ETAAC Report Recommendations Related to Advanced Technology Development

Sector	Page	Recommendation
Introduction	1-4	create a balanced portfolio of economic and technology policies
Finance	2-7	encourage RD&D (see also p9-4)
	2-11	support demonstration finance
	2-12	target RD&D funding for carbon reductions
	2-18	cleantech workforce training
Transportation	3-6	increase transportation sector RD&D
	3-23	new vehicle technology improvements
	3-26	low carbon fleet standards and procurement policies
Industrial, Commercial, Residential Energy Use	4-3	rebates for load reduction
	4-6	distributed renewable energy: solar PV
	4-11	industry-government partnerships to reduce industrial energy intensity
	4-12	revolving fund for technology demonstration projects
Electricity/Natural Gas	5-5	aggressive LED energy efficiency
	5-12	renewable energy technology assessments
	5-15	electricity storage as enabling technology for renewable energy
	5-19	smart grid as enabling technology for renewables & vehicles
	5-21	carbon capture and storage
Agriculture	6-3	manure-to-energy
	6-6	enteric fermentation
	6-7	agricultural biomass utilization
	6-11	soil carbon sequestration
	6-17	fertilizer use and water management efficiency
Forestry	7-7	forest sector RD&D needs

Appendix II - California and Other Programs That Support Technologies to Reduce Global-Warming Emissions

This Appendix updates the original February 2008 ETAAC report appendix summarizing technology development programs. The programs listed herein support four functions on the path from research to commercial application for technologies that can reduce global-warming emissions. The functions are:

1. Basic technology research
2. Development (R&D) of new or improved technology
3. Demonstration of new or improved technology
4. Installation or operation of proven technology (including site-specific projects to reduce energy use)

The list does not include grant programs for education, training, or market development for new technologies.

This list includes programs funded at least in part by the American Recovery and Reinvestment Act (ARRA) of 2009. Often, funds from that act are short-term augmentations to pre-existing programs on the list. However, much of the funds from the act are offered via new one-time solicitations by the US DOE's Office of Energy Efficiency and Renewable Energy. That office's ARRA program can be read at www1.eere.energy.gov/recovery/. A few of the solicitations by the office are included in this list, but most are most efficiently viewed by going to that web site. Many have already been closed, while some have not yet been announced.

For functions 1, 2, and 3, the support offered by a listed program may be offered as grants (usually), contracts, or investments. For the installation or operation of technology, the support may be offered as loans but is usually offered as subsidies ("incentives").

Each listed program supports projects in prescribed technical areas, industries, and/or types of emission sources. These are shown in the table "Summary of Programs" in the column "Eligible Business/Technical Areas"

The economic sectors wherein the supported technologies may be applied are classified as:

- Agriculture and forest products
- Energy production
- Energy use
- Transportation
- Industrial

Some of the listed programs are directed against global-warming emissions, specifically. Others (e.g., the Carl Moyer Program) are directed at other types of emission problems but also can foster reductions of global-warming emissions. Some of the listed entities are program directories, rather than actual support programs, *per se*.

All the listed programs are available at regional (multi-county), state, or national levels. The list does not cite individually the incentive (subsidy) programs run by cities, counties, municipal utility districts, or (with a few exceptions) the large regulated utilities. These local and utility programs are catalogued at "California Incentives for Renewables and Efficiency", www.dsireusa.org/incentives/index.cfm?re=1&ee=1&spv=0&st=0&srp=1&state=CA, which provides web links to them.

Except as specifically noted, the information shown here was obtained from the web sites cited for the programs in the Summary table and web documents linked from those sites.

Program: **Alternative and Renewable Fuel and Vehicle Technology Program (**AB 118)
http://www.energy.ca.gov/altfuels/

Sponsor: California Energy Commission

Funding source: Vehicle registration fees

Eligible business and technology areas: See "funding"

Functions supported: No information

Type of support: *Economic sectors affected:* Transportation, energy production

Geographic limits:

Funding:	Electric Drive	$46 million
	Hydrogen Fueling Stations	$40 million
	Biodiesel	$6 million
	Ethanol	$12 million
	Natural Gas	$43 million
	Propane	$2 million
	Market & Program Development	$27 million

Grant amount: No information

Grants as % of applications: No information

Overview

Assembly Bill 118 (Núñez, 2007) created the Alternative and Renewable Fuel and Vehicle Technology Program. The statute authorizes the California Energy Commission to spend up to approximately $120 million per year over seven years to "develop and deploy innovative technologies that transform California's fuel and vehicle types to help attain the state's climate change policies."

The statute, amended by Assembly Bill 109 (Núñez, 2008), directs the Energy Commission to create an advisory committee to help develop and adopt an Investment Plan to determine priorities and opportunities for the program, and describe how funding will complement existing public and private investments, including existing state and federal programs. The Energy Commission will use the Investment Plan as a guide for awarding funds. The statute calls for the Investment Plan to be updated annually.

Program: **California Clean Energy Fund** (CalCEF, "Fund 1") www.calcef.org

Sponsor: CalCEF (non-profit)

Funding source: PG&E bankruptcy settlement

Eligible business & technical areas: Renewable fuels, energy efficiency, energy storage, clean fossil fuels, green buildings

Functions supported: Business finance

Type of support: Investment (venture capital)

Economic sectors affected: Energy production, energy use, transportation

Geographic limits: PG&E service territory

Funding: $30 million (total)

Grant amount: No information

Grants as % of applications: No information

Overview

CalCEF is a non-profit organization that makes equity investments in emerging clean-energy technology companies. Funds are invested in private companies that are creating technologies or products that should reduce reliance on non-renewable fuels. These include companies that focus on renewable energy, better energy efficiency, and energy storage. They also include companies that provide products and services, such as software, that are designed to enhance some aspect of the clean-energy sector. CalCEF acts as a critical funding source for emerging clean-energy companies that are too young to access traditional venture capital.

The Fund arises from the PG&E bankruptcy settlement negotiated by the California Public Utilities Commission. CalCEF invests in companies located in PG&E's service territory and elsewhere that are developing technology or products that could benefit the service territory.

Measures of Effectiveness

No information

Program: **California Solar Initiative** www.gosolarcalifornia.ca.gov/

Sponsors: Calif. Public Utilities Commission (CPUC)

Funding source: Rate-payers of PG&E, SDG&E, and SCE

Eligible business & technical areas: Photovoltaics and solar heating in commercial buildings and existing homes

Functions supported: Installation

Type of support: Incentives (subsidies)

Economic sectors affected: Energy production

Geographic limits: Service territories of PG&E, SDG&E, and SCE

Funding: $2.16 billion over 10 years (2007-2016)

Grant amount: For >100 kW: $.03 - $.50 / kW-hr; for <100 kW: $0.20 - $3.25 / W

Grants as % of applications: First come, first served

Overview

CPUC's California Solar Initiative, provides subsidies for installing or using photovoltaic power systems in existing residential homes and existing and new commercial, industrial, and agricultural properties. All utility customers who do not receive subsidies for distributed generation, do not pay at interruptible power rates, and do not resell power are eligible.

Measure of Effectiveness

The goal for the program is 3,000 MW of new photovoltaic capacity installed by 2017. Thirteen percent of the goal has been installed.

For systems > 50 kW, payments are made per kW-hr produced. Thus, payment is for "performance".

Program: **California Solar Initiative R&D** (proposal) www.calsolarresearch.org/

Sponsor: California Public Utilities Commission (PUC)

Funding source: Utility rate payers

Eligible business & technical areas: Photovoltaic distributed generation

Functions supported: Mostly demonstration; also R&D and deployment

Type of support: Grants, incentives

Economic sectors affected: Energy production

Geographic limits: California

Funding: $50 million over 10 years

Grant amount: $0.2 to $3 million

Grants as % of applications: No experience yet

Overview

The PUC will initiate a program to promote photovoltaic distributed generation. The intended outcomes are to:

- Move the market from the current retail solar price of $9/watt or about 30 cents/kWh to levels that are comparable to the retail price of electricity.
- Install increasing volumes of solar DG that build from the current range of 160 MW per year to 350 MW or more per year.

The current (first) solicitation offers up to $15 million for the integration of photovoltaics into the utility grid.

Measures of Effectiveness

No projects have been funded yet.

Program: **Carl Moyer Memorial Air Quality Standards Attainment Program**
www.arb.ca.gov/msprog/moyer/moyer.htm

Sponsor: State of California (administered by AQMDs and CARB)

Funding source: Vehicle registration fees, State grants

Eligible business & technical areas: NOx, PM, and ROG reductions from commercial and government vehicle fleets

Functions supported: Replacement and retrofitting

Type of support: Incentives(subsidies)

Economic sectors affected: Agriculture & forest products, transportation

Geographic limits: California

Funding: $140 million per year

Grant amount: Buses, farm equipment, agricultural. pumps--$12,000 per unit (avg.)
Marine vessels, construction equipment--$50,000 per unit (avg.)

Grants as % of applications: No information

Overview

The Carl Moyer Program provides subsidizes the incremental cost of cleaner-than-required engines and equipment. ("Cleaner" is in reference to emissions of ozone precursors and PM. Greenhouse gases are not addressed. However, to the extent that fuel economy is improved by replacing or retrofitting old engines, the program indirectly provides reduced CO_2 emissions.) Eligible projects include cleaner engines for on-road and off-road vehicles, marine vessels, locomotives, and stationary agricultural pumps, as well as for forklifts, airport ground support equipment, and auxiliary power units. The program also supports light-duty vehicle scrapping. Grants are based on the cost-effectiveness of the capital cost of achieving super-regulatory emission reductions. Determinations vary by air-quality management district.

Measures of Effectiveness

The Carl Moyer Program measures reductions of criteria and toxic pollutants achieved in excess of reductions that are occurring from regulatory compliance. Grants are based in part upon the emission reductions to be achieved according to prescribed procedures of calculation. Those reductions must cost less than prescribed amounts, per ton of reduction.

Calculations and statistics for cost per ton have not been kept for reductions of greenhouse gas emissions that have been incidental to reduced criteria and toxic emissions.

