions in 2004 (metric tons of CO2)**

| Segment | 2004 |
|---|---|
| Power Generation | 10,587 |
| Industry | 4,742 |
| Transport | 5,289 |
| Residential, Services, Ag, Govt | 3,297 |
| Other | 2,165 |
| **Total** | **26,080** |

*Source: International Energy Agency*

**Figure 254 Total Greenhouse Gas Emissions By Region**

| Country | Share in GHG 2005 | Share CO2 2005 | Share CO2 2009 |
|---|---|---|---|
| China | 17% | 20% | 26% |
| USA | 15% | 20% | 17% |
| EU-27 | 11% | 14% | 12% |
| Russia | 5% | 6% | 5% |
| India | 5% | 4% | 5% |
| Japan | 3% | 5% | 4% |

*Source: International Energy Agency*

**Figure 255 Total Greenhouse Gas Emissions By Region (Mt CO2e)**

| Region | 2000 |
|---|---|
| United States | 5,800 |
| United Kingdom | 537 |
| Other OECD | 6,574 |
| Middle East | 1,183 |
| Former USSR | 2,313 |
| Non-OECD Europe | 265 |
| China | 4,769 |
| Asia | 2,499 |
| Latin America | 907 |
| Africa | 814 |
| **Total** | **25,661** |

*Source: International Energy Agency*

# 16. Climate Change Adaptation

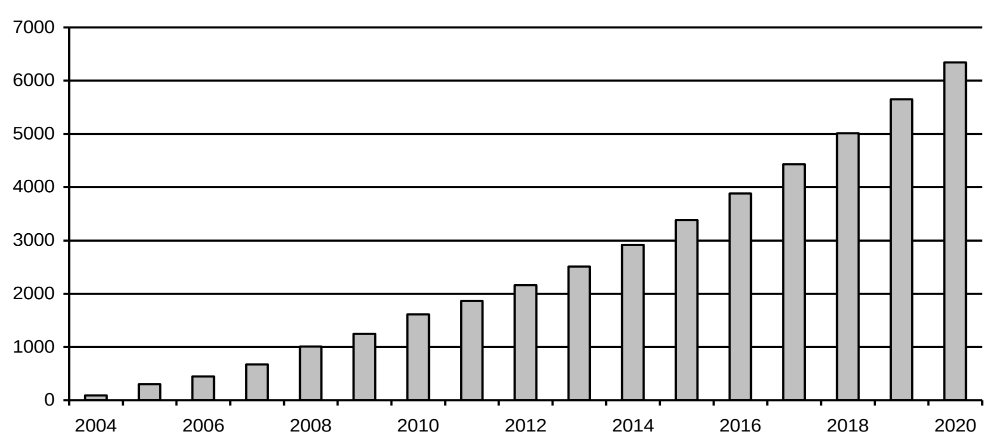
Policymakers have rightfully focused on greenhouse gas emission reductions, but even under the most favorable mitigation scenarios, the impacts of climate change will force communities, governments and businesses to adapt to their surroundings.

The U.S. climate change adaptation industry is just emerging, led by consulting & engineering firms doing assessment and planning work. EBI estimates that adaptation will grow to a billion-dollar industry in the United States by 2015, followed by exponential growth once design and construction of adaptation measures begin in earnest.

Globally, EBI expects the climate change adaptation industry to reach $6-7 billion by 2020. The market is estimated in the neighborhood or half a billion dollars in 2008 in both dedicated projects (mostly assessments and scenario planning) and portions of existing construction projects in water resources and distribution and many projects in low-lying areas.

While the December 2009 climate change meetings in Copenhagen failed to produce an agreement of any substance, it did provide some added impetus for climate change adaptation. Most acknowledged that Copenhagen precipitated the involvement of the United States and a number of developing nations, notably China, in the global discussion overall and that national policies are now under new pressure to deliver meaningful programs. Significantly some observers noted that the involvement of developing nations changed from an emphasis on resisting emissions reductions targets for their nations to positioning for funding for both adaptation and mitigation.

**Figure 256 Projected Size of the Global Climate Change Adaptation Industry 2004-2020 $mil**




*Source: EBI Inc. Adaptation industry model derived from CCBJ interviews with project sponsor, project mangers and academics*

One review of the meeting characterized these outcomes:

• Boost climate funds from $10 billion a year to $100 billion a year. Developed countries committed to provide new and additional funding "approaching $30 billion" for the three years from 2010 to 2012. The funds are intended to be balanced between spending on adaptation and mitigation projects. There is a further commitment to "mobilise" $100 billion a year by 2020, from national government, multilateral and private sources, to support climate change projects in developing countries.

• Establish the Copenhagen Green Climate Fund. This fund will be an operating entity of the financial mechanism of the UNFCCC. The mission of the Climate Fund is to support projects and policies in developing countries covering REDD, adaptation, capacity building, technology development and transfer.

• Create a Technology Mechanism to enhance technology transfer. The technology mechanism will be designed to accelerate the development and transfer of technologies to reduce GHG emissions and to help developing countries with their climate change adaptation efforts. Further details will be negotiated by the UN's working groups.

EBI estimates markets in five distinct subcategories of the climate change adaptation industry as listed below. As of early 2010, a number of dedicated projects are identifiable in the first two areas (Assessment & Analysis and Planning) but only a few in Design, Engineering & Construction. In equipment areas, analytical equipment and systems like LIDAR (see review below) already constitute a defined market, although much of the equipment does have multiple applications so cannot all be counted in the climate change adaptation industry.

**Figure 257 Segments of the Climate Change Adaptation Industry**

| |
|---|
| **Consulting & Engineering** |
| Assessment & Analysis |
| Planning |
| Design, Engineering & Construction |
| **Equipment & Systems** |
| Analytical & Information Systems |
| Construction Materials & Supplies |

**Figure 258 Global Climate Change Adaptation Industry (Est. 2010)**

| | **2010** |
|---|---|
| **Consulting & Engineering** | |
| Assessment & Analysis | 328 |
| Planning | 233 |
| Design, Engineering & Construction* | 450 |
| **Equipment & Systems** | |
| Analytical & Information Systems | 300 |
| Construction Materials & Supplies | 300 |
| **Total** | **1611** |
| Growth | 29% |

*Source: EBI climate change adaptation industry model in $mil; *Note: Project revenue is estimated in both dedicated projects (mostly assessments and scenario planning) and portions of existing construction projects*

## 16.1. Climate Change Adaptation Market

The climate change adaptation industry is just beginning to take shape in the United States, lead mostly by the federal government. The Environmental Protection Agency (EPA) has made grants to managers of vulnerable estuaries and published guidebooks on dealing with extreme heat events and adapting water and wastewater systems. The Department of Interior, National Oceanic and Atmospheric Administration and National Aeronautics and Space Agency have begun to fund research to downscale climate change maps for use by river basin managers and communities. The U.S. Department of Agriculture is beginning to fund research on how climate will affect farming. And the U.S. Geological Survey recently announced grant funding for three-dimensional mapping of highly vulnerable coastal areas.

Although some federal agencies are beginning to provide funding and technical assistance, the federal government has yet to take up climate change adaptation with adequate urgency—especially when the costs of adaptation are compared to the costs of inaction. While definitive cost estimates for the country are lacking, an analysis by Next10, a California think tank, estimated that without adaptation strategies, the state will incur tens of billions of dollars of direct costs every year and that trillions of dollars of assets will be subject to collateral risk.

"If you compare the money being spent on the physical and social sciences of climate change with the money we need to prepare the country to adapt to what we already know about climate change, the difference is huge," said Matthias Ruth, director of the Center for Integrative Environmental Research, which has performed economic analyses of climate change impacts for more than a dozen U.S. states. "Yes, we need to squeeze a little more accuracy out of the climate data and models, but we also need to switch to studying impacts," said Ruth. "Even if we cut emissions to zero today, we'll have climate change for the next hundred years and sea level rise for over a thousand years."

**Figure 259 Climate Change Adaptation Funding and Technical Assistance from Federal Agencies**

| | |
|---|---|
| EPA | Funding for vulnerable estuaries |
| EPA | Guidance for adapting to extreme heat events |
| EPA | Guidance for adapting water/wastewater systems |
| NOAA, NASA | Funding refinement of climate models |
| Dept. of Interior | Refinement of climate models |
| USDA | Research on farm impacts |
| USGS | LIDAR mapping of vulnerable coasts |

Anne Choate, vice president of $700-million consulting firm ICF International (Fairfax, Va.), says her firm has seen attention to adaptation wax and wane over many years of consulting for federal agencies. "Some people felt that if you talked about adaptation, you'd undermine mitigation.… Others said, 'if you talk about adaptation people are going to believe it's real, and we don't believe it's real.'"

California, Florida and other states have released studies on their vulnerability to climate change, but in the current budget climate, funding is rare to non-existent. Survey data from the Pew Research Center doesn't augur well for building political will to spend public dollars on adaptation. Only 35% of U.S. adults surveyed in October 2009 considered global warming a "very serious problem." That percentage was down from past years, probably due to lobbying against cap-and-trade and the cool summer in most of the United States. But even at the peak levels of concern recorded by Pew in 2006, more than half of those surveyed thought climate change was only "somewhat serious" or "not a problem."

Additionally, government officials who consider building or upgrading infrastructure to adapt to climate change face an additional policy conundrum: what climate change projections do they build for? If they're looking at armoring a coastal community, do they pick the low end—7 inches—or the high end—24 inches—of mean sea level rise (SLR) projected by 2050?

Furthermore, local and regional governments lack adequate data and models about how their specific region or resources will be affected. "Getting accurate predictions at the regional level, let alone the water utility level, is a huge challenge," said Ed Means, vice president of consulting engineering firm Malcolm Pirnie. "How do you plan when rainfall levels might go from a 10 percent increase to a 20 percent decrease? How do you rationalize to a board of directors that you need to spend $1 billion, and you might be wrong?"

This lack of clarity about climate impacts is the main reason "civil engineering planning and the resulting infrastructure projects basically do not consider that climate change is happening," said Carol Ellinger Haddock, a manager with the City of Houston Public Works Department and chair of the American Society of Civil Engineers' committee on energy, environment and water. "Within ASCE, we have a small but growing constituency who think civil engineers need to be engaged in dealing with this issue, we have a large silent group, then we have a small loud group saying we shouldn't be involved because predictions ranges from a half-inch of sea level rise to 40 inches so we can't plan for it. Currently most design standards do not incorporate a factor for impacts of climate change."

Public subsidies for other segments of the clean energy industry have upsides that even climate-change doubters can grasp: jobs, energy cost savings, less pollution, more electricity supplies and less reliance on imported fossil fuels. Plus, private parties—from homeowners buying PV systems to investors backing wind farms—pay a large share of the costs of clean-energy investment costs.

It is the public purse almost exclusively that must be tapped to prepare for rising sea levels, increased frequency and intensity of storms, extreme heat events, water resource stress and other impacts. Yes, large corporations are under increasing pressure to disclose their climate risks (see AER profile below), and businesses of many types and sizes will eventually have to invest in a variety of adaptation measures. But governments will be the main responsible parties, just as they are for natural hazards and disasters.

