ETAAC Advanced Technology Development Report
Energy Efficiency Focus
DRAFT
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Energy Efficiency: A Critical Path to GHG Reductions

California has long supported programs, technologies, and policies that promote energy efficiency as a cost-savings means of achieving critical air quality, energy use reduction, and greenhouse gas (GHG) mitigation goals,. The success of existing programs have played a major part in California's ability to keep per-capita electricity demand flat rather than following the national trend of increasing per-capita demand for electricity. While California will continue to enjoy the cost-savings and environmental benefits of electricity consumption a third less than other areas of the country, meeting California's GHG goals will require accelerating that trend with development of advanced technologies for both electricity and natural gas efficiency. These technologies will also play an important role in meeting air quality goals and helping keep California's businesses competitive while promoting the development of new markets that can help California's economy.

Existing Policy Framework

The following brief overview of relevant California activities underscores the State's commitment to this policy tool. In 2003, the *California Energy Action Plan*—a joint publication of the California Public Utilities Commission (CPUC) and the California Energy Commission (CEC) —established energy efficiency as California's top-priority resource for meeting energy demand. A 2005 update to the *Plan* reiterated this policy, noting, "Energy efficiency is the least cost, most reliable, and most environmentally-sensitive resource, and minimizes our contribution to climate change." (*California Energy Action Plan II*, page 3).

The CPUC's *Long-Term Energy Efficiency Strategic Plan,* published in 2008, focuses on technologies and actions that will significantly optimize California's energy use—and dramatically decrease GHG—over the next 10 years. Other state activities, including legislation and the Governor's Green Building Executive Order, further highlight California's reliance on advanced energy efficiency technologies to achieve significant GHG reductions.

As administrators of energy efficiency programs overseen by the CPUC, California's investor-owned utilities (IOUs) have implemented increasingly strategic approaches to energy efficiency for the past 30 years. The most recently proposed three-year program, slated for approval in late 2009, includes both measures that ensure near-term energy and emission reductions and forward-looking programs that lay the foundation for achieving the *Strategic Plan* goals, including goals aimed in part at GHG mitigation. Together, the proposed statewide IOU portfolios implemented between 2009 and 2011 could save some 95,000 gigawatt-hours of electricity and 2,500 million therms of gas, leading to a reduction of roughly 69 million life-cycle tons of carbon dioxide (CO_2) (IOU-proposed *Energy Efficiency Portfolio*, July 2, 2009, mandatory scenario) over the lives of measures installed through the 2009-11 program cycle as proposed. Similar programs run by the State's publicly owned utilities (POUs), as required by AB2021, will also yield GHG reductions.

Building on this momentum, the *Climate Change Scoping Plan*, published in 2008 by the California Air Resources Board (CARB), envisions applying energy efficiency to reduce electricity demand by 32,000 gigawatt-hours and gas use by 800 million therms, thereby cutting GHG emissions by more than 26 million metric tons, by 2020 (*Scoping Plan,* Tables 7 and 8, page 44). However, the *Plan* cautions, "Achieving the energy efficiency target will require redoubled efforts to target industrial, agricultural, commercial, and residential end-user sectors, comprised of both new initiatives … and improvements to California's traditional approaches of improved building standards and utility programs. (*Scoping Plan*, page 42).

Finally, California's long-term planning process, embodied in the *Integrated Energy Policy Report* and the long-term procurement plan, provides a basis for both assessing GHG potential as well as the mechanisms—described above—that lead to the promised GHG reductions.

This document updates to the adopted February 2008 ETAAC report by providing a brief overview of critical advanced technologies that will lead to significant GHG reductions.

Promising New Technologies for Enhanced Energy Use and GHG Reductions

Among the new initiatives called for in the *Scoping Plan* are advanced technologies that can help California retain its lead in energy use and GHG reductions. Described below are the key new technologies either on the horizon or recently introduced that could, with additional support, join the State's arsenal of energy efficiency measures and lead to significant GHG reductions. Table 1 provides a brief summary of these technologies.