Program: **Driveclean.CA.gov** (directory of programs)
www.driveclean.ca.gov/en/gv/driveclean/demoprog.asp

Sponsors: Several government agencies

Funding source: Particular to the agency providing the incentive

Eligible business & technical areas: Electric, hybrid, and CNG vehicles

Functions supported: Purchase and use

Type of support: Incentives (subsidies)

Economic sectors affected: Transportation

Geographic limits: Particular to the agency providing the incentive

Funding: Particular to the agency providing the incentive

Grant amount: Particular to the agency providing the incentive

Grants as % of applications: No data available

Overview

Various incentives for purchasing EVs, hybrids & CNG vehicles, their fueling infrastructures, and parking such vehicles are available from governmental agencies. These are provided by federal, regional, local governments.

Measures of Effectiveness

No information

Program: **Electric Drive Programs in Asia**

China Electric Drive Vehicle Programs

Purpose: China wants to raise its annual production capacity to 500,000 hybrid or all-electric cars and buses by the end of 2011 from 2,100 in 2008. (By comparison, CSM Worldwide, a consulting firm that does forecasts for automakers, predicts that Japan and South Korea together will be producing 1.1 million hybrid or all-electric light vehicles by then and North America will be making 267,000.)[1]

China is also seeking to reduce dependence on foreign oil imports.

Barriers Targeted: Capital costs, infrastructure (such as charging stations).

Funding Level & Source(s): No information on total funding has been located.

Geographic scope: Vehicle purchase incentives are targeted to specific cities as described below.

Description:

- *Infrastructure*. The state electricity grid has been ordered to set up electric car charging stations in Beijing, Shanghai and Tianjin.

- *Purchase incentives:* Subsidies of up to $8,800[2] are being offered to taxi fleets and local government agencies in 13 Chinese cities for each hybrid or all-electric vehicle they purchase.

- *Manufacturers:* China has a $1.5 billion dollar (10 billion yen) program to help the industry with automotive innovation.[3] Shanghai Automotive Industrial Corportaion (SAIC) will invest more than $1.7 Billion US (12bn Yuan) in hybrid and electric power-trains with municipal government support through subsidies, purchasing and helping SAIC and the local supply chain in R&D and training.[4]

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[1]New York Times, April 1, 2009, China Vies to be World's Leader in Electric Cars", by Keith Bradsher, accessed at http://www.nytimes.com/2009/04/02/business/global/02electric.html?_r=1&scp=1&sq=china%20electric%20vehicle&st=cse
http://economistonline.blogspot.com/2009/04/chinas-electric-car-ambition.html

[2] http://www.businessweek.com/globalbiz/content/apr2009/gb20090421_725638.htm

[3] "China Outlines Plans for Making Electric Cars", New York Times April 10, 2009, by Keith Bradsher. Accessed at http://www.nytimes.com/2009/04/11/business/energy-environment/11electric.html?scp=3&sq=china%20electric%20vehicle&st=cse

[4] Automotive Wold.com Environment, July 2009, p8.

Success Overcoming Barriers:
Due to the recent or in-progress nature of these programs, it is not yet possible to judge their ultimate success.

A report by McKinsey & Company last autumn estimated that replacing a gasoline-powered car with a similar-size electric car in China would reduce greenhouse emissions by only 19 percent. It would reduce urban pollution, however, by shifting the source of smog from car exhaust pipes to power plants, which are often located outside cities.

Japan Next Generation Battery Development Project

Purpose: Program goals for the Next Generation Battery Development Project include reduced oil consumption & imports, technology development, and protecting Japan's competitive advantage manufacturing advanced technology batteries.

Barriers Targeted: Capital costs, infrastructure (such as charging stations), standards (safety& regulatory).

Funding Level & Source(s): Funding levels for 2008 are a sub-set of the overall $470 million US ($45 billion yen) funding for both battery-electric and fuel cell vehicles.

Geographic scope: National, implemented by the New Energy and Industrial Technology Development Organization (NEDO).

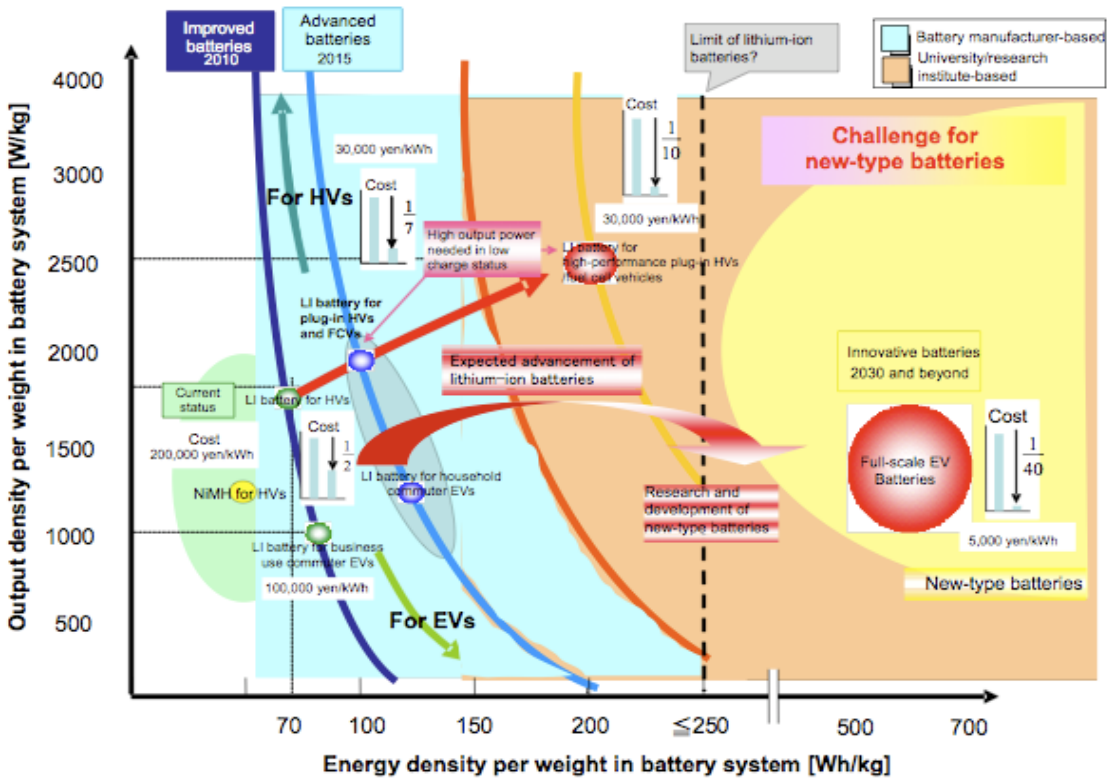
Description:

- *Infrastructure*. The program addresses safety standards, battery interface with charging stations, rate structures for electricity used to power vehicles, financial support for battery charging infrastructure. The program also supports battery mass-production, and incentives for next-generation vehicles.[5]
- *R&D*. The program will focus on industry-government-academia collaboration on research and development for producing low-cost/high-performance batteries for next-generation vehicles and renewable electricity.

Success Overcoming Barriers:

No information has been located.

[5] Source for graphic & information: NEDO 2006


Improved batteries 2010
Advanced batteries 2015
Limit of lithium-ion batteries?
Battery manufacturer-based
University/research institute-based
Challenge for new-type batteries
For HVs
Cost 1/7
30,000 yen/kWh
Cost 1/10
30,000 yen/kWh
High output power needed in low charge status
LI battery for high-performance plug-in HVs /fuel cell vehicles
LI battery for plug-in HVs and FCVs
Expected advancement of lithium-ion batteries
Innovative batteries 2030 and beyond
Current status
LI battery for HVs
Cost 200,000 yen/kWh
Cost 1/2
NiMH for HVs
LI battery for household commuter EVs
Research and development of new-type batteries
Full-scale EV Batteries
Cost 1/40
5,000 yen/kWh
New-type batteries
LI battery for business use commuter EVs
100,000 yen/kWh
For EVs
Output density per weight in battery system [W/kg]
4000
3000
2500
2000
1500
1000
500
70
100
150
200
≦250
500
700
Energy density per weight in battery system [Wh/kg]

Korea Electric Drive Vehicle Programs

Purpose: There are several programs for the development of electric-drive vehicles.

Barriers Targeted: Capital costs, infrastructure (such as charging stations)

Funding Level & Source(s): Total amount is assumed to be about 30 million dollars per year funded by the government's Ministry of Commerce and Ministry of Science and Technology) for development of electric-drive vehicles

Geographic scope: Vehicle purchase incentives are targeted to specific cities as described below.

Description: The infrastructure and demonstration program for the EV will start from next year. A preliminary project is being conducted now.

Consumer incentives for EV and PHEV are not available yet but are under development. Incentive programs for the HEVs are in operating now. Up to US $2,500 (3,100,000 won) can be deducted from the national tax and/or district tax.

A consultative group of government institutions and manufacturers involved in the auto industry will reportedly be launched for electric car development and infrastructure, while LG Chem separately announced that it will invest approximately $800 million (1 trillion won) to manufacture EV batteries for GM.[6]

Success Overcoming Barriers:
Due to the recent or in-progress nature of these programs, it is not yet possible to judge their ultimate success.

[6]Automotive Wold.com Environment, July 2009, p4

Program: **Electric Drive Programs in Europe**

United Kingdom Low Carbon Vehicle Innovation Platform

Purpose: The purposed of this program is to promote low carbon vehicle research, development and demonstration in the United Kingdom (UK) and deliver:

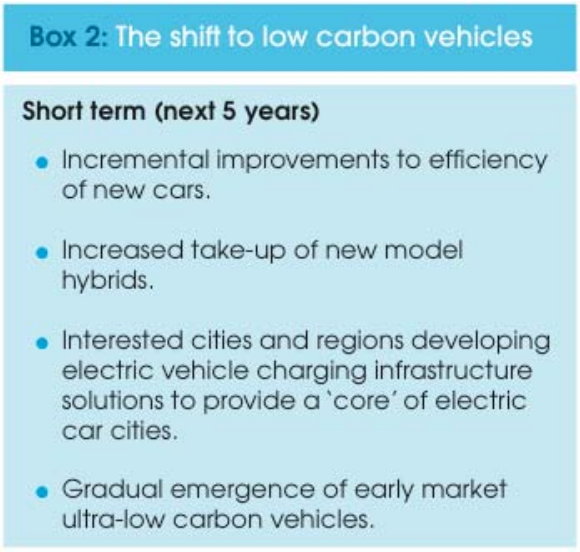
- Carbon reduction in domestic and international vehicle markets
- Introduction of low carbon vehicles faster than markets would deliver on their own
- Benefits to the UK automotive sector from growing domestic and international demand.[7]

Barriers Targeted: Demonstration, infrastructure, capital costs, as well as R&D barriers.