Insurers will also be in the center of the adaptation business. Lindene Patton, Climate Product Officer for Zurich Financial Services Group, characterized Zurich's level of activity in adaptation as "very significant." Patton's group is issuing white papers, sponsoring research and engaging in direct involvement with government policy, but in insurance product development it has broadened flood insurance and property coverage extensions. Beyond the scope of what insurers do, she anticipates lots of work in the engineering field, "heavy infrastructure if publicpolicy makers get it right... water, power, some building construction, both retrofit and new." She also expects a strong need for National Environmental Policy Act (NEPA) and state equivalent work to include GHGs, specifically lots of EIRs or Environmental Impact Reports. Consultants generally share this view but realize patience will be required for a consistent flow of dedicated projects.

**Figure 260 Global Climate Change Adaptation Industry**

| | 2007 | 2008 | 2009 | 2008 Growth | 2009 Growth |
|---|---|---|---|---|---|
| Adaptation Services: Analysis, Modeling, Planning | 0.67 | 1.01 | 1.25 | 50% | 24% |
| Adaptation Construction: Infrastructure, Relocation, Protection | - | - | - | | |
| **Total Adaptation Industry** | 0.67 | 1.01 | 1.25 | 50% | 24% |

*Source: EBI Inc. estimates derived from a variety of sources. Revenues in $ bil*

**Figure 261 U.S. Climate Change Adaptation Industry**

| | 2007 | 2008 | 2009 | 2008 Growth | 2009 Growth |
|---|---|---|---|---|---|
| Adaptation Services: Analysis, Modeling, Planning | 0.22 | 0.34 | 0.42 | 50% | 24% |
| Adaptation Construction: Infrastructure, Relocation, Protection | | | | | |
| **Total Adaptation Industry** | 0.22 | 0.34 | 0.42 | 50% | 24% |

*Source: EBI Inc. estimates derived from a variety of sources. Revenues in $ bil*

**Figure 262 California Climate Change Adaptation Industry**

| | 2007 | 2008 | 2009 | 2008 Growth | 2009 Growth |
|---|---|---|---|---|---|
| Adaptation Services: Analysis, Modeling, Planning | 0.04 | 0.06 | 0.07 | 59% | 31% |
| Adaptation Construction: Infrastructure, Relocation, Protection | | | | | |
| **Total Adaptation Industry** | 0.04 | 0.06 | 0.07 | 59% | 31% |

*Source: EBI Inc. estimates derived from a variety of sources. Revenues in $ bil*

**Figure 263 U.S. and California Adaptation Industry: Employment**

| | USA $bil in 2009 | USA 2009 Jobs | Calif. $bil in 2009 | Calif. 2009 Jobs | % of USA Jobs in Calif. |
|---|---|---|---|---|---|
| Adaptation Services: Analysis, Modeling, Planning | 0.42 | 3,200 | 0.07 | 630 | 19.8% |
| Adaptation Construction: Infrastructure, Relocation, Protection | 0.00 | 0 | 0.00 | | |
| **Total Adaptation Industry** | 0.42 | 3,200 | 0.07 | 630 | 19.8% |

*Source: EBI Inc. estimates derived from a variety of sources. Revenues in $ bil*

The approach that some city, state and federal agency managers and engineers are taking is to build climate-change adaptation into traditional projects. Additional procurement is rarely required to accomplish this because climate change is expected to amplify existing weather-related risk factors like storms, floods, wildfires and droughts. For water resource systems already under stress, concepts like stormwater retention, wastewater recycling, water efficiency measures and desalination are likewise already on the agenda: climate change just makes them more urgent.

For electric power utilities that will see summer peak loads increase with more extreme heat, more investment in the kinds of demand response and energy-efficiency programs that many are already pursuing can mitigate peak load stress. (Hydropower dependent utilities will face additional challenges compensating for expected loss of summer and fall generating capacity as precipitation shifts from snow to rain, especially in the Pacific Northwest.)

In many cases, consulting engineering firms are driving the conversation about climate change adaptation, often in the context of risk management. “Water and wastewater utilities do risk assessment all the time. What will happen if our aging infrastructure collapses? What are our security risks to something like a terrorist attack?” said Kathy Freas, global director for water resource and ecosystem management for $6.5 billion consulting engineering firm CH2M Hill. “Rather than look at climate change separately, which can be very confounding for a water utility, we bring it into the risk assessment process they’re familiar with. We look at the vulnerability of their system to flood events, droughts and other risks, analyze how resilient their system is, what pieces are most at risk and what the specific effects may be.”

Because so much of the work around climate change adaptation is being done in the context of more traditional projects, it is difficult to characterize the climate-change adaptation portion of many contracts and arrive at precise revenue estimates. “I could calculate a number but it would be so fraught with assumptions as to make it meaningless,” said Freas. “Climate change has become so thoroughly integrated into the way we think about the world that we can’t tease those [specific revenues] out very often. If we’re building a wastewater treatment plant on the coast, we’re automatically going to think about sea level rise and storm surges.”

But long-term, the adaptation business will be in the tens of billions annually and will most likely cross the $1 billion mark in the next five or six years, according to EBI estimates. Our initial assessment of climate change adaptation markets identified a small number of funded projects in a variety of settings including government agencies, non-profits, universities as well as a few well-placed consulting & enginering firms. Project work is understandably skewed towards front-end work of analysis, assessments and mapping with planning not out of the picture. The design, engineering and construction of responses or preventive measures will ultimately be the bulk of the market for C&E firms, but this activity is unlikely to take off within a 10-year time frame.

**Figure 264 U.S. Climate Change Adaptation Industry 2008-2009 ($mil)**

| | 2008 | 2009 |
|---|---|---|
| **Consulting & Engineering** | | |
| Assessment & Analysis | 84 | 95 |
| Planning | 52 | 60 |
| Design, Engineering & Construction | 100 | 120 |
| **Equipment & Systems** | | |
| Analytical & Information Systems | 50 | 70 |
| Construction Materials & Supplies | 50 | 70 |
| **Total** | **336** | **415** |
| Growth | 50% | 24% |

*Source: EBI climate change adaptation industry model*

The scope of this latter construction market will conceivably reach into the tens of billions a year. For water resources and wastewater treatment alone, CH2M Hill, the National Association of Clean Water Agencies and the Association of Metropolitan Water Agencies recently estimated costs of between $448 billion and $944 billion to deal with climate impacts through 2050. Those costs don't include the approximately $400 billion in water/wastewater infrastructure costs unrelated to climate change that the EPA has identified for the next 20 years.

These estimates are part of a critical mass building to support adaptation funding. "We've seen an explosion of interest in the last two years," said Joel Smith, principal of environmental firm Stratus Consulting.

For C&E firms looking to develop a climate-change adaptation practice, the choice of what states and regions to focus on should be driven by how much of a priority adaptation has become. Jerry Sparks, head of a new climate change group impacts group at Dewberry, said that the firm opened a new office in Sacramento in part because agencies in California seem poised to take action.

**Figure 265 U.S. Climate Change Adaptation Industry: Project Revenue Estimates**

| Assessment & Analysis<br>Number of contracts | Contract Size Range | Est. Contracts | Avg. Size | Revenues ($mil) |
|---|---|---|---|---|
| 10 to 20 | 2 or 3 million | 15 | 2.5 | 38 |
| 30 to 50 | 500k to 1 mil | 40 | 0.65 | 26 |
| 80 to 100 | 50-500k | 90 | 0.23 | 21 |
| | | | | **85** |
| **Planning** | | | | |
| 5 to 10 | 3 to 5 mil | 7 | 3.5 | 25 |
| 10 to 15 | 1 to 3 mil | 12 | 1.7 | 20 |
| 15 to 20 | 200k to 1imil | 17 | 0.4 | 7 |
| | | | | **52** |

*Source: EBI climate change adaptation industry model; Note: Not all the estimated active projects are being conducted by consulting & engineering firms. Non-profits, agencies, research labs, universities and other academia have also been identified with funded projects*

Often state authorities take the matter more to heart than local governments. In both North Carolina and Florida, consultants said that state government agencies were highly motivated to tackle adaptation planning, while local communities were more indifferent. In Alaska, where melting permafrost is displacing communities and record spring flooding caused a state of emergency this spring, both state and local governments are addressing climate-change impacts.

California is a leader in this regard, and the state published a sobering report in September 2009 showing that sea levels have already risen by as much as seven inches, the state is getting more extreme hot days, fewer cold nights, less precipitation as snow and more frequent and intense wildfires. Likely future scenarios will see more of all these changes, and the state's already stressed water resources will shrink while populations grows.

While the report hasn't galvanized the California's leaders to respond with spending for seawalls and water reuse projects—the state's budget has been eviscerated—many counties, metropolitan planning agencies and water districts are taking climate-change planning seriously. Several adaptation experts cited the San Francisco Bay Conservation and Development Commission and the Metropolitan Water District as entities leading the way.

Environmental consulting & engineering firms and government contractors can likely demonstrate the greatest competency in integrating the multi-faceted issues required to reach consensus among stakeholders in the complex issues surrounding adaptation. Their leadership will be required for both the sake of the business and the citizens and economies under the threat of climate change impacts.

## 16.2. Market Drivers

### 16.2.1. Climate Adaptation Research Needs

- Heat waves and public health: The relationship between temperature, air pollution episodes, and health endpoints, to protect vulnerable subgroups; Changes in atmospheric chemistry that change human pollution exposure; Differential risk to populations vulnerable due to physiological, socioeconomic, or occupational factors.
- Energy supply, demand, and delivery: Availability of energy resources and fuels
- Wildfires: The increased risk of wildfire impacts on natural resources, sensitive species and habitat; The types of human health conditions and priority interventions for sensitive populations
- Sea level rise: Analytical techniques to evaluating coastal storm surge and flooding; Development and evaluation of effective sea level rise adaptation strategies to minimize impacts to coastal development and ecosystems.
- Ecosystem impacts: Development of tools to forecast species' responses to climate change; Identification of critical connections/corridors taking into account alterations due to climate change; Forest management techniques to promote ecosystem health and resiliency; Establishing adaptation measures designed to reduce at-risk species and protect biodiversity.
- Floods and droughts: Prediction of storm events with the potential to generate major regional flooding; Increases in risk of flooding and repeated drought/flooding cycles due to extreme variability in rainfall patterns and more-rapid spring snowmelt.
- Air quality/respiratory health: The relationship between predicted ecological shifts and the potential for increased pollen production.

- Community design and land use: Assessment of how land-use decisions influence the amount of GHGs generated by a community and affect local climate.
- Health behaviors/communication: The policies/incentives that encourage more walking, bicycling, and use of public transportation; Ways to incorporate health impact assessments into land use planning.
- Surveillance: Determining key environmental and health indicators that need to be monitored on an ongoing basis for trends in the effects of climate change on human and ecosystem health.
- Mapping: GIS mapping capability to identify regions and populations most vulnerable to climate change impacts; High resolution mapping in coastal and bay regions to support sea level rise vulnerability assessments and evaluation of adaptation options; Vegetation mapping to track changes in distribution and condition, including pest and disease trends.
- Market development and commerce: Ways to fund and incentivize adaptation mitigation efforts for protecting biodiversity and maintaining ecosystem services; Adaptation measures that promote economic well-being co-benefits.