Solar Thermal Systems
Many are looking to solar thermal systems—which convert the sun's radiation into usable heat—as a means of sharply reducing natural gas consumption. Typical solar thermal systems employ lenses, a concentrating mirror, or any of an array of emerging technologies to concentrate sun's radiation. This concentrated heat in turn heats a fluid (often water/glycol mixtures or mineral oils) to almost 400℉ or higher. The hot fluid is then fed into a boiler to generate steam or hot water for process needs instead of on-site natural gas combustion or to generate electricity.

These solar thermal steam generators eliminate the need for much of the natural gas now consumed by most of the boilers and heaters used in the process industry and commercial buildings in California—a reduction that directly decreases GHG emissions.

Commercial and industrial users can currently expect a payback of five to ten years. That payback period will likely shrink as costs are assigned to GHG emissions, lowering a primary barrier to implementation. An interesting opportunity may occur if new electricity generation cross-fertilizes with other sectors with significant thermal and electrical needs. Many of the current cost reducing innovations (new materials, modular installation) taking place are specific to smaller scale hot water and steam systems. The RPS standards driving the solar thermal electricity generation sector is resulting in some spill-over in that the companies drawn to that market-place are also expanding into systems for commercial/industrial customers. It is a reasonable expectation that future specific technology developments for the electric generation sector can spill-over into customer scales steam, hot water, and even electric generation from solar.

Benefits to California companies include cost-savings and improved competitiveness for companies that adopt this technology, potential for increased job density in California when imported fuels are displaced, and installer and other potential jobs. Lastly, the ETAAC is currently evaluating whether additional measures are necessary to support this technology.

Wastewater Treatment
Technologies now coming to market can decrease the energy consumed in wastewater treatment and open the door to interrelated approaches that reduce the GHG—primarily methane—released from wastewater treatment processes.

Wastewater treatment falls primarily into two categories:

- **Municipal systems:** Taking the form of either a plant or a large lagoon (where land is available), municipal systems are operated by a city or county and receive waste from the municipal sewer system, which generally mixes wastes from many residential, commercial and industrial sources.
- **Industrial systems**: Typically smaller lagoons, industrial systems are operated on-site at an industrial or food processing facility. These systems treat waste generated only by that facility prior to discharge to land, water, or sewer.

Both municipal and industrial systems depend on two principal methods for treating wastewater: aerobic and anaerobic. The aerobic process treats waste in the presence of oxygen (supplied by electrically powered aerators); anaerobic digestion treats waste in the absence of oxygen. GHG emissions result from both the electricity required to power the treatment processes and from the treatment process itself, which can generate "fugitive" GHG emissions. Aerobic treatment generates CO_2, and anaerobic treatment generates methane (CH_4), a much more potent GHG than CO_2. The methane produced in the anaerobic treatment process can be flared or used for onsite generation, where the combustion process turns the methane into less potent CO_2.

Solar-powered water circulators and other new technologies aim to reduce the electricity needed in lagoon processes. However, technologies that capture fugitive emissions—especially methane—and enable its re-use to generate heat or fuel processes could yield far greater GHG reductions. Strict GHG regulations are needed to drive research and development of, and market shifts toward, technologies that improve methane capture at a variety of points, from sludge handling and treatment through anaerobic digestion. Such technologies include cogeneration systems, gas purification technologies, and anaerobic digestion systems. Also needed is additional research to address the challenging problem of quantifying GHG savings from reductions in fugitive emissions.

Increased use of anaerobic digestion can increase the supply of electricity and can result in wastewater solids or process waste (food scraps) having economic value. Technologies to reduce the energy use of aerobic treatment can reduce operating cost for wastewater treatment processing, and create jobs and business opportunities for the companies supplying those solutions.

Industrial and Commercial Refrigeration
Replacing today's refrigerants with new fluids specifically fabricated for low global warming potential (GWP) appears a straightforward approach to reducing GHG. However, some caution is merited. Currently, the performance of these new GWP refrigerants is not well understood, and most commercial and industrial refrigeration systems are custom engineered. Systems based on the new refrigerants are therefore likely to be more expensive and time-consuming to design and install than are conventional systems—and may not perform to targeted levels.