Funding Level & Source(s): The UK government has about $660 million US (£400 million) for the development & deployment of ultra-low carbon vehicles, with additional funding from industry sources, and another approximately $3.8 billion US (£2.3 billion) to assist automaker transitioning to zero and low carbon vehicles.

Geographic scope: National.

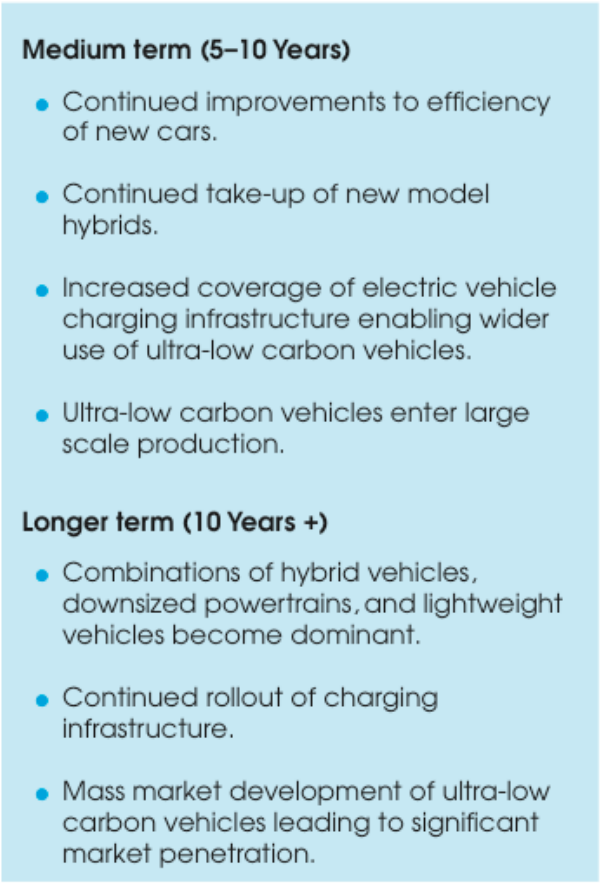
Description: First, about $40 million US (£25m) in R&D awards have been issued for internal combustion engines, hybrid and hybrid-electrics, and technologies that improve the efficiency of vehicles in general (such as lightweight materials). Additional applications for funding applications for electric and hybrid vehicle market development are under review (Note that hydrogen fuel cells for both stationary and transportation applications are covered by a different program.[8])



Second, the "Integrated Delivery Programme" is a new £200m investment jointly funded by Government and business to help speed up the introduction of new low carbon vehicles onto Britain's roads. The Programme will co-ordinate the UK's low carbon vehicle activity from initial strategic research through collaborative research and development, leading to the production of demonstration vehicles, through:

[7] http://www.innovateuk.org/ourstrategy/innovationplatforms/lowcarbonvehicles.ashx
[8] http://www.innovateuk.org/_assets/pdf/competition-documents/fuel%20cells%20and%20hydrogen%20technologies_071008.pdf

- University-based research targeted towards future technologies with good long-term commercialization prospects.
- An industry-led advisory panel of representatives of leading elements of the UK automotive industry and low carbon vehicle technology developers, as well as relevant academic experts
- Flexible rolling opportunities for industry to seek support for high quality collaborative research and development proposals which take technology through to system or vehicle concept readiness
- Funding to support demonstration of particularly innovative lower carbon vehicle options.



Third, the associated ultra low carbon vehicle demonstration competition aims to demonstrate new and emerging low carbon vehicle technology in real world situations. £25m in funding to demonstrate 340 vehicles was announced in June and provided some of the costs for business-led demonstration projects of vehicles with tailpipe emissions of 50g CO2/km or less and a significant zero tailpipe emissions range. Most of these vehicles will be on the road by the end of 2010.

The program is intended to reduce prices of electric and plug-in hybrid vehicles by £2000-£5000, or up to approximately $8,000 US, and compliment approximately $3.8 billion US (£2.3 billion) in assistance to the automotive industry for transitions to zero and low carbon vehicles.

In addition, the London congestion charge, which exempts electric vehicles, is an additional incentive for electric vehicles in that region.

Success Overcoming Barriers:
Due to the recent or in-progress nature of these awards, it is not yet possible to judge their ultimate success.

Sources: http://www.berr.gov.uk/files/file51017.pdf, http://www.innovateuk.org/ourstrategy/innovationplatforms/lowcarbonvehicles.ashx

German Vehicle Electrification – draft 10/6/09

Purpose: The German government has set a goal of putting one million vehicles with electric car technology on the road by 2020 and becoming a leader in electric car technology.[9]

Barriers Targeted: Infrastructure, capital costs; consumer incentives for market development receive a significantly lower funding level

Funding Level & Source(s): The German government has allocated over $700 million US (€500 million) for electric and hydrogen vehicles plus a $200 US (€140) tax exemption for purchases of electric cars[10]. Industry partners are expected to contribute approximately $530 million US (€360 million) for battery research.

Geographic scope: National

Description: The plan includes a large amount of economic stimulus funding for advanced battery development, investment in an electric car charging infrastructure, and tax credits for the adoption of electric cars and plug-in hybrids. Conceived by four separate German agencies — the departments of Economics, Transport, Environment, and Education/Research — the plan is on track to be signed into actual law at the beginning of the next German legislative session. The funding is aimed at industry rather than individual consumers.

German auto manufacturers have been developing electric and plug-in hybrids over the last several years. Mini is the first German auto manufacturer to come to market with an electric car, the Mini E, but both Daimler (electric Smart car) and VW (Golf Twin Drive) have electric or plug-in hybrid vehicle prototypes as well.[11]

By 2015 scientists working under the umbrella of the "Innovation Alliance" are to develop a new generation of powerful, affordable, safe, long-life batteries. The Federal Ministry of Education and Research (BMBF) is contributing approximately $100 million US (60 million Euro) to promote the development of this "highly attractive, forward-looking technology". Partners in industry will be investing about another $530 millino US (360 million Euro) in the research program. The Federal Ministry of Education and Research (BMBF) is now funding a consortium of selected universities and non-university research institutions in southern Germany coordinated by Forschungszentrum Karlsruhe and will

[9] http://www.bloomberg.com/apps/news?pid=20601130&sid=aoAKCL5tpAeU

[10] http://www.businessweek.com/globalbiz/content/apr2009/gb20090421_725638.htm

[11] http://gas2.org/2008/11/28/germany-wants-one-million-electric-cars-on-the-road-by-2020/

be granted 20 million Euros from the Economic Stimulus Package II for Gemany to reach a top level in international electrochemistry research again.[12]

In addition an e-mobility project will provide some 500 charging points in Berlin from RWE. Daimler will provide more than 100 electric cars from Mercedes-Benz and smart. Users will pay for the electricity via a special in-car communication system, probably an RFID chip, and the intelligent charging point. The project is being supported by the German federal government as well.[13]

Success Overcoming Barriers:
Due to the recent or in-progress nature of these programs, it is not yet possible to judge their ultimate success.

France

Purpose: Develop and deploy electric-drive vehicles and electric charging stations.

Barriers Targeted: infrastructure, market development, capital costs.

Funding Level & Source(s): $500 million US (€400 million) from the national government.

Geographic scope: National

Description: French carmakers Renault SA and PSA Peugeot Citroen have announced separate agreements with energy company Electricite de France (EdF) to develop and market green vehicles. In a joint statement with EdF, Peugeot Citroen said that their scheme will support the development of electric vehicles (EVs) and plug-in hybrids. Meanwhile, the Renault agreement will advance the development of an EV charging infrastructure, enabling a country-wide vehicle launch in 2011.[14]

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[12] http://www.germanyandafrica.diplo.de/Vertretung/pretoria__dz/en/__PR/2009__PR/03/03__Electric__Cars.html; http://www.nanowerk.com/news/newsid=11765.php

[13] http://www.ridelust.com/e-mobility-berlin-the-german-electric-car-infrastructure/ and http://news.cnet.com/8301-11128_3-10034960-54.html

[14] Andrew Williams, October 9, 2008, Red Green and Blue, web: http://redgreenandblue.org/2008/10/09/france-invests-549-million-in-electric-and-hybrid-cars/: last accessed October 6, 2009.

And "France to build electric car infrastructure by 2011", Tom Young, October 13, 2008, BuisinessGreen, web: http://www.businessgreen.com/business-green/news/2228114/france-electric-carn last accessed October 6, 2009

According to Nissan, the Renault Nissan Alliance aims to become the world's leading manufacturer of zero-emission vehicles.[15]

[15]Nissan, web at http://www.nissan-global.com/EN/NEWS/2008/_STORY/081009-01-e.html?rss, last accessed Octobe 6, 2009.

Program: **Emerging Renewables Program**
www.consumerenergycenter.org/erprebate/index.html

Sponsors: California Energy Commission (CEC)

Funding source: Regulated utility rate-payers

Eligible business & technical areas: Small wind turbines & hydrogen fuel cells for utility customers

Functions supported: Installation

Type of support: Incentives (subsidies)

Economic sectors affected: Energy production

Geographic limits: Regulated utility service areas

Funding: $118 million over 5 years

Grant amount: $1.5 to $3 per watt

Grants as % of applications: No experience

Overview

CEC Emerging Renewables Program provides rebates to consumers who install qualifying renewable energy systems (small wind or fuel cell electricity systems) on their property. The incentive varies according to the system size, technology, and installation method.