*Source: 2009 California Climate Adaptation Strategy Discussion Draft report, California Natural Resources Agency (CNRA)*

### 16.2.2. Army Corps Directives for Adaptation Planning

**Incorporating Sea-Level Change Projections into Planning, Engineering Design, Construction, and Operating Projects**

*Note: The following is adapted from a July 2009 U.S. Army Corps of Engineers circular.*

A. Planning, engineering, and designing for sea level change must consider how sensitive and adaptable 1) natural and managed ecosystems and 2) human systems are to climate change... Consider the following two documents:

(1) The Climate Change Science Program (CCSP) Synthesis and Assessment Product 4.1, Coastal Sensitivity to Sea-Level Rise: A Focus on the Mid-Atlantic Region details both how sea-level change affects coastal environments and what needs to be addressed to protect the environment and sustain economic growth. SAP 4.1 represents the most current knowledge on implications of rising sea levels and possible adaptive responses.

(2) The National Research Council's 1987 report Responding to Changes in Sea Level:Engineering Implications recommends a multiple scenario approach to deal with key uncertainties for which no reliable or credible probabilities can be obtained. In the context of USACE planning, multiple scenarios address uncertainty and help us develop better riskinformed alternatives.

B. Planning studies and engineering designs should consider alternatives that are developed and assessed for the entire range of possible future rates of sea-level change. These alternatives will include structural and nonstructural solutions, or a combination of both. Evaluate alternatives using "low," "intermediate," and "high" rates of future sea-level change for both "with" and "without" project conditions. Use the historic rate of sea-level change as the "low" rate. Base "intermediate" and "high" rates on the following:

(1) Estimate the "intermediate" rate of local mean sea-level change using the modified NRC Curve I... Consider both the most recent IPCC projections and modified NRC projections and add those to the local rate of vertical land movement.

(2) Estimate the "high" rate of local sea-level change using the modified NRC Curve III... Consider both the most recent IPCC projections and modified NRC projections and add those to the local rate of vertical land movement. This "high" rate exceeds the upper bounds of IPCC estimates from both 2001 and 2007 to accommodate for the potential rapid loss of ice from Antarctica and Greenland.

C. Determine how sensitive alternative plans and designs are to these rates of future local mean sea-level change, how this sensitivity affects calculated risk, and what design or operations and maintenance measures should be implemented to minimize adverse consequences while maximizing beneficial effects.

*Source: Adapted from a July 2009 U.S. Army Corps of Engineers circular providing guidance incorporating sea-level change entitled Water Resource Policies And Authorities Incorporating Sea-Level Change Considerations In Civil Works Programs*

### 16.2.3. Water Reuse in the Mix in Adaptation

Of all the strategies for dealing with water resource stress, water reuse, also known as water recycling, is perhaps the most controversial. While the concept is widely accepted for non-potable uses such as irrigation, water consumers resist drinking treated wastewater, no matter how much micro-filtration and reverse osmosis it has been through.

But indirect potable reuse—in which highly treated wastewater is channeled to groundwater basins or a reservoir—is definitely on the agenda of water districts whose traditional resources will be stressed by population growth, cyclical droughts and climate change. "I think it's the future, and it will be practiced worldwide," said Gordon Johnson, chief engineer for MWD.

"The concept is that wastewater would be treated to near distilled quality and would then be injected and spread into groundwater basins, then subsequently removed and treated for drinking water," said Johnson, adding that several projects are underway within MWD's service area. MWD is exploring development of a large regional reuse project. "It's in a very conceptual stage," he said.

Other experts agree with Johnson. "The climate change issue will propel reuse in the more arid parts of the country," said Ed Means, vice president of Malcolm Pirnie. "There are already supply shortages in the southwest and Texas and these will be accelerated by climate change."

Limits on discharging wastewater are also driving reuse, particularly in Florida, according to Means. "The environmental constraints and supply constraints are increasing, and the costs of traditional supplies have risen to the point where historically marginal supplies like recycled water are starting to pencil out."

The most advanced reuse project in the country is the Orange County Water District Groundwater Replenishment system, which uses treated wastewater to prevent saltwater intrusion into aquifers and to replenish groundwater that is recovered, treated and used as water supply. The Upper Occoquan Sewage Authority in Virginia is another leading project; it sends highly treated output to the Occoquan Reservoir, a drinking water source for Fairfax County.

As noted by Means, a major driver for reuse is the need to clean up sewage discharge to meet water quality requirements. Brown and Caldwell is working with the City of San Diego and the County Water Authority on a prospective reuse project for which pressure to reduce ocean discharge is a major impetus. “There’s also great interest in water supply augmentation and shifting more to local supplies to adapt to shortages and reduce the energy and greenhouse gas emissions associated with importing water,” said Paulson.

Paulson sees enormous opportunities for reuse in California. “It’s amazing how little wastewater is currently re-used in the state,” she said. Part of the design team for the Orange County system, Paulson believes “the public is not yet ready for full-on direct potable reuse but indirect potable reuse, as practiced in Orange County, is more acceptable. Even traditionally water-rich areas like King County in Washington are looking at this.”

There are some major hurdles in the paths of prospective reuse systems, however. For non-potable irrigation uses, customers are not always available. “There aren’t enough users like golf courses who want to buy that water,” said Paulson. “Also, in many cases, the existing customers are used to receiving reuse water virtually free, so getting new customers to pay for it can be difficult. Another big challenge is delivery: you have to build a dual pipeline system.”

Then there are questions about water ownership. “If a wastewater agency’s plant treats it, they often figure it should be their water,” said Paulson. “Other claims may come from the water utility that produced it before it was used. There may also be downstream users who believe they have a long-term implied water right to that discharge water.”

Finally, the public’s distaste for drinking treated wastewater must be addressed. “There are a lot of emotional factors, and the degree to which people experience fear will depend in large part on how much control and trust they feel,” said Malcolm Pirnie Chief Technology Officer Doug Owen. “The public must feel it has a choice and some control. … You also have to demystify the technology. If it’s hard to understand, people are more likely to be scared by it.... Where it has been successful, the message that water is a finite resource has been successfully conveyed. The public [needs to know that they] can’t enjoy a certain quality of life unless they consider all the water opportunities available to them,” said Owen. “When you can clearly describe the costs for developing new water supplies to the community, then you can get to the point where people will start to listen to technological solutions and how reuse can be part of the water portfolio for non-potable or indirect potable uses.”

**Decentralizing Reuse**

As water visionaries look to more reuse projects, they’re also exploring a concept of decentralized treatment and reuse. More capital intensive, this approach can save energy and cut greenhouse gas emissions. “In current reuse projects, you collect the water at the bottom end of a system and pump it back up to the top,” said Munévar of CH2M Hill. “If you can create a decentralized system that collects and treats wastewater closer to its sources, then use it to recharge groundwater, you can reduce your greenhouse gas emissions significantly.”

“Take an example like Pasadena,” said Brick. “All of Pasadena’s wastewater goes to Whittier Narrows off the San Gabriel River, which is about 400 feet lower in elevation. How do you get that water back? You don’t.... The model that has been used in California and throughout the country has been to develop these massive wastewater treatment facilities where everything is centralized,” said Brick. “If you want to reuse the water, you’d want to have smaller and more decentralized facilities to keep the water in the neighborhood, so to speak.”

For existing recycling programs, Brick says enormous costs are paid in energy dollars and emissions to move water from downstream treatment plants to upstream supply. “If you have a recycling facility for a smaller area you can put the water to use in that immediate area... In the future, there will be more of an emphasis on that sort of approach with smaller treatment plants designed put the treated wastewater to work right in that community.”

Another visionary approach is closed-loop recycling within buildings. “Office buildings are beginning to recycle their grey water onsite for use in toilets and other purposes,” said Brick of MWD. An early example of this approach: green buildings in New York City developed by American Water's Applied Water Management Group, including the Solaire which generates 25,000 gallons of water daily.

**Watershed Thinking**

Brock Dolman reported a tidal shift in attitudes in the professional water and wastewater community. "Various big engineering firms are coming around to this decentralized vision of thinking like a watershed," said Dolman. "A psychological challenge for the engineering community as the can-do-fix folks, is dealing with the fact that in many instances they are having to be primarily involved in undoing the very work of their prior fellow engineers." But Dolman's optimism is also burnished by a long list of local governments and water districts that are implementing a "don't drain, retain" philosophy as he advocates:

• The Sun Valley Watershed Project in which Los Angeles County retrofitted ball fields and parks with underground recharge chambers to increase local water supplies and alleviate flooding;

• The Street Edge Alternatives Program in Seattle in which street drainage systems were designed to mimic nature. According to Dolman, federal requirements to protect salmonid habitat in local streams was the stick that drove the project, while the carrot was enhancing the resilience of the city's water supplies in the face of climate uncertainty exemplified by recent dry spells;

• The Center for Watershed Protection (Ellicott City, Md.) which has produced design guidance manuals that give scientific and technical support for low-impact development;

• Stormwater retention programs in Tucson and Santa Fe that are harvesting rooftop rainfall for water supplies. "Some cities are saying no to any city water being used for residential landscape irrigation – all of it must be caught and stored from your own roof."

"The problems of flood control, wastewater treatment and water supply used to be thought of as independent and thus were dealt with by balkanized and fragmented bureaucracies that did not play well together," said Dolman. "Now astute planners are seeing that these elements can come together with land-use general plans, landscape maintenance, green building, urban forestry, urban agriculture green schools, eco-literacy and other concepts. It's about battening down the hatches of our local living lifeboats called watersheds."

**Figure 266 Impact of Sea Level Rise on Ocean and Coastal Resources**

- Increased Risks of Coastal Flooding in Low-Lying Areas
- More People and Assets – At Risk
- Public Infrastructure – Increased Risk of Inundation
- Levees and Structures – Require Retrofit
- Coastal Wetlands – Potential Loss
- Increased Erosion of Beaches, Cliffs and Dunes
- Private Property and Structures – At Risk
- Beach Recreation and Tourism – May Decrease in Select Areas
- Greater Expenditures for Beach Maintenance
- Increased Saltwater Intrusion into Coastal Groundwater Resources
- Agricultural Land – Degraded by Saltwater

*Source: 2009 California Climate Adaptation Strategy Discussion Draft report, California Natural Resources Agency (CNRA)*

## 16.3. Utility Profile: Metropolitan Water District

**Southern California**

To get water for their desert communities, Southern California water utilities began more than 100 years ago building audacious public works projects to exploit distant resources—sometimes at great ecological costs to the affected rivers and watersheds. The most notorious "water grab" was the diversion of water from California's Owens Valley, chronicled loosely in the 1974 Roman Polanski film Chinatown.

The region's largest water utility, Metropolitan Water District, wasn't involved in that project, but the MWD's first big project—the Colorado River Aqueduct—was funded through a hardball 1932 political campaign in which local governments and boosters produced a movie entitled "Thirst" and delivered pamphlets with every milk bottle on election day. Within 15 years, the $220 million, 240-mile aqueduct was complete, bringing water to fuel Southern California's extraordinary growth.

Over the ensuing decades, MWD built more aqueducts and reservoirs to store imported water, and most recently it concluded a complex and contentious deal to buy more Colorado River water from a nearby irrigation district.

But today's MWD is not your grandfather's water imperialist. In California's 1987-1992 drought, it started funding water-efficiency upgrades for consumers; today MWD estimates that 1 million acre feet per year of its 2.5 million acre feet of annual sales are supplied by conservation.

A water wholesaler jointly controlled by 26 cities and water districts, MWD subsidizes water reuse and groundwater replenishment projects, and stores up to 4 million acre feet in groundwater deals with nearby water districts.