Further, changing the refrigerant may lead to either a small increase or decrease in refrigeration system energy use. The challenge—and opportunity—lies in influencing customers to engineer systems that simultaneously reduce energy use and GHG emissions. These benefits can come from coordinating GHG regulations limiting high-GWP with energy-efficient equipment redesigns.

The potential GHG reductions promise to be significant. For example, replacing 1 pound of conventional refrigerant (such as R-744) with one pound of low GWP refrigerant can reduce GHG by 3,784 tons.

Solid-State Lighting
Because lighting accounts for so much of overall energy use, expectations are high for the next generation of lighting technologies. By saving energy, such technologies will also lead to decreased GHG. Solid-state lighting—comprising light-emitting diode (LED) and organic light-emitting diode (OLED) technologies—is the exclusive focus of Department of Energy (DOE) lighting research. Similarly, private companies based the majority of new products displayed at Lightfair 2009—the lighting industry's premier event—on solid-state technologies.

However, reliable, low-cost, high-performing products for many consumer applications may still be years away. And as LED technology advances, conventional technologies will also improve, narrowing the comparable benefits of solid-state options – although there is less room for improvement on existing technologies. Perhaps even more significant, the price of LED fixtures is not likely to compete with that of fluorescents in the near term except in applications where superior longevity yields other cost savings.

California's high tech infrastructure and entrepreneurial culture has fostered numerous solid-state start ups and as noted in chapter two lighting is one of the main sectors for "green" jobs in California. The California presence tends to focus on R&D and product development, as well as serving as a beach-head for U.S. sales and marketing. The major international LED chip manufacturers are Nichia, Seoul Semiconductor, Osram Sylvania, Phillips, GE, and CREE; the major U.S. fixture manufacturers (LED integrators) are Hubbell, Acuity, Cooper Industries, and Phillips Lighting. Developing the California market may help pull this technology to full commercialization and set a leadership example for others to follow.

Home Area Networks
Sometime in the not-too-distant future, homes across the U.S. may be equipped with smart networks—called home area networks or HAN—that give consumers near real-time information on their electricity usage. Studies have shown that real-time usage information not only heightens awareness, but can often trigger behavior changes that

result in lower energy use, and thus, GHG reductions. These changes can be in the simple form of turning off devices and/or unplugging them to more complex methods, such as using an energy management system to turn appliances off/on in response to pricing and other signals provided by the energy provider. Furthermore, consumers can obtain device level consumption information of specific appliances to identify "energy hogs" which can lead to energy efficiency measures, such as replacing equipment with newer equipment of a leaner energy profile.

DOE has identified ZigBee+HomePlug SE 2.0 as the Smart Grid communication standard within consumer premises. Still under development, this standard may be available in consumer devices as early as 2011. Smart meter infrastructure, now available and being installed in many areas, is a key requirement for HAN deployment. This technology can also move into the business and industrial sectors in California, helping improvement their competitiveness by helping them identify and reduce wasted energy and improved process management. While California does not have a large manufacturing market share for related technologies such as Smart Meters and programmable thermostats, there is important potential for economic development in California for software development and other applications.

In addition, while many of the component technologies required to implement HAN are available and reasonably well-understood, the full set of standards required to enable integration and broad-based interoperability are still not yet mature. That said, countless standards bodies with broad industry participation (e.g., OpenHAN) are actively working to develop and refine these standards. The state and federal governments can support these efforts by endorsing/funding HAN-related initiatives that are consistent with (and reinforce) the emerging standards. Furthermore, funding of additional resources to support work on standards will also likely accelerate the development timeline.

Zero-Net Energy Homes and Commercial Buildings

Two of the big bold strategies advanced in the CPUC's Strategic Plan focus on zero-net energy (ZNE) buildings. Specifically, the Plan envisioned that all new homes would be ZNE by 2020 and all new commercial construction would be ZNE by 2030. The CPUC defines ZNE as " . . . a combination of building energy efficiency design features and on-site clean distributed generation that result in no net purchases from the electricity or gas grid, at the level of a single 'project' seeking development entitlements and building code permits."[1] Because ZNE buildings would use far less energy than conventional buildings, their GHG footprint would be considerably smaller.