Measures of Effectiveness

No information

Program: **Energy Efficiency Financing Program**
www.energy.ca.gov/efficiency/financing/index.html

Sponsors: California Energy Commission (CEC)

Funding source:

Eligible business & technical areas: Renewable power generation & reduced power use by public institutions

Functions supported: Installation

Type of support: Loans

Economic sectors affected: Energy production, energy use

Geographic limits: California

Funding: $24 million in 2009

Grant amount: up to $3 million

Grants as % of applications: No experience

Overview

The CEC's Energy Efficiency Financing Program provides financing for schools, hospitals, and local governments through low-interest loans for feasibility studies and the installation of energy-saving measures. Some of the eligible expenses are:

- Lighting
- Motors or variable frequency drives and pumps
- Building insulation
- Heating and air conditioning modifications
- Automated energy management systems/controls
- Energy generation including renewable energy projects and cogeneration
- Streetlights/LED traffic signals

The interest rate is 3%, fixed for the term of the loan. The repayment schedule is negotiable up to 15 years and will be based on the annual projected energy cost savings from the project.

Measures of Effectiveness

Average annual return on loans to nine reported government agencies has been 22% per year (annual saving/loan).

Program: **Energy Efficiency and Conservation Block Grants Program** (EECBG)
http://www.eecbg.energy.gov/about/default.html

Sponsors: U.S. DOE

Funding source: U.S. Treasury

Eligible business & technical areas: Any wherein renewable energy or energy conservation can be done

Functions supported: Installation, retrofitting, process modification

Type of support: Grants to states, cities, and tribes

Economic sectors affected: energy production, energy use, transportation

Geographic limits: California

Funding: $351 million allocated as of July 2009

Grant amount: average $1.3 million allocated to CA cities

Grants as % of applications: n/a

Overview

The EECBG program assists state, local, and tribal governments in implementing strategies to reduce fossil fuel emissions; reduce total energy use; and improve energy efficiency in the transportation, building, and other appropriate sectors. Additional purposes of the program are to spur economic growth and create and/or retain jobs under the American Recovery and Reinvestment Act of 2009.

Grants can be used for energy efficiency and conservation programs and projects community wide, and renewable energy installations in or on government buildings. Activities eligible for use of funds include:

- Development of an energy efficiency and conservation strategy
- Building energy audits and retrofits, including weatherization
- Financial incentive programs for energy efficiency such as energy savings performance contracting, on-bill financing, and revolving loan funds
- Transportation programs to conserve energy
- Building code development, implementation, and inspections
- Installation of distributed energy technologies including combined heat and power and district heating and cooling systems
- Material conservation programs including source reduction, recycling, and recycled content procurement programs
- Reduction and capture of greenhouse gas emissions generated by landfills or similar waste-related sources
- Installation of energy efficient traffic signals and street lighting

- Installation of renewable energy technologies in or on government buildings
- Any other appropriate activity that meets the purposes of the program and is approved by DOE

Measures of Effectiveness

Recovery Act programs must meet specific goals and targets, and contribute to improved performance on broad economic indicators. For EECBG program funds, grantees are required to report regularly to DOE on jobs created and/or retained, energy savings, renewable energy capacity installed, greenhouse gas emissions reduced, and funds leveraged.

Program: **Energy Efficiency Program for Commercial/Industrial Large Business Customers**
www.socalgas.com/business/efficiency/largeBusinessCustomers.html

Sponsors: SoCal Gas Company

Funding source: Regulated utility rate-payers

Eligible business & technical areas: Reducing natural gas use by large customers

Functions supported: Retrofitting

Type of support: Incentives (subsidies)

Economic sectors affected: Energy use

Geographic limits: SoCal gas service area

Funding: No information

Grant amount: Up to $1 million per year per project

Grants as % of applications: No information

Overview

The program provides incentives up to $2,000,000 per premise per year for qualifying energy-efficient equipment retrofits and process re-designs that can save more than 200,000 therms per year..

There are no pre-determined measures for EEGP; however, electric generation natural gas savings projects are not eligible to participate in EEGP.

Measures of Effectiveness
No information

Program: **Federal Tax Credits for Energy Efficiency -- Commercial**
www1.eere.energy.gov/buildings/tax_commercial.html

Sponsors: Internal Revenue Service

Funding source: U.S. Treasury

Eligible business & technical areas: Heating, cooling, lighting

Functions supported: Installation or retrofit

Type of support: Tax rebates

Economic sectors affected: Energy use

Geographic limits: none

Funding: unlimited

Grant amount: Up to $1.80 per square foot for energy savings over 50%

Grants as % of applications: n/a

Overview

A tax deduction of up to $1.80 per square foot is available for buildings that save at least 50% of the heating and cooling energy of a building that meets ASHRAE Standard 90.1-2001. Partial deductions of up to $.60 per square foot can be taken for measures affecting: the building envelope, lighting, or heating and cooling systems. This act extends the deduction through December 31, 2013.

Buildings must be within the scope of ASHRAE Standard 90.1 and within the control of the building designer. Retrofit of existing buildings is also eligible for the tax deduction.

Measures of Effectiveness

No information

Program: **Federal Tax Credits for Energy Efficiency -- Residential**
www.energystar.gov/index.cfm?c=tax_credits.tx_index#s1

Sponsors: Internal Revenue Service

Funding source: U.S. Treasury

Eligible business & technical areas:

Functions supported: Purchase or installation in homes

Type of support: Tax rebates

Economic sectors affected: Energy production, energy use

Geographic limits: none

Funding: unlimited

Grant amount: Up to $1,500 per tax return for 2009 and 2010

Grants as % of applications: n/a

Overview

Tax credits up to $1,500 can be claimed on IRS returns for 2009 and 2010 for the domestic installation of energy-efficient building materials, appliances, solar heating, biomass heating, photovoltaics, wind turbines, microturbines, and fuel cells and for the purchase of electric, hybrid, and fuel-cell-powered vehicles. Domestic installations must qualify under ENERGY STAR.

Measures of Effectiveness

No information

Program: **Grants.gov** www.grants.gov/search/category.do

Sponsor: Multiple federal agencies

Funding source: |

Eligible business & technical areas: |

Functions supported: |

Type of support: |

Economic sectors supported: | -- All particular to the granting agency

Geographic limits: |

Funding: |

Grant amount: |

Grants as % of applications: |

Overview

This is a directory of all federal grant programs

Measures of Effectiveness

No information.

Program: **High Penetration Solar Development**
www1.eere.energy.gov/solar/financial_opps_detail.html?sol_id=258

Sponsor: US DOE

Funding source: US Treasury

Eligible business and technology areas: Integration of photovoltaics into power grids

Functions supported: R&D and demonstrations

Type of support: Grants

Economic sectors affected: Energy production

Geographic limits: none.

Funding: $37.5 million in 2009/10

Grant amount:

Overview

This project will accelerate the placement of high levels of photovoltaic (PV) penetration into existing or newly designed distribution circuits. By facilitating increased growth of grid-tied PV installations, this project supports the acceleration of widespread commercialization of clean solar energy technologies in the United States. The three goals are:

- Develop modeling tools and database of experience with high penetration scenarios of PV on a distribution system
- Develop monitoring, control, and integration systems to enable cost-effective widespread deployment of small modular PV systems
- Demonstrate integration of PV and energy storage into Smart Grid applications.

The project's success will require both modeling tools and actual performance and validation data, so the focus will be in four R&D areas: improved modeling tools development, field verification of high-penetration levels of PV into the distribution grid, modular power architecture, and demonstration of PV and energy storage for Smart Grids.

Measures of Effectiveness

Program: **Innovative Clean Air Technologies (ICAT) Grant Program**
www.arb.ca.gov/rsearch/icat/icat.htm

Sponsor: Air Resources Board (CARB)

Funding source: Research Division of CARB

Eligible business and technology areas: New technologies for reducing criteria, toxic, or global-warming emissions

Functions supported: Demonstrations

Type of support: Grants (cost-share up to 50%)

Economic sectors affected: All

Geographic limits: US. Supported technologies must be useful in California.

Funding: ~ $1 million per year

Grant amount: Average $200,000

Grants as % of applications: 5% to 10%

Overview

ICAT co-funds practical demonstrations of innovative technologies that can reduce air pollution, including GHGs. Its purpose is to advance such technologies toward commercial application in California, thereby reducing emissions and helping the state's economy. ICAT seeks technologies that are not yet marketed but are substantially ready for practical demonstrations of their utility to potential users. It focuses on co-funding such demonstrations. It does not support research, R&D that is not intrinsic to performing a particular demonstration, or marketing activities.

Measures of Effectiveness

The following table compares statistics from ICAT and four grant programs by various State and federal agencies. The statistics can be viewed as measures of the effectiveness of grant funds or of the quality of the technologies that were selected for support.

Table 1. Program Evaluation Statistics

	Annual Grants (MM$/yr)	Sample Size	Commer-cialization Rate	Time to Sale #	Benefit: Cost ^	Annual Revenue / $ Granted	Grants leveraged funds	Grants critical to projects
SBIR		100's	25% *	~4 yrs				
ATP	145	100's			8:1		33%	16%
PIER	62	34			1.3 to 3.4:1			
CalTIP	~5	75	31%	2 yrs		3 /yr	>38%	31%**
ICAT	*~0.9*	*15*	*53%*	*1.7 yrs*		*1 /yr ^^*	*37%*	*50%*

* >$300,000 revenue
\# Defn of "Time 0" varies.
^ Defn of "benefit" varies.
** derived by staff from data in CalTIP report
^^ $1.2 million revenue in 2004 among 6 grantees who received $1.1 million in grants

Program: **Low-Emission School Bus Program**
www.arb.ca.gov/msprog/schoolbus/schoolbus.htm

Sponsor: CARB

Funding source: State bond

Eligible business and technology areas: Diesel school buses

Functions supported: Replacement and retrofit

Type of support: Incentives (subsidies)

Economic sectors affected: Transportation

Geographic limits: California

Funding: $200 million

Grant amount: No information

Grants as % of applications: No information

Overview

The program provides grant funding for new, safer school buses and to put air pollution control equipment (i.e., retrofit devices) on buses that are already on the road. Then Proposition 1B bond act approved in November 2006 authorizes $200 million for replacing and retrofitting school buses. ARB has allocated $191,000,000 to AQMD's for grants to school districts. However, disbursements by the State have been mostly suspended.