As Southern California contemplates a future of greater water stress brought on by climate change, MWD is a leader in preparing for that future. "We've always had to deal with climate variations and differences between rainy years and dry years," said MWD Chairman Tim Brick. "But the element of climate change introduces a quantum difference in our planning requirements. In the past, we've largely looked at the last 100 years and the patterns of supply and rainfall as a model for development."

Realizing that climate change would push hydrologic cycles outside of the last century's norms, MWD scientists reviewed data going further back in time and discovered, according to Brick, that "the last 100 years was actually a fairly wet period of time. So we needed to recalibrate our models for that awareness, as well as incorporating new layers for climate change."

Brick says MWD's planning would benefit from more research on climate change's likely impacts. "The models are pretty general, and they need to be refined to deal with specific watersheds and river basins," he said. "We're pushing for such refinement, and there is good work being done by NOAA and a lot of academic institutions. The Department of Interior recently announced that they've initiated three contracts for an extensive look at the Colorado River and two other water basins."

Projections so far are "pretty scary," said Brick. "Most experts predict a 10 percent to 20 percent reduction in Colorado River flows over the next 40 years." (Some of the most horrifying projections have been retracted, including a 50-percent probability estimate that Hoover Dam would be empty by 2021, according to Brick.)

Another commonly agreed upon prediction is that snowpack in the Sierra Nevada range will decline, sharply reducing the amount of water the district and other California water users can expect to import from the Sacramento-San Joaquin river system. "In the past, we'd thought that seven years out of 10, we'd be able to bring water south and store it. Now the model shows three years out of 10," said MWD Chief Engineer Gordon Johnson.

**A Future of Water Limits**

"We no longer anticipate that imported water will provide supplies for future growth," said Brick. "We expect to develop water locally through more conservation and efficiency, cooperative transfer programs with agriculture, recycling and some role for desalination."

"Looking to the next 20 years, we expect that conservation alone will probably produce an additional 400,000 to 500,000 acre-feet per year," said Brick, noting that MWD worked with Natural Resources Defense Council and other advocates to secure legislation committing the state to reducing per capita water usage by 20% by 2020; In November 2009, Governor Schwarzenegger signed the bill. Critics note that it exempts agricultural users. "There are some standards in the bill with regard to development of appropriate conservation steps for agriculture as well, although it is primarily focused on urban water districts," said Brick.

MWD is exploring a partnership with the Los Angeles County Sanitation Department to develop a major water recycling project, according to Brick. He added that recent policy changes by the state's Water Resources Control Board will make it somewhat easier for water agencies to develop new projects for water recycling, also known as water reuse.

Like most such projects, however, the new potential supplies from a project with the sanitation department will be limited to non-potable uses, primarily irrigation. One pioneering Southern California water reuse project—Orange County Water District's Groundwater Replenishment System—uses treated wastewater to recharge groundwater basins for indirect potable reuse, but health regulations and public resistance make such projects very difficult (see preceding MWD profile.)

"We're not talking about indirect potable reuse yet," said Brick. "That's not on the immediate horizon, although I understand that the City of Los Angeles does have [direct potable reuse] in its master plan for 15 to 20 years out."

Los Angeles, the largest MWD member in terms of population, is also focusing on conservation and recycling; and the city has adopted tough retention requirements for new developments, a change that will help recharge groundwater and avoid pollution issues from runoff. "The city now requires that new developments of more than an acre have the ability to absorb a three-quarter inch rainfall in 24 hours," said Brick. "If they don't do that, they have to have a treatment facility for the runoff."

An emblem of the city's perspective is its decision to abandon a proposed desalination plant, according to Brick. "They think other steps need to be taken first, with particular emphasis on conservation and recycling of water."

**More Desal on the Horizon**

MWD's perspective is that desal will be needed in Southern California to cope with reduced imports occasioned by both anthropogenic climate change and the natural return of drier weather cycles. The district began exploring desal at the turn of the century, then developed agreements with five member agencies to pursue joint projects. Costly, controversial and energy intensive, most of the proposed projects are several years away from breaking ground, according to Brick. Only the Carlsbad Desalination Project, a joint venture of the City of Carlsbad and Poseidon Resources (Stamford, Ct.) is on the short-term horizon.

According to the Carlsbad project website, construction began in November 2009, with the developers expecting to start delivering 50 million gallons per day (about 56,000 acre feet per year) to Northern San Diego County water users by 2012.

To stimulate other desal developments, MWD is discussing providing member agencies with a subsidy akin to its support for conservation and recycling projects; such projects have been paid up to $250 per acre foot for the water they produce.

**Retaining Water Locally**

Brick predicts that throughout Southern California there will be a "be a renewed emphasis on local supplies and retention of water locally." A longtime advocate of progressive water policy, Brick spearheaded an ambitious project to restore major sections of the Arroyo Seco, home of the Rose Bowl and a major tributary to the Los Angeles River.

The valley's stream—a trickle in summer and fall, but a torrent during heavy rains—was channelized in concrete decades ago. "In the old days, people didn't understand how much that water resource was worth," said Brick. "The idea was to sweep it to the ocean as quickly as possible, which meant that the community lost the water value and ended up polluting the ocean with the kind of gunk and street runoff that accumulates in such flood channels."

With restoration programs and creation of a meandering side channel, the stream supports native fish and wildlife, functions as a natural amenity—and does a better job recharging local groundwater. Brick says climate change—as well as water quality laws—will induce more local governments in Southern California to similarly restore their channelized streams.

"Urban development has diminished the ability of nature to absorb water and keep it for future use," he said. "Future planning will hopefully look at it in different ways, with methods such as small-scale onsite retention of rainfall as Los Angeles is requiring. This allows rainwater to slowly seep into groundwater basins."

With climate change affecting snowpack throughout the West, Brick says Southern California must rely more on its own surface and groundwater—currently supplying about 30% to 40% of resources. "A lot of it needs to be designed into buildings and landscaping," he said. "Stormwater ought to be a major water source for Southern California."

## 16.4. Technology Tool: LIDAR

As noted in the previous Coastal Cities discussion, state and local governments want more accurate three-dimensional maps of their coastal terrain to plan for climate change, and the best technology for acquiring such data is known as LIDAR, or light detection and ranging. "Everybody seems to want it," said Greg Snyder, LIDAR program development manager for the U.S. Geological Survey.

LIDAR devices are laser scanners paired with global positioning and inertial navigation systems that can be mounted on a tripod or a mobile platform such as a car, boat or airplane. The scanners emit up to 200,000 beams per second, generating hundreds of millions of three-dimensional points in a scanning period. Combined with sophisticated back-end software, the systems can produce highly accurate digital elevation models (DEMs) that show bare ground and digital surface models (DSM) that show trees, buildings and everything that's on the landscape.

"For climate change adaptation, LIDAR can develop extremely accurate elevation data so one can model various sea level rise scenarios in terms of inundation from floods and storm surges," said Snyder. LIDAR is used for many purposes, from measuring forest biomass to creating as-built surveys of project sites for engineering drawings. For many such applications, tripod-mounted LIDAR is sufficient, and many engineering firms have in-house capabilities.

To create accurate DEMs and DSMs, airborne LIDAR is the technology of choice, although vehicle-mounted mobile LIDAR technology is advancing rapidly and can complement airborne LIDAR for some topographic conditions, according to Richard Vincent, general manager, laser imaging division, of the geospatial mapping firm Sanborn (Colorado Springs, Colo.).

"Airborne combined with a mobile laser can provide the data for engineering analysis and mitigation, plus the emergency response information, such as what roads will not be closed by flooding," said Vincent. Sanborn owns its own single and dual-engine turboprop planes, which it seeks to deploy eight to nine months per year depending on weather, according to Vincent. Crews of two—pilot and operator—average four hour missions twice a day, although some contracts call for 24-hour-a-day operation. Costs vary based on job size, distance from the airports at which Sanborn's planes are based, accuracy and density of the data required. "The average for what's called a FEMA product which will meet FEMA requirements can range from about $150 to $200-plus per square mile," said Vincent, depending on project specifications.

**LIDAR Suppliers**

With 20 to 30 airborne LIDAR providers in the United States, the business is competitive, keeping prices reasonable, in Vincent's view. He ranks his firm along with Fugro Earthdata and Photo Science as among the top three to five U.S. firms "in terms of assets, number of aircraft, sensors, staff and number of square miles of information collected and processed." (3001, acquired by Northrop Grumman in 2008 for $92 million, is another top LIDAR provider.) Vincent estimated that the geospatial mapping industry in North America (which includes technology other than LIDAR) is earning close to $600 million in annual revenues.

Snyder mentioned equipment manufacturers Leica of Switzerland, Riegl of Austria, Optech of Canada, as well as software developers Terrasolid of Finland, and U.S. firms GeoCue and QCoherent as other firms that support LIDAR acquisition and data delivery. The business is capital intensive: along with planes, firms need LIDAR sensors that cost between $750,000 and $1.8 million, according to Vincent. "You also need IT infrastructure and skilled labor to do the post processing to turn all this information into useable data," he said.

"It's a dynamic industry. Every two to three years there are major technology changes that allow major shifts in not only accuracy and data density and quality but also in costs. At the same time data requirements are always going up."

Climate change is just emerging as a business driver for geospatial mapping, according to Vincent. "The Florida Division of Emergency Management has done a coastal LIDAR program to model storm surges, floods and the effects of climate change," said Vincent. But other than that project, he has seen few RFPs that specifically mention climate change. "It's more of a byproduct," he said.

That will probably change. According to Julia Wyman, policy analyst for the Coastal States Organization, more LIDAR data is the number-one priority of state officials planning for climate change adaptation. Not only is more data needed, but the CSO wants the federal government to set a national standard for LIDAR data, which has been collected at different scales. "That way each state can use the same framework as they move toward their own adaptation plans," said Wyman.

According to Snyder of USGS, "federal, state and regional agencies have collected data using a variety of specifications, so we have incompatible data sets which makes cross-project analysis very difficult.... We're focused on developing a common national LIDAR data specification to ensure consistent and compatible national coverage," said Snyder. Under the auspices of the USGS and the American Society for Photogrammetry and Remote Sensing, this specification may evolve into a national standard. He noted that there is currently grant funding from USGS, courtesy of the ARRA package, for LIDAR mapping of areas of high vulnerability to SLR, storms and hurricanes.

## 16.5. Consultant Profile: Ryerson Master Associates

Ryerson Master Associates (RMA, Santa Barbara, Calif.) is a small California firm that has built a large reputation for helping public sector agencies and power utilities verify their greenhouse gas (GHG) emissions and design climate action programs. This business has grown sharply in the last few years, driven by California's first-in-the-nation GHG reduction law. Vice President Ivor John and Director of Climate Strategies Ann Hewitt said they believe a new wave of business will be propelled by the imperative to adapt to climate change.

"We see climate change adaptation really becoming a fairly major part of our business in a year or two," said John. "The demand will be there, and the needs fit very well with our skill sets. I think we'd also want to complement our skills with additional expertise or establish relationships with foresters for example and other land-use planning specialists. … We can't force the market but we want to be ready for it when the market says it needs us."

"A lot of different clients, especially cities and local government agencies, are now talking about adaptation, and we're just beginning to work with them on a contract basis," said John. "Most of our work in the last few years has been with cities and counties, mostly in California, to assess their operational emissions and the emissions in their communities. We're now working with a few on climate action plans, focusing on what they can control and mitigate. We're finding now that the conversation is starting to change. Climate adaptation is getting on their radar now. In cases where we're still driving or leading that conversation, clients are becoming much more responsive."