This broad definition enables utility programs charged with making ZNE construction a reality to analyze and implement a wide range of energy efficiency and renewable options. At the most basic level, these programs aim to design buildings with very low energy demand and distributed renewable generation technologies to generate enough energy to net out those loads, usually on an annual basis.

Reducing building loads will require advances in construction materials, systems, and technologies, as well as in design processes and strategies for integrating these elements. For example, advanced building envelope design and construction methods lower the overall need for heating, cooling, and lighting; advanced lighting and HVAC

[1] Interim Opinion on Issues Relating to Future Savings Goals and Program Planning for 2009-2011 Energy Efficiency and Beyond, Decision 07-10-032, October 18, 2007, page 38.

systems can meet the lower demand more efficiently and appropriately than today's systems; and integration of all can weave together individual systems to enhance the energy performance of the structure as a whole. Also needed is optimum integration with the renewable generation technology—at either the project site or a remote location—selected to net out the low building loads. Thus achieving ZNE will require maintaining a consistent vision of design and performance goals throughout the entire design and construction process.

Building energy use is a large percentage of national energy consumption; significant reductions in the loads of zero net energy projects will result in corresponding greenhouse gas reductions. Ultimately, as advanced building systems, technologies, and design strategies evolve and transform the market, they will become part of standard design practice, pushing the built environment towards the big bold CPUC goals.

Table 1. Promising Advanced Energy Efficiency Technologies

Technology	Market Introduction/ Penetration Timeline	Location of production	GHG Reduction Potential	Implementation Strategy	Barriers to Implementation	Impact on CA economy
Solar thermal (steam)	1-5 years		600 MM therms/yr x 0.0053 MT CO_2/therm = 3.19 MMT CO_2/yr (derived from CARB Scoping Plan 2009)	CA energy efficiency Programs, CA Solar Initiative	First cost, lack of experience with technology	
Solid State Lighting	2007-2020	Primarily outside USA	Technical potential of 189 TWh for U.S. (DOE/ Navigant 2008)	Partnership with DOE Consortium	Relative size of near term market potential (lack of qualified product & high initial cost).	Creation of R&D positions and installer jobs
Efficient Aerobic Treatment for Wastewater Lagoons	Currently in the market		1,000 GWh/yr x 0.00044 MT CO_2/kWh = 0.44 MMT CO_2/yr (derived from CARB Scoping Plan 2009)	CA energy efficiency programs	First cost, lack of experience with technology	Job creation and system manufacturing opportunities
Low GWP Refrigerant	1-5 years		1 lb low GWP refrigerant can reduce GHG by 3,784 tons compared to 1 lb of a typical CO_2 refrigerant, such a R-744; Note: *use of R-744 is in "its infancy". As of early 2008, 9 systems were using R-744 for in use in the*	GHG regulations	Limited understanding of new refrigerant performance characteristics	Minimal impact

			entire US.			
Home Area Network	2010-2011		May lead to up to a 6% reduction in energy use	CA IOU proof of concept demonstrations expected in 2010	Standards still in development. Enabling technology, HAN Gateway (located in the SSN SmartMeter), is required.	Potential increased business competitiveness; software and related applications

Lessons Learned and Policy Recommendations

Decades of ground-breaking work in energy efficiency and emissions reductions have provided California a rich lexicon of lessons learned. The current push for GHG mitigation can draw on this body of knowledge to speed and optimize efforts. This section briefly touches on a partial list of lessons and recommendations that might be incorporated into action or policy.

Increased Collaboration
First, collaboration will be critical to achieving GHG goals efficiently and rapidly. As noted in the *Scoping Plan,* "Successful implementation of many of the proposed programs and measures described in this plan will require strong leadership and a shared understanding of the need to reach viable and lasting solutions quickly. This challenge will also require establishing a wide range of partnerships, both within California and beyond our borders." (*Scoping Plan,* page 113) As noted earlier the path to successful developing a new technology can be short-circuited by a lack of coordination at a number of points. ETAAC can work with existing organizations[2] to flag coordination issues.