Measure of Effectiveness

The measure is the expected emissions reductions: 3,000 tons NOx, 200 tons PM, 22,000 tons CO2 through 2020.

Program: **New Solar Homes Partnership**
www.gosolarcalifornia.ca.gov/nshp/index.html

Sponsor: California Energy Commission (CEC)

Funding source: CEC

Eligible business and technical areas: Photovoltaics in new homes

Functions supported: Installation

Type of support: Incentives (subsidies)

Economic sectors affected: Energy production

Geographic limits: Service areas of PG&E, SDG&E, SCE, & Bear Valley Electric

Funding: $400 million over 10 years

Grant amount: No experience yet

Grants as % of applications: No experience yet

Overview

The CEC has a 10-year, $400 million program to encourage photovoltaics in new home construction. Strict standards for energy efficiency are applied. Depending on the total installed photovoltaic capacity in the state, the proposed subsidy will be $0.25 to $2.60 per watt.

Measures

The goal for the program is 3,000 MW of new photovoltaic capacity installed by 2017. 2.8 MW have been installed, as of May 2009. The corresponding subsidies total $7.8 million.

Program: **Public Interest Energy Research Program (PIER)**
www.energy.ca.gov/pier/index.html

Sponsor: California Energy Commission (CEC)

Funding source: Investor-owned utility ratepayers

Eligible business and technical areas: Production and use of energy

Functions supported: Research, R&D, and demonstration

Type of support: Grants and contracts

Economic sectors affected: All

Geographic limits: US

Funding: $62 million per year

Grant amount: Varies by program area

Grants as % of applications: No information

Overview

PIER supports energy research, development and demonstration (RD&D) projects that will bring environmentally safe, affordable and reliable energy services and products to the marketplace. PIER Program partners with RD&D organizations including individuals, businesses, utilities, and public or private research institutions. PIER supports these RD&D program areas, some with contracts and some with grants:

- Buildings End-Use Energy Efficiency
- Climate Change Program
- Energy Innovations Small Grant Program
- Energy-Related Environmental Research
- Energy Systems Integration
- Environmentally-Preferred Advanced Generation
- Industrial/Agricultural/Water End-Use Energy Efficiency
- Natural Gas Research
- Renewable Energy Technologies
- Transportation Research

Grant programs are administered separately in these areas.

Supported technologies should:

- Reduce the cost of electricity and increase the value
- Increase the reliability of the electric system
- Reduce the environmental impacts of electricity generation, distribution and use
- Enhance California's economy
- Demonstrate a connection to the market

- Advance science and technology not provided by competitive and regulated markets

In 2009, CEC is offering up to $21 million (of the annual $62.5 million) of PIER funds as co-funding to awardees of federal funding under the American Recovery and Reinvestment Act.

Measures of Effectiveness

From *Independent PIER Review Panel Interim Report* (March 2004):

> "Since PIER's inception in 1998, a total of about $260 million has been encumbered for research contracts. A review of contracts completed through 2002 revealed a total of 20 commercialized products with projected benefits of $221 to $576 million. The benefits are significant in comparison to the total contract disbursements of about $125 million between 1998 and 2002, resulting in a benefit-to-cost ratio between 2 and 5 to 1.
>
> . . .
>
> The IRP believes that except for minor issues the current PIER research portfolio is well focused, addresses issues relevant to California as outlined in the Energy Action Plan, meets PIER objectives and is well balanced."

Also, see the table on the page for ICAT grant program.

Program: Recovery Act funding for biofuels
http://apps1.eere.energy.gov/news/daily.cfm/hp_news_id=164

"As part of the ongoing effort to increase the use of domestic renewable fuels, U.S. Secretary of Energy Steven Chu today announced plans to provide $786.5 million from the American Recovery and Reinvestment Act to accelerate advanced biofuels research and development and to provide additional funding for commercial-scale biorefinery demonstration projects.

The $786.5 million in Recovery Act funding is a mix of new funding opportunities and additional funding for existing projects. It will be allocated across four main areas:

$480 Million Solicitation for Integrated Pilot- and Demonstration-Scale Biorefineries -- Projects selected under this Funding Opportunity Announcement will work to validate integrated biorefinery technologies that produce advanced biofuels, bioproducts, and heat and power in an integrated system, thus enabling private financing of commercial-scale replications.

DOE anticipates making 10 to 20 awards for refineries at various scales and designs, all to be operational in the next three years. The DOE funding ceiling is $25 million for pilot-scale projects and $50 million for demonstration scale projects.

These integrated biorefineries will reduce dependence on petroleum-based transportation fuels and chemicals. They will also facilitate the development of an "advanced biofuels" industry to meet the federal Renewable Fuel Standards.

$176.5 Million for Commercial-Scale Biorefinery Projects -- $176.5 million will be used to increase the federal funding ceiling on two or more demonstration- or commercial-scale biorefinery projects that were selected and awarded within the last two years.

The goal of these efforts is to reduce the risk of the development and deployment of these first-of-a-kind operations. These funds are expected to expedite the construction phase of these projects and ultimately accelerate the timeline for start up and commissioning.

$110 Million for Fundamental Research in Key Program Areas -- The Biomass Program plans to use $110 million to support fundamental research in key program areas, distributed in the following manner:

- Expand the resources available for sustainability research through the Office of Science Bioenergy Research Centers and establish a user-facility/small-scale integrated pilot plant ($25 million)
- Create an advanced research consortium to develop technologies and facilitate subsequent demonstration of infrastructure-compatible biofuels through a competitive solicitation ($35 million)

- Create an algal biofuels consortium to accelerate demonstration of algal biofuels through a competitive solicitation ($50 million).

This funding will help to develop cutting-edge conversion technologies, including generating more desirable catalysts, fuel-producing microbes, and feedstocks.

$20 Million for Ethanol Research -- The Biomass Program is planning to use $20 million of the Recovery Act funding in a competitive solicitation to achieve the following:

- Optimize flex-fuel vehicles operating on high octane E85 fuel (85% ethanol, 15% gasoline blend)
- Evaluate the impact of higher ethanol blends in conventional vehicles
- Upgrade existing refueling infrastructure to be compatible with fuels up to E85.

Program: Rural Energy for America Program Grants/ Renewable Energy Systems / Energy Efficiency Improvement Program

http://www.rurdev.usda.gov/rbs/busp/9006grant.htm

Sponsor: US Department of Agriculture (USDA)

Funding source: US Treasury

Eligible business and technical areas: Renewable energy production and energy efficiency projects in agriculture and rural small businesses

Functions supported: Installation and retrofit

Type of support: Incentives & guaranteed loans; < $250,000 for energy efficiency; < $500,000 for renewable energy; <25% of project cost

Economic sectors affected: Agriculture and forest products, energy use, energy production

Geographic limits: Rural US

Funding: No information

Grant amount: No information

Grants as % of applications: No information

Overview

The REAP/RES/EEI Grants Program provides grants for energy audits and renewable energy development assistance. It also provides funds to agricultural producers and rural small businesses to purchase and install renewable energy systems and make energy efficiency improvements.

The program is designed to assist farmers, ranchers and rural small businesses that are able to demonstrate financial need. All agricultural producers, including farmers and ranchers, who gain 50% or more of their gross income from the agricultural operations are eligible. Small businesses that are located in a rural area can also apply. Rural electric cooperatives may also be eligible to apply.

Most rural projects that reduce energy use and result in savings for the agricultural producer or small business are eligible as energy efficiency projects. These include projects such as retrofitting lighting or insulation, or purchasing or replacing equipment with more efficiency units. Eligible renewable energy projects include projects that produce energy from wind, solar, biomass, geothermal, hydro power and hydrogen-based sources. The projects can produce any form of energy including, heat, electricity, or fuel.

Measure of Effectiveness:No information

Program: **Small Business Innovation Research (SBIR) & Small Business Technology Transfer (STTR)** www.science.doe.gov/sbir

Sponsor: Eleven large federal agencies (DOE is highlighted here); coordinated by the federal Small Business Agency

Funding source: Agency R&D budgets

Eligible business and technical areas: Broad spectrum of DOE's research and R&D programs

Functions supported: Research, R&D

Type of support: Grants

Economic sectors affected: All

Geographic limits: US

Funding: SBIR -- 2.5% of each agency's research budget STTR -- 0.3%

Grant amount: Research -- up to $100,000 R&D -- up to $750,000

Grants as % of applications (DOE): Research -- 20% R&D -- 50%

Overview

SBIR and STTR are U.S. Government programs in which federal agencies with large research and development (R&D) budgets set aside a small fraction of their funding for competitions among small businesses only. The major difference between the programs is that STTR projects must involve substantial (at least 30%) cooperative research collaboration between the small business and a non-profit research institution. Small businesses that win awards in these programs keep the rights to any technology developed and are encouraged to commercialize the technology.

Each year, the federal agencies that participate in SBIR and STTR set aside 2.5% and 0.3%, respectively, of their extramural R&D budgets. For the DOE in FY 2005, these set-asides correspond to $102 million and $12 million, respectively.

Each year (typically around the beginning of October), DOE issues a solicitation inviting small businesses to apply for SBIR/STTR Phase I grants. It contains technical topics in such research areas as energy production (Fossil, Nuclear, Renewable, and Fusion Energy), Energy Use (in buildings, vehicles, and industry), fundamental energy sciences (materials, life, environmental, and computational sciences, and nuclear and high energy physics), Environmental Management, and Nuclear Nonproliferation. Grant applications submitted by small businesses MUST respond to a specific topic and subtopic during an open solicitation.

SBIR and STTR have three distinct phases. Phase I explores the feasibility of innovative concepts with awards up to $100,000 for about 9 months. Only Phase I award winners may compete for Phase II, the principal R&D effort, with awards up to $750,000 over a two-year period. There is also a Phase III, in which non-Federal capital is used by the

small business to pursue commercial applications of the R&D. Also under Phase III, Federal agencies may award non-SBIR/STTR-funded, follow-on grants or contracts for products or processes that meet the mission needs of those agencies, or for further R&D.

Measures of Effectiveness

SBIR measures "success" in terms of the fraction of "Phase 2" products that have provided at least $300,000 in revenue. The recent success rate is reported to be 25%. The post-grant time until revenues occur is "often … about four years".