**Local Governments and States Shoulder the Early Burden**

According to Hewitt, local governments are increasingly being approached by businesses seeking information about potential climate change impacts on their business properties and operations. "Governments are being asked to assess what the risks are, and what changes businesses in their communities will have to adapt to." Hewitt notes that the California Natural Resources Agency's August 2009 draft Adaptation Strategy Discussion Draft has raised the level of concern and awareness by many in local governments. "The report built on other State reports that have assessed the potential impacts. This one is more about what sectors will be affected and how."

"As an example, public health will be a major area of impact because of the extreme weather conditions that are projected," she said. "If you grew up on the coast in California, you may not know what to do when it gets hot. Many seniors who don't have air conditioners may not know that they're actually at risk of dying in extreme heat events." She says local governments in coastal regions may have to consider programs to promote energy-efficient air conditioners or set up cooling centers, while inland towns and cities may have to expand existing facilities where seniors and other vulnerable people without air conditioning can go on extremely hot days.

Coastal California will also face multiple challenges from the sea level rise (SLR) associated with climate change, according to Hewitt. On the one hand, habitats of threatened and endangered animals and plants may be pushed inland, affecting future coastal development. "Then you also have the impacts of rising sea levels on water infrastructure, and transportation infrastructure."

With California's epic budget shortfalls, towns, cities and counties have little money to begin planning for these challenges. John advocates federal emergency stimulus funding similar to what water system operators received after September 11, 2001. "EPA gave approximately $100,000 to each city to look at the security risks in their water systems. Something like that would encourage every community to start looking at their vulnerabilities," he said. "Local governments are going to need some help with this because they don't have the funds to do what they need to do."

**Insurance Industry Will Require Adaptation Plans**

Hewitt says that she expects insurers to begin requiring climate change vulnerability assessments from large business policyholders. "This is happening more slowly than I thought it would, with a few exceptions like Travelers and Swiss Re. But we're starting to hear talk from the insurance industry about requiring adaptation plans for more vulnerable customers." She also noted that the Climate Disclosure Project, which asks large corporations to report their GHG emissions and reduction plans, has begun asking about adaptation as well.

With clients in the electric power sector, RMA is very aware of just how sensitive hydropower resources are to climate change. "With renewable energy requirements, utilities that have hydro resources have been smiling because they have lower emissions," said John. "But they're also getting really nervous because the snowpack in California is already melting earlier, affecting their ability to deliver renewable power when and where it's needed."

"With renewable energy requirements, utilities with hydro resources have been smiling, but they're also getting nervous because snowpack in California is already melting earlier"

"Others are looking at hydro as a response strategy to mitigate their climate change impacts, but a full-on shift to hydro only sounds good initially until they look at it and see that the hydro resource itself is vulnerable to climate change. We see those discussions happening now. Climate science is still not precise enough to give them really strong data to plan around. It's a challenging time for people who have to make those big investment decisions."

In January 2009, RMA was acquired by Lloyd's Register Americas, a member of the Lloyd's Register Group of entitites. According to the RMA website, the 250-year-old Lloyd's Register Group provides independent assurance to companies operating high-risk, capital-intensive assets in energy, marine and transportation to enhance the safety of life, property, and the environment, thereby helping its clients ensure safe, responsible, and sustainable supply chains.

With Lloyd's Register's maritime experience, John says that RMA may collaborate with its new parent organization to work specifically with ports on climate change adaptation. "Lloyd's Register has surveyors, naval architects and engineers, people who understand ships and port environments very well," he said. "Since we have a strong focus on the electric power sector, we may well bring in Lloyd's Register's geological and engineering expertise to help us with hydropower water management issues. We think that would be a very interesting and appropriate area for us to focus on."

## 16.6. California Climate Adaptation Strategy

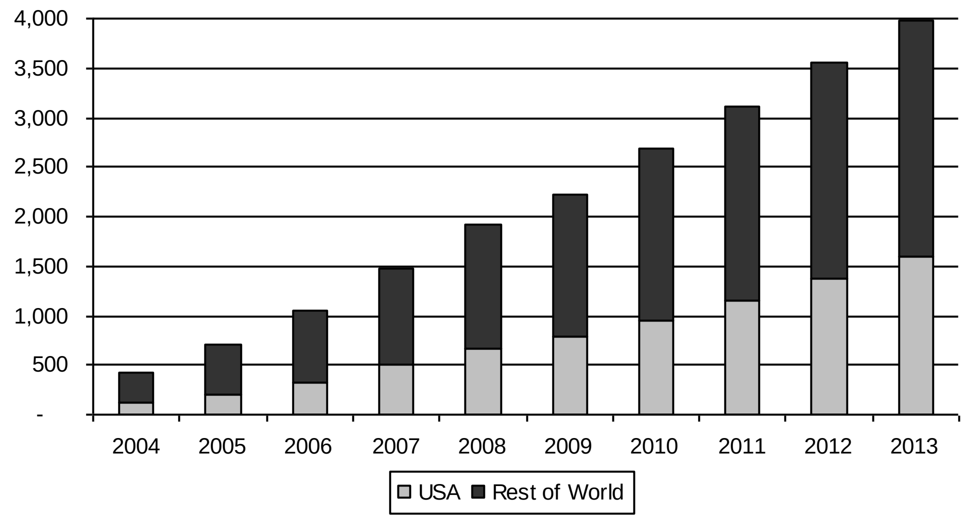
With the passage and implementation of the Global Warming Solutions Act (AB 32), the California Resources Agency has undertaken the complicated task of developing California's first comprehensive Climate Adaptation Strategy (CAS). The California Resources Agency will coordinate the CAS with Cal/EPA, the Climate Action Team, the Business, Transportation and Housing Agency, the California Department of Public Health and other key stakeholders. The CAS will have six different Climate Adaptation Working Groups that will identify and prioritize climate adaptation strategies on a per-sector basis, including: (1) Oceans and Coastal Resources; (2) Water; (3) Biodiversity and Habitat; (4) Public Health; (5) Working Landscapes (forestry and agriculture) and (6) Infrastructure (roads, levees, buildings, etc.).

# 17. Climate Change Consulting

Consulting & engineering firms have evolved to offer various levels of technical expertise since environmental issues hit the scene in the 1970s. Many have developed competency in business and management consulting or business-oriented disciplines like risk analysis and financial reporting. These and other skills will all be tested as the emerging market in climate change consulting begins to mature in coming years.

Specialty consultants currently compete with global management consultancies, accounting firms, law firms and insurance firms for intellectual leadership in climate change consulting. Throw in niche expertise like carbon trading, renewable energy development, energy efficiency, and green building design and you have a significantly broadened competitive mix.

**Figure 267 Climate Change Consulting Market ($Mil)**




*Source: EBI Inc., derived from a variety of sources including CCBJ 2008 survey, EBJ annual survey of environmental consulting firms, CCBJ interviews with consultants and experts.*

While CCBJ estimates 2008's climate change consulting market at $1.9 billion worldwide and $670 million in the United States, we expect those figures to more than double in the next five years, even fully accounting for a hitch in demand created by the financial meltdown of 2008. The market is somewhat analagous to the U.S. environmental consulting & engineering market that was about $600 million in billings in 1976, six years after the foundation of the U.S. Environmental Protection Agency. That market doubled by 1980, grew 10-fold to $12 billion in 1990 and stands at $27 billion in 2008, according to detailed annual research by EBI.

Core climate change consulting only counts for 2-3% of environmental C&E revenues today, but EBI believes a similar growth trajectory awaits as a result of rapidly evolving regulation, strengthening economic drivers, and a strong response from a wide range technical providers in the service segments listed in a table later in this report.

**Figure 268 Global Climate Change Consulting Market: Worldwide Number of Firms**

| Annual CCC Revenues | # of Firms | Avg Revenue | Total Rev $mil |
|---|---|---|---|
| $50-100 million | 4 | 65 | 260 |
| $20-50 million | 10 | 26 | 260 |
| $10-20 million | 30 | 14 | 420 |
| $5-10 million | 70 | 7 | 490 |
| $2-5 million | 130 | 3 | 390 |
| <$2 million | 200 | 0.5 | 100 |
| Total | 444 | | 1,920 |

*Source: EBI Inc., derived from a variety of sources including CCBJ 2008 survey, EBJ annual survey of environmental consulting firms, CCBJ interviews with consultants and experts. Services included are listed in the 'core' table below.*

EBI defines the climate change consulting services on two levels: core services and a breadth of service offerings directly supporting one of the eight other primary segments in the clean energy industry.

Core climate change consulting services include:

- Carbon footprint analysis: greenhouse gas emissions inventories; energy use analysis; product lifecycle analysis for carbon intensity
- Corporate compliance & planning for climate change: carbon/GHG risk analysis; carbon/GHG compliance; carbon reduction strategies; energy technology evaluation/recommendation for carbon emissions
- Strategic Advisory Services: corporate level financial analysis; consumer-perception impact; corporate liabilities and exposures; business strategy
- Policy development: regulatory-program analysis and development; voluntary-program development; verification standards; compliance assurance/support contracts; institution building
- Emissions trading and offsetting: carbon market analysis; credit verification; CDM/JI opportunity analysis; offset project development; auction development and support; economic validation for credit purchase/sell

This core group of services accounted for the $670 million U.S. market in 2008. The majority of analysis in this report will be on the core services although companies interviewed and profiled below often comment on the broader categories.

# 17.1. Climate Change Consulting & Research Statistics & Review

**Figure 269 Core U.S. Climate Change Consulting Market ($Mil)**

| Core U.S. Climate Change Consulting | % of Market | 2008 USA $mil |
|---|---|---|
| Carbon footprint analysis: greenhouse gas emissions inventories; energy use analysis; product lifecycle analysis for carbon intensity | 35% | 235 |
| Corporate compliance & planning for climate change: carbon/GHG risk analysis; carbon/GHG compliance; carbon reduction strategies; energy technology evaluation/reccomendation for carbon emissions | 26% | 174 |
| Strategic Advisory Services: corporate level financial analysis; consumer-perception impact; corporate liabilities and exposures; business strategy | 12% | 80 |
| Policy development: regulatory-program analysis and development; voluntary-program development; verfication standdards; compliance assurance/support contracts; institution building | 8% | 54 |
| Emissions trading and offsetting: carbon market analysis; credit verification; CDM/JI opportunity analysis; offset project development; auction development and support; economic validation for credit purchase/sell | 19% | 127 |
| **Core climate change consulting** | **100%** | **670** |

*Source: EBI Inc., derived from a variety of sources including CCBJ 2008 survey, EBJ annual survey of environmental consulting firms, CCBJ interviews with consultants and experts. Services included are listed in the'core' table below.*

Other services surveyed by EBI but included as service sub-categories in other clean energy industry segments include:

- Renewable energy development: site assessment & feasibility; environmental/ecological studies; community outreach; facility design & engineering; construction management; post-construction monitoring
- Energy efficiency: systems/facility investigation and analysis; audits, engineering. design and implementation (not including the ESCO segment)
- Green building services: assessment, design, construction management
- Climate Adaptation analysis & planning: risk analysis; weather & climate analysis and studies; social & ecological studies; economic and technical analysis; program evaluation; public education