A first step to building these partnerships would be to increase communication and collaboration among the multiple agencies and organizations described in the first section of this chapter. Helping these organizations effectively integrate GHG reduction goals into their efforts would help ensure the success of this GHG mitigation effort.

The ETAAC is evaluating specific recommendations for how various agencies should coordinate and collaborate.

Guidance on AB 32 Implementation
As implementers of energy efficiency programs, the IOUs would greatly benefit from clear guidance from the CPUC and CARB on AB 32, particularly on the effects of AB 32 implementation on eligibility for California ratepayer-funded incentives. As discussed in the previous report, this effort might draw on the precedents established for other statewide efforts, such as the Governor's Green Building initiative. The bottom line is that all stakeholders need to be accountable for achieving energy savings targets and GHG reductions. To the extent that IOUs leverage CPUC-authorized energy efficiency programs using ratepayer funds, the stakeholders, CPUC, CEC, ARB, and IOUs should collaborate to reach agreement on attribution so that parties can claim savings from projects that are also mandated to achieve GHG reductions.

Leverage of Federal Stimulus Funding
The American Recover and Reinvestment Act (ARRA) is making $38.6 billion available for energy efficiency nationally. Of this, California expects to receive $ 798 million, to be distributed through numerous agencies, including DOE, CEC, Housing and Urban Development, Department of Agriculture, and General Services Administration. Part of the funding coming to California includes $3.2 billion from DOE slated for block grants to local governments. This money can help pay for energy efficiency retrofits using

[2] For example, the Investor-Owned Utilities in California coordinate through a standing committee.

advanced technologies. By leveraging stimulus dollars with utility funded-incentives (as long as the utility is offering an incentive on the technology), government, residential, and commercial customers can cover most, or perhaps even all, all of the incremental costs of an energy efficient project - a barrier that ETAAC has recognized as both prevalent and significant. Incentive programs can also help overcome information barriers, which can be especially effective when combined with incentives. Given the inflow of these funds, no time is better than the present to begin to realize GHG reductions from energy efficiency projects funded by stimulus funds and push forward the development of promising energy efficiency advanced technologies such as those identified earlier.

Incorporating Pending Federal Legislation
As part of ongoing efforts to revamp federal energy legislation and create federal climate policy, the House of Representatives has passed HR 2454: The American Clean Energy and Security Act of 2009, and the Senate is debating a similar bill. The final legislation, when enacted, will undoubtedly affect California's energy efficiency and GHG mitigation efforts, and managing these impacts may present challenges. In all likelihood this legislation will explicitly or implicitly promote emerging technologies in specific areas.

As an example of these challenges, the following summary examines HR 2454 measures related to lighting, appliance and building technologies:

Lighting and Appliances:

- More stringent HR 2454 appliance standards, and associated policies and procedures, could increase energy efficiency savings for the state, for measures where federal standards currently preempt the State from advancing its own standards.
- California Title 20 appliance standards are same as federal standards, except where:
    - No federal standard exists, in which case California can develop a state standard
    - California has a specific exemption from federal preemption, allowing the State to implement a more aggressive standard.
- HR 2454 exempts California from federal preemption on several new appliances, allowing California to pursue more stringent standards for these appliances.

Building Technologies:

- California would need to implement several measures proposed in HR 2454, such as a program to retrofit entire buildings and a building energy performance labeling program. The labeling program would require significant state effort to achieve the desired 90% compliance. Efforts could include hiring inspectors, creating manuals, providing training, etc. Failure to comply could result in loss of funding and carbon credits.
- Local building code offices may be eligible to receive proposed HUD grants for local code enforcement agencies.
- Due to differences between proposed federal and California existing building code timetables, California would not be compliant with national commercial building standards until year 2 of the federal timetable. However, California would be compliant with national residential building standards in year 1.

In addition, the ETAAC is currently evaluating the following topics:

- Absent policy initiative, valuable efficiency opportunities will be missed
- Standards have been effective at overcoming a number of market barriers. Standards can also be effective at overcoming market barriers to advanced technology development
- Energy efficiency opportunities are not finite; new opportunities are likely to open up as new technology is developed
- Accurate measurement will be critical to enable energy efficiency