SBIR also mentions an "environmental metric" that would count "pollutant reductions" &/or cost savings, but that apparently is not put into practice. No general protocol for producing such a metric is presented in the material that ARB staff have received.

Program: **Self-Generation Incentive Program**
www.cpucwww.cpuc.ca.gov/PUC/energy/DistGen/sgip/

Sponsor: California Public Utilities Commission (CPUC)

Funding source: Regulated utility rate-payers

Eligible business and technical areas: Microturbines, fuel cells, & wind turbines

Functions supported: Installation

Type of support: Incentives (subsidies)

Economic sectors affected: Energy production

Geographic limits: California

Funding: $75 million in 2007

Grant amount: $1.50 to $4.50 per Watt

Grants as % of applications: No information

Overview

SGIP is a statewide program to provide incentives for the installation of certain renewable and clean generation. The SGIP provides rebates for systems sized up to 3 MW. Generation technologies involved in the SGIP include photovoltaic (solar) systems, microturbines, fuel cells, and wind turbines. Incentives vary by technology and fuel type. The intent is to reduce the average cost for a 50 kW photovoltaic system from $450,000 to $300,000.

Measure of Effectiveness

1200 projects have been funded. Through 2006, 190 MW had been installed at a program cost of $100 million.

Program: **Solar Water Heating Pilot Program**
http://www.cpuc.ca.gov/PUC/energy/Solar/swh.htm

Sponsor: California Public Utilities Commission (CPUC)

Funding source: Regulated utility rate-payers

Eligible business and technical areas: Solar water heating

Functions supported: Installation

Type of support: Incentives (subsidies)

Economic sectors affected: Energy use

Geographic limits: San Diego Gas & Electric service area

Funding: $1.5 million

Grant amount: See below

Grants as % of applications: No information

Overview

SWHPP provides incentives to business and customers who install qualifying solar water heating systems. These incentives will go to qualified, licensed contractors to promote the installation of clean, renewable solar water heating systems. The California Center for Sustainable Energy (CCSE) is administering the program. The program includes residential, commercial, and industrial electricity customers of SDG&E. To be eligible to participate, customers must provide SDG&E billing data, allow their systems to be monitored, and consent to being interviewed or surveyed during program evaluation.

For residential systems, the maximum incentive is $1500 per dwelling and varies according to the system installed and other installation details.

For larger systems, the incentive is a function of collector area:

- $15/sq ft for open-loop systems
- $20/sq ft for closed-loop systems
- Pool and spa heating systems are not eligible
- Maximum incentive is $75,000.

Measures of Effectiveness

No information

Program: **Stanford Global Climate and Energy Project (GCEP)**
http://gcep.stanford.edu/research/areas.html

Sponsor: Stanford University

Funding source: ExxonMobil, General Electric, Schlumberger, and Toyota

Eligible business and technology areas: Energy production & storage; carbon sequestration

Functions supported: Research

Type of support: Subcontracts for research by Stanford

Economic sectors affected: Energy production, industrial, transportation

Geographic limits: None, but only academic entities are eligible

Funding: $225 million over 10 years

Grant amount: $1.2 million, average

Grants as % of applications: No information

Overview

The Project's sponsors will invest a total of $225 million over a decade or more as GCEP explores energy technologies that are efficient, environmentally benign, and cost-effective when deployed on a large scale. GCEP's specific goals include:

- Identify promising research opportunities for low-emissions, high-efficiency energy technologies.
- Identify barriers to the large-scale application of these new technologies.
- Conduct fundamental research into technologies that will help to overcome these barriers and provide the basis for large-scale applications.
- Share research results with a wide audience.

GCEP sponsors research at Stanford and other leading universities and research institutions. It does not sponsor research by businesses or individuals.

Measures of Effectiveness

14 patent applications

Program: **Technology Advancement Program**
www.aqmd.gov/tao/About/index.html

Sponsor: South Coast Air Quality Management District (AQMD)

Funding source: Vehicle registration fees, regulatory violation settlements, State & federal grants

Eligible business and technology areas: Criteria and toxic emissions from processes and fuels

Functions supported: R&D, demonstration

Type of support: Cost-sharing

Economic sectors affected: Industrial, transportation

Geographic limits: South Coast Air Basin

Funding: $9 to $15 million per year

Grant amount: Range -- $6,000 to $3 million

Grants as % of applications: Varies by type of solicitation; overall: ~40%

Overview

The Technology Advancement Program expedites the development, demonstration and commercialization of cleaner technologies and clean-burning fuels. It uses cooperative partnerships with private industry, academic and research institutions, technology developers, and government agencies to cosponsor projects intended to demonstrate the successful use of clean fuels and technologies that lower or eliminate emissions. The supported technologies are chosen to provide emission reductions in the AQMD in the context of the AQMD's emission-reduction strategies.

Typically, the public-private partnership enables the AQMD to leverage its public funds with an average of $3 from outside sources for every dollar contributed by the AQMD.

Awards are made to both proposals made in response to RFPs with specific objectives and to unsolicited proposals for new technologies.

Measures of Effectiveness

As of 2004, twelve technologies supported by the clean technologies program had become commercialized.

SUMMARY OF PROGRAMS

Program	Web Page	Sponsor	Funding Source	Eligible Business / Technical Areas	Function Supported	Type & Terms of Support	Economic Sectors of Application: Ag. & Forest	Energy Prod.	Energy Use	Indus-trial	Trans-port.	Funding / period	Avg. Grant	Annual grants / applicants
Advanced Technology Program DISCONTINUED	www.atp.nist.gov/	National Institute of Standards & Technol. (NIST)	NIST	Materials, chemi-cals, biotechnology, manufacturing	Early R&D (not product development)	< 50% cost share				x		$155 M / year	$2.5 M	11%
Agriculture & Food Industries Loan Program DISCONTINUED	www.energy.ca.gov/process/agriculture/loansolicitation/	CEC		Specific power-generation and demand-reducing technologies	Installation	Loans at 3.2%, up to $500,000	x					$3 million in 2007	No experience yet	
California Clean Energy Fund (CalCEF) (Fund 1)	www.calcef.org	CalCEF	PG&E bankruptcy settlement	Renewable fuels, energy efficiency & storage, clean fossil fuels, green bldgs.	R&D	Business investment		x	x		x	$30 M (total funds)		
California Solar Initiative	www.gosolarcalifornia.ca.gov/	CPUC	Investor-owned utility ratepayers	Photovoltaics & solar heating in comm'l blgs. & homes	Installation	Incentives: Grant ≤ $.50 / kW-hr or $3.25 / watt		x	x			$2.2 B / 10 yrs	n/a	First-come, first-served
California Solar Initiative R D &D	http://www.cpuc.ca.gov/PUC/energy/Solar/rdd.htm	CPUC	Investor-owned utility ratepayers	Photovoltaic distributed generation	Research, R&D, demonstration, deployment	Grants of $0.2 to $3 million		x				$50 M / 10 years	No experience yet	
Clean Energy Angel Fund	http://www.calcefangelfund.com/	CalCEF	PG&E bankruptcy settlement	Clean/alternative energy, energy efficiency, green bldgs.	Potentially profitable businesses	Business investment		x	x				$0.3 to $0.5 M (expected)	two investments to date
Carl Moyer Program	www.arb.ca.gov/msprog/moyer/moyer.htm	CARB & air quality management districts	Vehicle reg. fees, tire disposal fees, "Smog-check" fees, State grants	Commercial & gov't fleets of vehicles & equipment	Purchase of clean industrial & vehicular engines	Incentives: Grant ≤ value of emission reduction.	x				x	$1.4B / 10years	Buses, agr. eq. & pumps: $12K/unit Marine & constr. equip.: $50K/veh	
Driveclean (directory of incentives)	www.driveclean.ca.gov/en/gv/driveclean/demoprog.asp	Federal, regional, and local gov'ts	Particular to the agency offering incentives	Electric, CNG & hybrid vehicles	Purchase	Incentives particular to the agency					x		Particular to the agency offering incentives	
Emerging Renewables Program	www.consumerenergycenter.org/erprebate/index.html	CEC		Small wind turbines and H fuel cells for utility customers	Installation	Incentives: Grants of $1.50 to $3 / W		x				$118 million over 5 years	No experience yet	
Energy Efficiency Financing Program	www.energy.ca.gov/efficiency/financing/index.html	CEC		Power generation & use by public institutions	Installation	Loans at 3%, up to $3 million		x	x			26 million in 2007	No experience yet	
Energy Efficiency and Conservation Block Grants Program	www.eecbg.energy.gov/about/default.html	U.S. DOE	U.S. Treasury	Any wherein renewable energy or energy conservation can be done	Installation, retrofitting, process modification	Grants to states, cities, and tribes		x	x		x	$351 million allocated for California	$1.3 million avg. allocation among CA cities	n/a
Energy Efficiency Program for Commercial / Industrial Large Business Customers	www.socalgas.com/business/efficiency/largeBusinessCustomers.html	So. Cal Gas Co.	Investor-owned utility ratepayers	Nat'l gas use by large customers	Retrofitting to reduce NG use by ≥200,000 therms/yr	Incentives up to $1 million per project.			x					
Federal Tax Credits for Energy Efficiency--residential	www.energystar.gov/index.cfm?c=tax_credits.tx_index#s1	IRS	U.S. Treasury	Solar heat, photovoltaics, wind turbines, fuel cells, EVs, hybrid vehicles	Purchase or installation in homes	30% tax credits up to $1,500. Installations must qualify under ENERGY STAR		x	x					
Federal Tax Credits for Energy Efficiency--commercial	www1.eere.energy.gov/buildings/tax_commercial.html	IRS	U.S. Treasury	Heating, cooling, lighting	New construction & retrofits	Tax deduction up to $1.80 per sq. ft. for 50% energy saving			x					
Grants.gov (directory of federal grants)	www.grants.gov/search/category.do	Various federal agencies		---------- Various ----------			All sectors affected						Particular to the agency offering grants	
High Penetration Solar Development	http://www1.eere.energy.gov/solar/financial_ops_detail.html?sol_id=258	US DOE	U.S. Treasury	Modeling, monitoring, control & integration of photovoltaic systems into distribution grids	R&D and demonstration	Grants		x				$37.5 million in 09/10		
Innovative Clean Air Technolgies (ICAT)	www.arb.ca.gov/research/icat/icat.htm	CARB	Research Division	Innovations in control of criteria, toxic & G-W emissions	Field demonstration	≤ 50% cost share	All sectors affected					$1M / year	$200,000	5% to 10%