**Figure 270 Climate Change Consulting Global Market Estimates: Revenues in $mil**

| Climate Change Consulting | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|
| Global | 420 | 710 | 1,060 | 1,480 | 1,920 | 2,230 | 2,680 | 3,110 | 3,550 |
| USA | 100 | 169 | 271 | 420 | 670 | 820 | 1,040 | 1,270 | 1,500 |
| Global Growth | | 70% | 50% | 40% | 30% | 16% | 20% | 16% | 14% |
| USA Growth | | 70% | 60% | 55% | 60% | 22% | 27% | 22% | 18% |
| % USA of Global | 24% | 24% | 26% | 28% | 35% | 37% | 39% | 41% | 42% |

*Source: EBI Inc., derived from a variety of sources including CCBJ 2008 survey, EBJ annual survey of environmental consulting firms, CCBJ interviews with consultants and experts.*

**Figure 271 Global Climate Change Consulting & Research Industry**

| | 2007 | 2008 | 2009 | 2008 Growth | 2009 Growth |
|---|---|---|---|---|---|
| Consulting: advisory, inventories, footprints, compliance, trading | 1.48 | 1.92 | 2.23 | 30% | 16% |
| Climate Science & Studies: Government, Academic, Non-profit | 5.32 | 5.18 | 5.94 | -3% | 15% |
| Climate Change Consulting & Research | 6.80 | 7.10 | 8.17 | 4% | 15% |

*Source: EBI Inc. estimates derived from a variety of sources*

**Figure 272 U.S. Climate Change Consulting & Research Industry**

| | 2007 | 2008 | 2009 | 2008 Growth | 2009 Growth |
|---|---|---|---|---|---|
| Consulting: advisory, inventories, footprints, compliance, trading | 0.50 | 0.67 | 0.78 | 34% | 16% |
| Climate Science & Studies: Government, Academic, Non-profit | 1.90 | 1.85 | 2.70 | -3% | 46% |
| Climate Change Consulting & Research | 2.40 | 2.52 | 3.48 | 5% | 38% |

*Source: EBI Inc. estimates derived from a variety of sources*

**Figure 273 California Climate Change Consulting & Research Industry**

| | 2007 | 2008 | 2009 | 2008 Growth | 2009 Growth |
|---|---|---|---|---|---|
| Consulting: advisory, inventories, footprints, compliance, trading | 0.09 | 0.12 | 0.15 | 34% | 23% |
| Climate Science & Studies: Government, Academic, Non-profit | 0.11 | 0.11 | 0.15 | -1% | 41% |
| Climate Change Consulting & Research | 0.20 | 0.23 | 0.30 | 15% | 31% |

*Source: EBI Inc. estimates derived from a variety of sources*

**Figure 274 U.S. Climate Change Consulting & Research Industry as a Percentage of Global Total**

| | 2007 | 2008 | 2009 |
|---|---|---|---|
| Consulting: advisory, inventories, footprints, compliance, trading | 34% | 35% | 35% |
| Climate Science & Studies: Government, Academic, Non-profit | 36% | 36% | 45% |
| Climate Change Consulting & Research | 35% | 35% | 43% |

*Source: EBI Inc. estimates derived from a variety of sources*

**Figure 275 California Climate Change Consulting & Research Industry as a Percentage of U.S. Total**

| | 2007 | 2008 | 2009 |
|---|---|---|---|
| Consulting: advisory, inventories, footprints, compliance, trading | 18.0% | 18.0% | 19.0% |
| Climate Science & Studies: Government, Academic, Non-profit | 5.7% | 5.8% | 5.6% |
| Climate Change Consulting & Research | 8.3% | 9.0% | 8.6% |

*Source: EBI Inc. estimates derived from a variety of sources*

**Figure 276 U.S. and California Climate Change Consulting & Research Industry: Employment**

| | USA \$bil in 2009 | USA 2009 Jobs | Calif. \$bil in 2009 | Calif. 2009 Jobs | % of USA Jobs in Calif. |
|---|---|---|---|---|---|
| Consulting: advisory, inventories, footprints, compliance, trading | 0.78 | 6,000 | 0.15 | 1,250 | 20.9% |
| Climate Science & Studies: Government, Academic, Non-profit | 2.70 | 20,800 | 0.15 | 1,160 | 5.6% |
| Climate Change Consulting & Research | 3.48 | 26,800 | 0.30 | 2,410 | 9.0% |

*Source: EBI Inc. estimates derived from a variety of sources*

**Figure 277 Ranking of client types for climate change consulting services in 2008**

| Client Types |
|---|
| Non-Profits/NGOs |
| Universities |
| Petroleum/oil & gas |
| State government |
| Local/City government |
| Federal government |
| Developers |
| Electronics/computer manufacturing |
| Food & beverage |
| Manufacturing |
| Transportation mfg (auto & aero) |
| Consumer retail companies |
| Investors/Investment Funds |
| Primary metals |
| Chemical industry |
| Mining |
| Water utilities |
| Banks & Law Firms |
| Pulp & paper |
| Metals fabricating/coating |

*Source: CCBJ/EBJ Climate Change Consulting Survey conducted November-December 2008. Question was: Please rate the following customer areas in terms of demand for climate change consulting services in 2008.*

**Figure 278 Ranking of client types for climate change consulting services in 2009-2010**

| Client Types |
|---|
| Power utilities |
| Federal government |
| State government |
| Local/City government |
| Petroleum/oil & gas |
| Water utilities |
| Non-Profits/NGOs |
| Investors/Investment Funds |
| Universities |
| Mining |
| Properyy Developers |
| Food & beverage |
| Transportation manufacturing (auto & aero) |
| Chemical industry |
| Banks & Law Firms |
| Other manufacturing |
| Electronics/computer manufacturing |
| Consumer retail companies |
| Pulp & paper |
| Metals |

*Source: CCBJ's Climate Change Consulting Survey 2010. Question was: Please rate the following customer areas in terms of demand for climate change consulting services in 2009-2010. Sorted by a weighed factor of all five categories.*

**Figure 279 U.S. Clean energy industry Consulting & Engineering Market ($Mil) 2008-2012**

| Service | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|
| ***Core Climate Change Consulting*** | 670 | 820 | 1,040 | 1,270 | 1,500 |
| Renewable energy development | 670 | 765 | 1,076 | 1,459 | 1,798 |
| Energy efficiency | 510 | 612 | 734 | 881 | 969 |
| Green building services | 2,148 | 2,443 | 2,612 | 2,992 | 3,323 |
| Climate Adaptation | 408 | 465 | 561 | 673 | 808 |
| **U.S. Clean energy industry Consulting & Engineering** | **4,405** | **5,105** | **6,023** | **7,275** | **8,398** |
| Growth | | 16% | 18% | 21% | 15% |

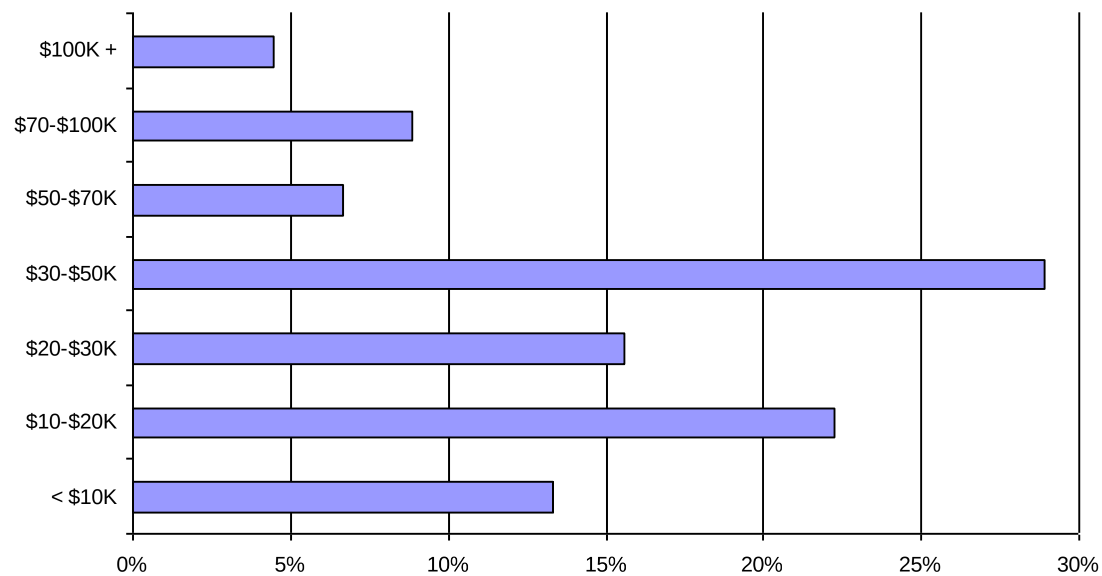
*Source: EBI Inc. derived from a variety of sources including CCBJ 2008 survey, EBJ annual survey of environmental consulting firms, CCBJ interviews with consultants and experts.*

**Figure 280 Ranking of geographic regions in demand for CCC services in 2009-2010**

| Client Types |
|---|
| Western Europe |
| United States |
| Canada |
| Australia/NZ |
| All Non-USA |
| Eastern Europe |
| India |
| China |
| Japan |
| Central & South America |
| Rest of Asia |
| Middle East |
| Africa |
| Mexico |
| Russia |

*Source: Source: CCBJ's Climate Change Consulting Survey 2010. Question was: Please rate the following regions in terms of their demand for climate change consulting services sales in 2009.*

**Figure 281 Climate Change Consulting Projects Tend to be Small**




*Source: CCBJ/EBJ Climate Change Consulting Survey conducted November-December 2008. Question was: Estimate the contract size of a typical climate change project in your indicated service categories. n=49*

## 17.2. Trends & Drivers

Climate change and sustainability experts from a range of professional services firms told EBI that they believe climate change policy is inevitable in the United States and other developed countries where it hasn't yet been enacted—and they advise their clients to plan accordingly. Many also see major developing country governments taking significant action in coming years, a prediction bolstered by the commitments from China, India, Brazil and South Africa in Copenhagen in late 2009.

Speaking of Copenhagen, while the accord disappointed NGOs, to leaders of small island states and many Europeans—whose leaders weren't even at the negotiating table for the accord—it sent a strong signal to U.S. emitters that federal climate policy is more likely than ever, according to advisers interviewed by EBI. "It was the first time we've seen the U.S. and the developing world come together and make an agreement of this nature," said David Hampton, managing partner of climate change consultancy Irbaris. "Any U.S. company investing in assets with 20 to 30 year lifecycles can't ignore the writing on the wall."

On the policy front, there may be some surprising developments ahead in the courts, according to one carbon policy expert. While the U.S. Environmental Protection Agency's greenhouse gas reporting rule and the main climate bills in the legislature would affect entities emitting more than 25,000 tons of CO2 annually, there is a significant risk that much smaller emitters could find their greenhouse gas emissions regulated under the Clean Air Act as a result of litigation aimed at forcing the EPA to set thresholds as low as 250 tons per year (the levels for sulfur dioxide and nitrogen dioxide).

"We know environmental groups are planning to litigate on that, and we're seeing companies getting increasingly concerned," said Allan Bedwell, Vice President and Director for the North American Sustainability Strategies Group of CantorCO2e, the brokerage unit of the financial services firm Cantor Fitzgerald.

**Non-Policy Drivers Kick In**

Even without tougher national policies, international agreements or court decisions, other forces are pushing businesses toward shrinking their carbon footprints and developing sustainability strategies around their consumption of energy, water and other resources.

• Institutional investors and lenders are increasingly pressuring or requiring companies to disclose greenhouse gas (GHG) emissions and other climate change-related liabilities and to demonstrate their mitigation and adaptation plans.

• By some interpretations, U.S. securities law already requires publicly held companies to disclose climate change risks as potential liabilities. The January 2010 Securities and Exchange Commission vote to provide public companies guidance about their climate change disclosures underscored that many companies will have to focus increasingly on this area going forward.

• Consumers and major retail buyers like WalMart are demanding more information about the carbon footprints and other environmental measures associated with consumer products.

• State and regional policies for increasing renewable energy and reducing carbon emissions will not go away if federal legislation stalls next year.

• Carbon and other environmental metrics, not just costs but also the revenues that can be generated with carbon emissions reductions, are becoming more important in overall business performance and valuation.

**Figure 282 Rating of market drivers for climate change consulting**

| | Very Strong: Positive | Strong: Positive | No Impact | Strong: Negative | Very Strong: Negative |
|---|---|---|---|---|---|
| Carbon markets (regulated credits & voluntary offsets) | 40% | 49% | 12% | 0% | 0% |
| Renewable energy standards or mandates | 29% | 62% | 10% | 0% | 0% |
| High price of oil | 26% | 66% | 0% | 8% | 0% |
| Consumer concern about climate change | 22% | 73% | 5% | 0% | 0% |
| Global corporations pursuit of carbon-reduction strategy | 36% | 45% | 14% | 2% | 2% |
| U.S./Regional/State climate change policy development | 30% | 55% | 13% | 0% | 3% |
| Incentives/subsidies for renewable energy | 30% | 53% | 18% | 0% | 0% |
| Existing climate change programs/regulation | 30% | 51% | 19% | 0% | 0% |
| Cost of electricity | 22% | 66% | 5% | 7% | 0% |
| New int'l climate change policy development | 17% | 62% | 19% | 0% | 2% |
| Heightened activity in power sector | 16% | 47% | 29% | 8% | 0% |
| Costs of renewable energy technology | 17% | 32% | 34% | 17% | 0% |
| December '07 USA Energy Bill | 3% | 35% | 53% | 5% | 5% |
| Changing weather patterns/increased storms | 3% | 33% | 59% | 5% | 0% |
| Activity in resource extraction industries | 6% | 25% | 56% | 11% | 3% |
| Global war on terror | 0% | 5% | 77% | 15% | 3% |
| Rate of inflation | 3% | 18% | 53% | 24% | 3% |
| Declining property values | 0% | 11% | 50% | 32% | 8% |
| Sub-prime mortgage crisis | 0% | 3% | 43% | 40% | 14% |
| Federal budget cuts | 3% | 8% | 28% | 55% | 8% |
| State budget cuts | 3% | 3% | 32% | 47% | 16% |
| Economic downturn/recession | 7% | 7% | 10% | 64% | 12% |

*Source: CCBJ/EBJ Climate Change Consulting Survey conducted November-December 2008. Question was: Rate the impact of the following market drivers on your ability to generate revenues from climate change consulting assignments in 2008.*

## 17.3. Climate Change Consulting Competitors

The universe of firms providing advice and professional services to corporations exposed to climate change risk is populated by outfits of varying types and sizes with diverse business models. Environmental consultants such as Environ and ERM, as well as engineering firms with environmental consulting capabilities like billion-dollar firms Black & Veatch, URS and CH2M Hill have been leading actors since the early days.

Point Carbon, New Energy Finance and similar firms combine subscription-based carbon market insights with advisory services, while IHS/CERA operates on a similar business model but with a broader scope of data, information systems and issue expertise.

Environmental brokerage houses like Cantor CO2e and Evolution Markets have developed advisory and consulting divisions. CantorCO2e, for example, leverages its carbon trading experience in regulated and voluntary markets to help its consulting clients with strategies to limit their risk and create opportunities as carbon limits come to the United States and other developed countries. Additionally, scores of small startups are offering carbon footprinting, sustainability planning and marketing help to "green" their clients' images.

Firms also get climate change advice and services from large management consultancies like McKinsey & Co. and Booz & Co.; from the accounting and assurance firms—especially the Big Four, PwC, KPMG, Ernst & Young and Deloitte; from economic and financial consultants that specialize in energy such as Charles River Associates and The Brattle Group; and from specialist management consultancies like Irbaris and a number of smaller boutique firms.

"There are a lot of new entrants, partly due to the market being fairly ill-defined," said Nick Pennell, the London-based Booz partner who heads up the firm's low-carbon practice globally. "There are lots of companies in this space, trying to figure out what the winning formula is for success, which is not quite clear right now. We see our traditional competitors, like McKinsey, and the Big Four accounting firms focusing on the reporting side. And we see the environmental consultancies moving upstream into the strategy space." Hourly rates and contract sizes vary dramatically.

One executive said that his firm's partners bill \$400 to \$800 per hour, while other firms—particularly those who often work for governments—will bill \$150 per hour or less. Some rarely take on projects for less than \$100,000, while others will execute assignments for \$20,000 or less. Contract structures are also diverse, with a mix of fixed-fee for specific deliverables and time-and-materials billing with upfront estimates. Some firms, notably Deloitte, are beginning to offer contracts structured around value-based compensation. These models are akin to the ESCO model in which vendors are often paid based on energy savings, only in the climate change and sustainability space such contracts will incorporate carbon emission reductions, resource consumption, waste streams and other parameters.

**Figure 283 Market shares in climate change consulting services**

| Climate Change Consulting | $mil in USA CCC in 2008 | Share % |
|---|---|---|
| Accounting Firms | 104 | 16% |
| Management Consultants | 82 | 12% |
| Law Firms | 50 | 7% |
| Specialist Climate Change or Sustainability Firms | 69 | 10% |
| Environmental Consulting & Engineering Firms | 225 | 34% |
| Energy Consulting Firms | 100 | 15% |
| Other | 40 | 6% |
| **Total in $mil USA** | **670** | |

*Source: Climate Change Business Journal estimates derived from surveys and interviews; Other includes economic and financial consulting firms, carbon trading and IT firms.*

**Figure 284 Climate Change Consulting Competitor Types and Examples**

**Environmental C&Es:** ICF, ENVIRON, ERM, CH2M Hill, URS, SAIC

**Management Consultants:** McKinsey, Booz, Accenture

| |
|---|
| **Big 4 Accounting Firms:** Ernst & Young, Deloitte, KPMG, PwC<br>**Insurance:** Zurich<br>**Carbon Brokers:** Cantor CO2e, EcoSecurities, NatSource<br>**Specialist/Boutique:** Stratus, Eastern Research |

**Figure 285 Other Climate Change Consulting Sector Competitors**

| |
|---|
| **ESCOs:** Johnson Controls, Siemens, Honeywell, Ameresco<br>**Demand Response:** Comverge, EnerNOC<br>**Green Building Design:** URS, AECOM, Fluor, Kimley-Horn, Tetra Tech, Gensler<br>**CCS Consultants:** E&E, Potomac Hudson, MJ Bradley, Monitor Sciences |

In terms of the competitive positioning used by C&Es against one another, a common theme is to paint their own firm as one that takes a holistic or systems view of a client's climate change exposures and opportunities, while other firms look at problems in a linear or one-off approach, offering commodity services like footprints, trading or energy-efficient lighting. C&E leaders most frequently cited in climate change included;

- ICF
- SAIC
- ERM
- CH2M HILL
- WSP
- URS
- Tetra Tech
- Cameron-Cole
- Ecology & Environment
- AECOM and
- ENVIRON

ICF is regarded by EBI as the top global practice in climate change with more than 300 professionals, a more than 25 year history, and project experience with 75 of the Fortune 500 and 60 governments, according to a presentation by practice leader Craig Ebert at EBI's Environmental Industry Summit in March 2010. McKinsey and Deloitte were mentioned most frequently in terms of serious competition posed by professional services firms, but overall only 9% of CCBJ survey respondents believed management consultants were best suited to leadership in climate change consulting. 56% believed environmental C&E firms were best suited, but it should be noted that these firms represented 47% of the respondent pool.

Another noteworthy element in the competitive environment is that consultants in the clean energy industry feel compelled to make their own commitments to sustainability and climate change mitigation and to declare that they'll push their clients in that direction—whether those clients ask them to or not. Walking the talk is also recognized as crucial to morale and recruitment.

In an industry that is getting as much press as the clean energy industry, there are a lot of new competitors vying for business with C&Es that already have established climate change practices. "There are a lot of new startups driven by all this activity," said Jim Renner, senior geologist and principal in Golder Associates' Atlanta office. "Ten years ago people weren't paying attention to greenhouse gas management. Now you can't go to a business meeting in Atlanta without running into someone hanging out a shingle."

## 17.4. CCBJ's Climate Change Consulting Survey

This section presents CCBJ's Climate Change Consulting Survey results

**Figure 286 Impact of market drivers**

Rate the impact of the following market drivers on your ability to generate revenues from climate change consulting assignments in 2008

| Rating of market drivers for climate change consulting | Very Strong: Positive | Strong: Positive | No Impact | Strong: Negative | Very Strong: Negative |
|---|---|---|---|---|---|
| Carbon markets (regulated credits & voluntary offsets) | 40% | 49% | 12% | 0% | 0% |
| Renewable energy standards or mandates | 29% | 62% | 10% | 0% | 0% |
| High price of oil | 26% | 66% | 0% | 8% | 0% |
| Consumer concern about climate change | 22% | 73% | 5% | 0% | 0% |
| Global corporations pursuit of carbon-reduction strategy | 36% | 45% | 14% | 2% | 2% |
| U.S./Regional/State climate change policy development | 30% | 55% | 13% | 0% | 3% |
| Incentives/subsidies for renewable energy | 30% | 53% | 18% | 0% | 0% |
| Existing climate change programs/regulation | 30% | 51% | 19% | 0% | 0% |
| Cost of electricity | 22% | 66% | 5% | 7% | 0% |
| New int'l climate change policy development | 17% | 62% | 19% | 0% | 2% |
| Heightened activity in power sector | 16% | 47% | 29% | 8% | 0% |
| Costs of renewable energy technology | 17% | 32% | 34% | 17% | 0% |
| December '07 USA Energy Bill | 3% | 35% | 53% | 5% | 5% |
| Changing weather patterns/increased storms | 3% | 33% | 59% | 5% | 0% |
| Activity in resource extraction industries | 6% | 25% | 56% | 11% | 3% |
| Global war on terror | 0% | 5% | 77% | 15% | 3% |
| Rate of inflation | 3% | 18% | 53% | 24% | 3% |
| Declining property values | 0% | 11% | 50% | 32% | 8% |
| Sub-prime mortgage crisis | 0% | 3% | 43% | 40% | 14% |
| Federal budget cuts | 3% | 8% | 28% | 55% | 8% |
| State budget cuts | 3% | 3% | 32% | 47% | 16% |
| Economic downturn/recession | 7% | 7% | 10% | 64% | 12% |