Program	Web Page	Sponsor	Funding Source	Eligible Business / Technical Areas	Function Supported	Type & Terms of Support	Economic Sectors of Application: Ag. & Forest	Energy Prod.	Energy Use	Indus-trial	Trans-port.	Funding / period	Avg. Grant	Annual grants / applicants
Low Emission School Bus Program	www.arb.ca.gov/msprog/schoolbus/schoolbus.htm	CARB	State bond, federal stimulus money	Existing diesel school buses	Replacement & retrofit	Incentives via AQMDs					x	$200M (total) ($191 million allocated)		
New Solar Homes Partnership	www.gosolarcalifornia.ca.gov/nshp/index.html	CEC		Photovoltaics in new homes	Installation	$0.25 to $2.6 per installed watt		x				$400 M / 10years	$7,000 per system	77%
Public Interest Energy Research (PIER)	www.energy.ca.gov/pier/index.html	CEC	Investor-owned utility ratepayers	Production and use of energy	Research, R&D, demonstration	Grants & contracts; co-funding of fed'l ARRA projects	All sectors affected					$62M / year	Varies by program area	(10 programs)
Recovery Act funding for biofuels	http://apps1.eere.energy.gov/news/daily.cfm/hp_news_id=164	US DOE	U.S.Treasury	Production of biofuels	Research, pilot plants, demonstrations, commercial plants			x				$787 million		
Renewable Energy Systems & Energy Efficiency Improvements Program DISCONTINUED	www.rurdev.usda.gov/rbs/farmbill/what_is.html	USDA	U.S.Treasury	Renewable energy systems & energy eff'cy by agr. & rural small businesses	Installation	Incentives: Grant < 25% of project cost Loan < 50% of project cost	x		x			$23 million / year	Grants: $150,000 Loans: $5 million	
Rural Energy for Ameri-ca Program Grants/ Renewable Energy Systems / Energy Efficiency Improve-ment Program	http://www.rurdev.usda.gov/rbs/busp/9006grant.htm	USDA	U.S.Treasury	Energy efficiency & renewable energy in agriculture & rural small business	Installation and retrofit	Incentives < $250,000 for energy efficiency < $500,000 for renewable energy; <25% of project cost	x	x	x				20% of grants must be for less than $20,000	
SBIR & STTR	www.science.doe.gov/sbir	US DOE	2.8% of DOE's extra-mural R&D budget	Broad spectrum of DOE's R&D programs	Research, R&D	Grants	All sectors affected					$102M / 2005	Res'rch: <$100K R&D: <$750K	Varies by agency
School Facility Program - Modernization Grants	http://www.opsc.dgs.ca.gov/Programs/SFProgams/Mod.htm	CA Dept. of General Services		Photovoltaics in old school buildings	Intallation	Incentives		x						
Self-Generation Incentive Program	www.cpuc.ca.gov/PUC/energy/DistGen/sgip/	CPUC		Microturbines, fuel cells, & wind turbines.	Installation	Incentives: $1.50 to $4.5 / W up to 3 MW		x				$75 million in 2007		
Solar Water Heating Pilot Program	www.cpuc.ca.gov/PUC/energy/Solar/swh.htm	CPUC	SDG&E ratepayers	Solar water heating in SDG&E service area	Installation	Incentives. Residential: < $1500 Commer'l: < $75,000			x			$1.5 million	No experience yet	
Stanford GCEP	gcep.stanford.edu/research/areas.html	Stanford University	Toyota, GE, Exxon-Mobil, Schlumberger	Energy production & storage; carbon sequestration	Research	Recipients are sub-contractors to Stan-ford. Supports only academic research.		x		x	x	$225 / 10years	$1.2 million	
Supplemental Energy Payments (SEPs)	www.energy.ca.gov/2007publications/CEC-300-2007-006/CEC-300-2007-006-ED3-SD.PDF	CEC	Renewable Energy Public Goods Charge funds	Renewable power producers	Power production bought by electric utilities	Subsidy of above-market power costs		x				$734 million over five years	No experience yet	
Technology Advance-ment Program	www.aqmd.gov/tao/About/Index.html	SCAQMD	Vehicle reg. fees, violation settlements, State & fed'l grants	Criteria & toxic emissions from processes & fuels	R&D, demonstra-tion, commer-cialization	Cost sharing		x		x	x	$9M-$15M / year	range:$6,000 to $3 million	Varies by type of solicitation. Overall: ~40%
Technology Incentive Program	www.pge.com/biz/rebates/2007_incentive_application/index.html	PG&E	Investor-owned utility ratepayers	Demand response technology for large power customers	Installing equip-ment & software	Incentives			x					
Incentive programs of localities, municipal utility districts & regulated utilities	www.dsireusa.org/library/includes/map2.cfm?CurrentPageID=1&State=CA&RE=1&EE=1	- - - - - - - - - - - - See web site - - - - - - - - - - - -			Installations & operation	Incentives	- - - - - - - - - - - - See web site - - - - - - - - - - - -							
Alternative & Renew-able Fuel & Vehicle Technology Program	www.energy.ca.gov/altfuels/	CEC	Vehicle reg. fees	(See "Overview")	TBD	Grants and loans		x			x	TBD	No information	

Appendix III - Current Biofuel Pathways

Biofuels have become a major focus in achieving compliance with the Low Carbon Fuel Standard of California. Provided that full lifecycle GHG emissions from growing, harvesting and processing biomass are low, biofuels provide an attractive option for reducing GHG emissions since CO_2 emissions from biofuel combustion are counter-balanced by carbon sequestered during the biomass growth. There are a wide array of biomass types that can be utilized for biofuel production such as sugar/starch crops, oil seeds, dedicated energy crops, agriculture residues, municipal solid waste, waste grease and fat, and algae. Depending on the conversion technologies utilized, biofuels with different characteristics, carbon intensity and final use can be obtained. Broadly speaking, there are five conversion technology pathways: (1) fermentation (2) thermochemical conversion (3) hydrotreatment (4) trans-esterification and (5) biomethane production.

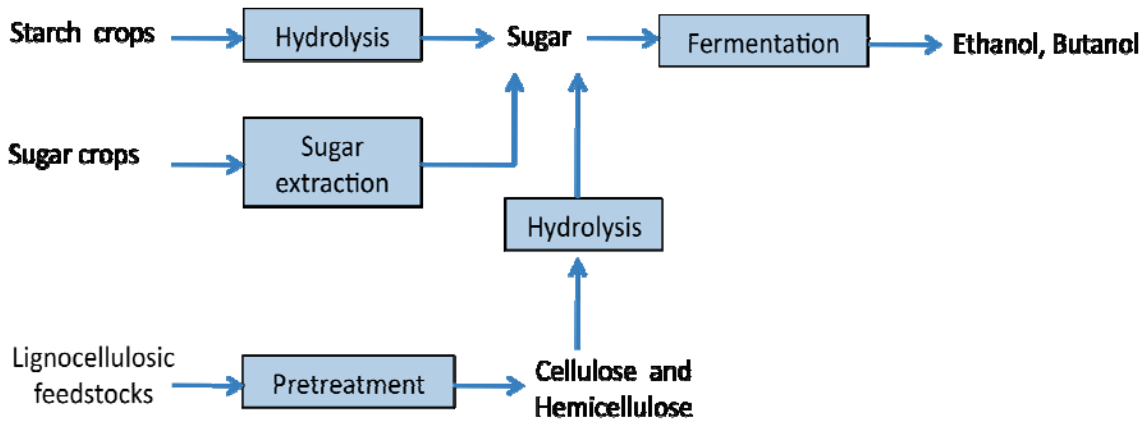

Fig. 1 Butanol and ethanol production via hydrolysis and fermentation

Fermentation technologies can be used to produce ethanol and butanol from starch, sugar or lignocellulosic feedstocks (Fig. 1). Butanol has higher energy content and lower vapor pressure than ethanol, and can be shipped through pipelines in blended form. A butanol multimedia assessment is currently underway to determine whether butanol can be a legal fuel component in California fuels. While sugar crops can readily be fermented, starch crops require an additional step before fermentation to hydrolyze starch into sugars using enzymes. Due to established agricultural feedstock supply and mature fermentation technologies, sugar and starch crops have grown rapidly and currently supply the bulk of biofuels produced worldwide. With growing concerns about GHG emissions from land use changes, direct and indirect, and potential food-fuel conflicts, the attention has now been shifted to encouraging commercialization of ethanol and butanol from lignocellulosic feedstocks.

However, lignocellulose cannot be directly converted into sugars. Pretreatments are required to separate lignin from cellulose and hemicellulose and make these carbohydrates amenable to hydrolysis (Fig. 1). Successful commercialization of cellulosic ethanol and butanol hinges on significantly improving the pretreatment and hydrolysis steps. It is projected that lignocellulosic technology can produce 115 gallons of cellulosic ethanol per dry ton of biomass (West et al., 2009).