*Source: CCBJ's Climate Change Consulting Survey 2008*

**Figure 287 Ranking Client Types 2010**

| Customer Trends: Please rate the following customer areas in terms of demand for climate change consulting services in 2009-2010: For these questions, feel free to respond only to areas that apply to your company. | Very strong | Strong demand | Modest demand | Weak demand | No demand at all |
|---|---|---|---|---|---|
| Power utilities | 27% | 46% | 18% | 5% | 4% |
| Federal government | 22% | 41% | 18% | 10% | 10% |
| State government | 13% | 37% | 27% | 13% | 10% |
| Local/City government | 17% | 24% | 33% | 20% | 6% |
| Petroleum/oil & gas | 13% | 28% | 23% | 26% | 11% |
| Water utilities | 4% | 37% | 33% | 22% | 4% |
| Non-Profits/NGOs | 15% | 24% | 15% | 29% | 17% |
| Investors/Investment Funds | 13% | 21% | 38% | 13% | 15% |
| Universities | 13% | 13% | 44% | 16% | 13% |
| Mining | 5% | 28% | 26% | 23% | 18% |
| Properyy Developers | 7% | 21% | 26% | 33% | 12% |
| Food & beverage | 3% | 29% | 26% | 18% | 24% |
| Transportation manufacturing (auto & aero) | 3% | 18% | 47% | 13% | 18% |
| Chemical industry | 5% | 14% | 40% | 26% | 16% |
| Banks & Law Firms | 3% | 18% | 28% | 31% | 21% |
| Other manufacturing | 5% | 8% | 42% | 29% | 16% |
| Electronics/computer manufacturing | 3% | 17% | 44% | 8% | 28% |
| Consumer retail companies | 5% | 16% | 27% | 16% | 35% |
| Pulp & paper | 0% | 11% | 53% | 21% | 16% |
| Metals | 0% | 13% | 32% | 32% | 24% |

*Source: CCBJ's Climate Change Consulting Survey 2010. Question was: Please rate the following customer areas in terms of demand for climate change consulting services in 2009-2010. Soreted by a weighed factor of all five categories.*

**Figure 288 Ranking in Geographic Regions 2010**

| Geographic Trends: Please rate the following regions in terms of their demand for climate change consulting services sales in 2009 | Very strong | Strong demand | Modest demand | Weak demand | No demand at all |
|---|---|---|---|---|---|
| Western Europe | 10% | 62% | 23% | 3% | 3% |
| United States | 13% | 33% | 41% | 13% | 0% |
| Canada | 0% | 31% | 47% | 19% | 3% |
| Australia/NZ | 0% | 30% | 39% | 21% | 9% |
| All Non-USA | 3% | 17% | 61% | 17% | 3% |
| Eastern Europe | 9% | 6% | 35% | 41% | 9% |
| India | 5% | 14% | 35% | 30% | 16% |
| China | 0% | 21% | 41% | 26% | 13% |
| Japan | 0% | 13% | 52% | 26% | 10% |
| Central & South America | 0% | 12% | 35% | 29% | 24% |
| Rest of Asia | 0% | 9% | 24% | 48% | 18% |
| Middle East | 3% | 6% | 17% | 49% | 26% |
| Africa | 3% | 3% | 18% | 42% | 33% |
| Mexico | 0% | 3% | 19% | 56% | 22% |
| Russia | 0% | 3% | 22% | 38% | 38% |

*Source: CCBJ's Climate Change Consulting Survey 2010. Question was: Please rate the following regions in terms of their demand for climate change consulting services sales in 2009*

**Figure 289 Prospects for sales growth**

| Please rate following service categories in terms of prospects for sales growth in 2010-2013: | Best Growth Oppt'y | Very Strong Growth | Strong Growth | Modest Growth | Flat | Decline |
|---|---|---|---|---|---|---|
| Energy efficiency | 23% | 23% | 37% | 7% | 5% | 5% |
| Renewable energy development | 21% | 26% | 26% | 13% | 8% | 5% |
| Green building services | 15% | 24% | 29% | 17% | 8% | 7% |
| Corporate compliance & planning for climate change | 15% | 22% | 34% | 17% | 3% | 8% |
| Strategic Advisory Services | 12% | 21% | 30% | 23% | 7% | 7% |
| Carbon footprint analysis | 10% | 21% | 33% | 21% | 8% | 7% |
| Policy development | 10% | 20% | 27% | 25% | 8% | 8% |
| Climate Adaptation analysis & planning | 11% | 14% | 30% | 23% | 14% | 9% |
| Emissions trading and offsetting | 10% | 12% | 28% | 26% | 16% | 9% |

*Source: CCBJ's Climate Change Consulting Survey 2010. Question was: Please rate following service categories in terms of prospects for sales growth in 2010-2013*

**Figure 290 Impact of market drivers on revenues from climate change**

| Rate the impact of the following market drivers on your ability to generate revenues from climate change consulting assignments in 2009: | Very Strong: Positive | Strong: Positive | No Impact | Strong: Negative | Very Strong: Negative |
|---|---|---|---|---|---|
| U.S./Regional/State climate change policy development | 25.9% | 51.9% | 11.1% | 7.4% | 3.7% |
| Existing gov't climate change programs/regulation | 21.7% | 56.7% | 15.0% | 5.0% | 3.3% |
| Corporate sustainability initistives | 22.8% | 52.6% | 15.8% | 3.5% | 5.3% |
| Renewable energy standards or mandates | 21.1% | 47.4% | 24.6% | 5.3% | 1.8% |
| Incentives/subsidies for renewable energy | 19.2% | 51.9% | 25.0% | 3.8% | 3.8% |
| Federal budgets | 13.0% | 61.1% | 14.8% | 7.4% | 3.7% |
| New int'l climate change policy development | 20.7% | 37.9% | 31.0% | 6.9% | 3.4% |
| Price of carbon in USA (regional schemes or offsets) | 17.0% | 41.5% | 24.5% | 13.2% | 3.8% |
| Consumer concern about climate change | 15.3% | 45.8% | 32.2% | 3.4% | 3.4% |
| Cost of electricity | 10.7% | 58.9% | 17.9% | 8.9% | 3.6% |
| Price of oil | 10.5% | 52.6% | 26.3% | 10.5% | 1.8% |
| Global corporations specific pursuit of carbon-reduction strategy | 11.5% | 46.2% | 32.7% | 3.8% | 5.8% |
| Heightened activity in power sector | 5.6% | 46.3% | 37.0% | 7.4% | 3.7% |
| Changing weather patterns/increased storms | 8.6% | 22.4% | 58.6% | 8.6% | 3.4% |
| Activity in resource extraction industries | 2.0% | 28.0% | 56.0% | 10.0% | 4.0% |
| Price of carbon in EU | 7.7% | 19.2% | 59.6% | 7.7% | 5.8% |
| Property values | 5.9% | 13.7% | 62.7% | 11.8% | 5.9% |
| State budgets | 9.4% | 45.3% | 26.4% | 18.9% | 3.8% |
| Costs of renewable energy technology | 9.8% | 27.5% | 39.2% | 19.6% | 3.9% |
| Global war on terror | 3.9% | 13.7% | 56.9% | 17.6% | 7.8% |
| State of the economy | 12.3% | 35.1% | 10.5% | 31.6% | 12.3% |

*Source:CCBJ's Climate Change Consulting Survey 2010*

# 18. Conclusions and Recommendations

The objective of this study was to define, characterize, quantify and forecast the growth of the clean energy industry in California, and to put its economic contribution into context. Research consisted primarily of obtaining consensus on the industry definition and list of segments, building databases of companies in each segment or subsegment, conducting interviews and surveys of industry participants and a compilation and study of reliable secondary market data. Data was then aggregated into segment models to estimate market size, growth, geographic breakdowns, leading companies and other qualitative aspects like business trends and market drivers.

The study concludes that the clean energy industry was a $27-billion industry in California in 2009, 12% of the U.S. clean energy industry of $223.6 billion and 2.5% of the global total of $1.1 trillion. In economic terms, the $27-billion clean energy industry in California represented 1.4% of the California economy in 2009, employing 123,000 Californians, or 1.1% of the state's total of 12.6 million jobs, according to the state's Employment Development Department.

Growth in the clean energy industry slowed from double-digit annual growth to 5% globally, 1% in the United States and -1% in California due to the recession in 2009. California's comparatively lower growth in 2009 is mostly attributable to more pronounced downturns in green buildings and hybrid automotive sales, higher growth in wind energy in developing economies, and growth of transportation options in Japan and Europe, and carbon credit market in Europe. Interim data indicates grwoth in 2010 was 8%. California's growth, or lack thereof, in the 48 sub-segments of the clean energy industry quantified in this report is often related to specific regulatory programs or financial incentives. California's Global Warming Solutions Act, AB 32, the Air Resources Board Scoping Plan and a number of other state programs are expected to increase both the growth prospects and the competitiveness of the California clean energy industry.

California plays a leading role in some segments and lags noticeably in others, partially due to the influence of government policy. The consensus of analysis of regulatory-driven industries like the environmental industry and the clean energy industry clearly indicates that the competitiveness of an industry in a nation or state is largely driven by domestic or state policy and the corresponding consistency of market demand usually driven by enforcement. In the emerging clean energy industry, California's pioneering policies have often created a framework for competitive advantage not always fully leveraged by consistent implementation or accompanying federal programs and initiatives, yet California still is home to some of the world's most innovative companies in the business of the many segments of the clean energy industry. As California enters the new era of AB 32 and emissions trading, this study serves as an important benchmark of a large and growing industry that is still in its infancy.

In a way, the California clean energy industry finds itself at a crossroads, if not perhaps on a launching pad, at the beginning of 2011. Decades of relatively progressive (although many argue not always consistent or broadly coordinated) policy in air, water, waste, energy efficiency and renewable energy have led to the evolution and emergence of a clean energy industry. With the implementation of AB 32, California promises a significantly more ambitious effort to coordinate programs and policy that will drive growth in all clean energy industry segments, in addition to creating a powerful market mechanism to find the most cost-effective solutions and stimulate innovation in energy use, storage, generation, transmission and efficiency and a host of supporting services and technology that will accelerate the transition to a more sustainable economy.

## 18.1. Recommendations

This study represents a first step in defining the clean energy industry, quantifying its market size and economic contribution, and an assessment of California's role in the global energy market.

The years 2011-2012 will see the implementation of AB 32, in addition to other clean energy, climate change and greenhouse gas initiatives in the State of California, which promise to stimulate more demand for clean energy industry products and services in all of the clean energy segments detailed in this report. This assessment of clean energy industry economic data in 2008-2010 will serve as a useful benchmark as ongoing research seeks to capture the growth and competitive trends in the emerging global clean energy industry.

While considerable effort has been undertaken to produce the market and industry analysis in this report and EBI is confident that it represents by far the best available compilation of data on these segments, the novelty and fragmentation of many of the industry sectors assures that this report's numerous estimates are far from perfect. EBI recommends that this study be viewed as a benchmark for the clean energy industry prior to the complete implementation of AB 32 and its cap-and-trade program, and that ongoing research is conducted on California's clean energy industry and global markets.

If properly and consistently implemented, California's clean energy and greenhouse gas reduction policies should enhance the competitiveness and economic contribution of California's clean energy industry. Future studies will be able to more accurately assess revenue generation, growth in local markets, employment and possibly evolve to the level of an accurate assessment of import-export models by segment and international rade balances.

It is clear that most leading nations of the world are not standing still on clean energy and climate change, or on the policies that stimulate demand leading to the development of the businesses that speed energy security, emissions reduction and economic objectives. California cannot be accused of standing still on cleam energy or the clean energy industry, and the bold yet measured steps of 2011 and 2012 will play a significant role in California's economic future in clean energy and across the entire economy and population.

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Glossary of Terms, Abbreviations, and Symbols

Appendices