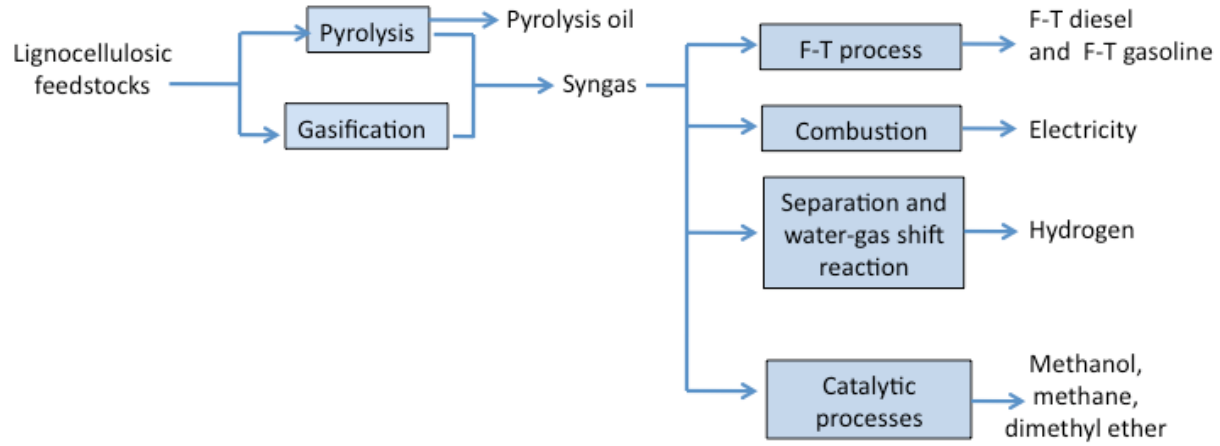

Fig. 2 Biofuel production via thermochemical conversions

Thermochemical conversion technologies are attractive because they can provide a wide range of fuels that include hydrogen, electricity, diesel, gasoline, and methanol (Fig. 2). Thermochemical conversions are more suitable for lignocellulosic feedstocks and start with either pyrolysis or gasification. Gasification results in syngas whereas pyrolysis results in both oils and syngas. Syngas is primarily a mixture of carbon monoxide, carbon dioxide, and hydrogen. The amounts of pyrolysis oils and syngas produced depend on how pyrolysis is done. For example, flash pyrolysis produces more oils than syngas. Syngas can be directly combusted to produce electricity, or it can be subjected to additional processing to convert it into other valuable fuels:

- Hydrogen can be created by subjecting syngas to water-gas shift reaction and hydrogen separation.
- F-T diesel and F-T gasoline can be produced using the Fischer-Tropsch process from syngas. The Fischer-Tropsch process was originally used to produce diesel from coal and later on from natural gas.
- Syngas can be converted to methanol, methane, and dimethyl ether using catalytic processes.

Although thermochemical conversions are more versatile than hydrolysis and fermentation, their applications to lignocellulosic feedstocks for biofuel production are still in the research and development phase.

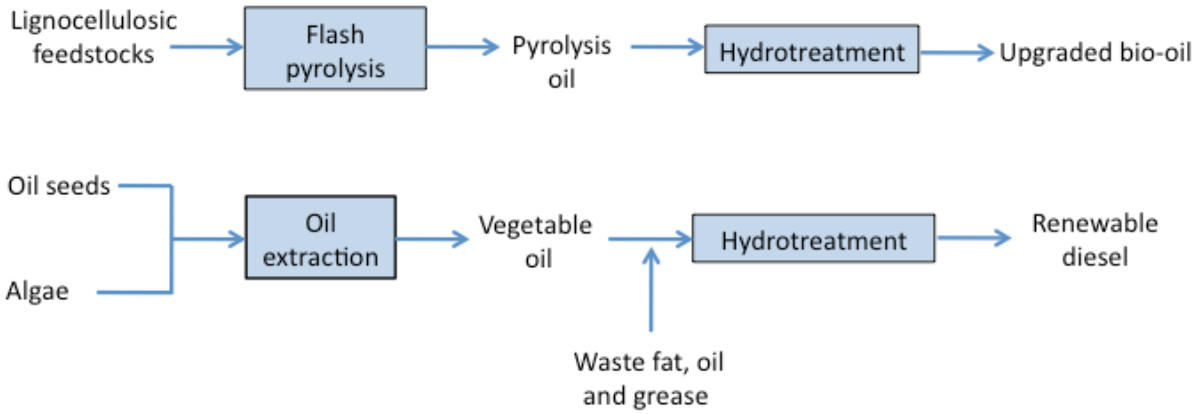

Fig. 3 Bio-oil and renewable diesel production using hydrotreatment.

Hydrotreatment provides an alternative pathway for producing diesel like renewable fuels (Fig. 3). Oils obtained from algae, oil seeds, and waste fat and grease can be hydrotreated to produce renewable diesel. Pyrolysis oils can be upgraded using hydrotreatment to produce high quality gasoline and diesel like fuels called upgraded bio-oils.

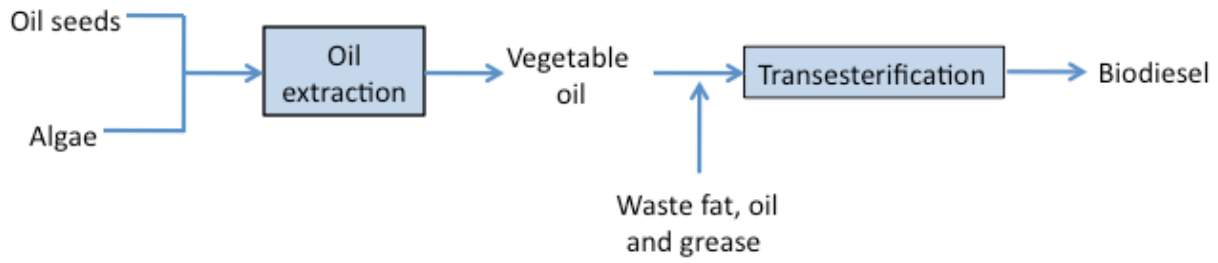

Fig. 4 Biodiesel production using trans-esterification

Biomass that contains significant amounts of lipids such as algae and oil seeds, and oils derived from animal fat, waste grease & oil can be used to produce biodiesel via trans-esterification (Fig. 4). Biodiesel comprises of mono-alkyl esters. Soybean is the main feedstock used in biodiesel production in the US whereas the rapeseed is the major feedstock for biodiesel production in Europe, but any biomass with significant amounts of lipids can be used.

Recently, there has been a growing interest in algae as a potential feedstock for the production of both renewable diesel and biodiesel. The main reason behind this interest is the higher growth rates and oil content of some naturally and genetically engineered algae. An NREL study (Sheehan et al., 1998) reported oil content as high as 59%. For comparison, soybeans, the current major source of biodiesel, have only 20% oil content. Genetically engineered algae can have an oil content of up to 80%. The per acre oil production from algae can be 100-300 times more than that from soybean. Since algae can be grown either

heterotrophically in fermenters; or phototrophically in salty water, ponds in deserts, and on marginal lands not suitable for crops; it can avoid the issues of competing with land for other uses. In a heterotrophic process, algae feed on nutrients and carbon substrates whereas in an autotrophic process algae utilizes photosynthesis for growth and deriving energy. However, several challenges remain. Diesel from algae is not yet cost competitive with conventional diesel due to high processing costs. For example, Solix Biofuel, a California based start-up, is capable of producing biodiesel at $33/gallon, which is far higher than the current diesel price (Greentech Media, 2009).

Production of diesel fuels from algae is still in the research and development phase. Several new startups and established companies such as Exxon Mobil and DOW Chemical have stated they will invest significant amounts of money in related research. Exxon Mobil expects that it would be able to commercially produce renewable diesel from algae within 5-10 years. Opportunities do exist for reducing the cost of production to $3.5/gallon in the near future.

Besides the issues of scale and economics, there are technological hurdles that need to be overcome for commercialization of biodiesel from algae. The most prominent among them are algae cultivation, harvest, oil extraction and maintaining the controlled environment for algae cultures to achieve the maximum yields (CARB, 2009).

Biomethane is one additional pathway to low carbon biofuels fuels. Biomethane can be produced from sources such as landfills, wastewater treatment plants, and agricultural waste. Methane from these sources can be used for energy recovery instead of being flared. (In some cases, methane emissions could escape directly to the atmosphere if not captured for energy recovery or destruction.) Flaring converts CH_4 into CO_2, which is less harmful to the climate, and destroys volatile organic compounds. However, flaring misses an opportunity to displace other fuels and can create some combustion contaminants. A California Energy Commission report states that biomethane has the potential to displace diesel used for transportation purposes and achieve large GHG emissions reductions.

Biomethane is well suited for applications where the producer owns natural gas powered vehicles in their fleet, as the biomethane can be utilized for energy recovery without additional infrastructure (such as a connection to a natural gas pipeline or an electricity-generating combustion device). For instance Clean Energy's McCommas Bluff landfill in Dallas produces 4 million cubic feet per day, equal to 33,000 gallons of gasoline. CO_2, sulfur compounds, and other contaminants are removed so that the fuel is essentially the same as pipeline quality natural gas.

Biomethane produced from waste products avoids issues regarding land use since no additional land is consumed to produce the feedstock. There are also competing uses for biomethane, some of which are listed in Section 4.2 of this report on renewable electricity generation, which may reduce its availability as a transportation fuel.

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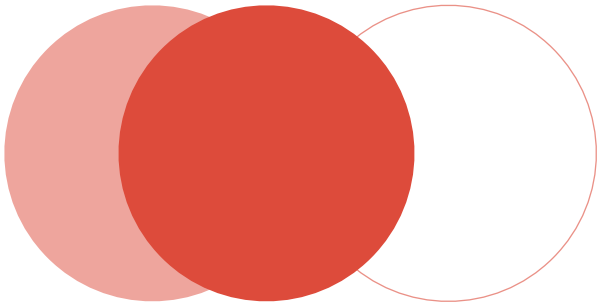

A policy-relevant summary of black carbon climate science and appropriate emission control strategies

June 2009

THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

The goal of the International Council on Clean Transportation is to dramatically improve the environmental performance and efficiency of cars, trucks, ships, airplanes and the transportation systems that support them with the aim to protect and improve public health, the environment, and quality of life. The organization is guided by a Council of regulators and experts from leading auto markets around the world who participate as individuals based on their experience with air quality and transportation issues.

This document does not necessarily represent the views of organizations or government agencies represented by ICCT participants. Their endorsement is based on their experience with air quality and transportation issues.

The following individuals attended the 2009 International Workshop on Black Carbon held 5-6 January in London, UK. This document was informed by discussions held there and by subsequent follow-up with workshop participants.*

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* All presentations and materials distributed at the UK workshop are available online at http//www.theicct.org. Workshop attendance does not necessarily imply endorsement of this document. The ICCT takes sole responsibility for its contents.

EXECUTIVE SUMMARY

This document provides policy-relevant guidance on black carbon. The information it contains is consistent with the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) published in 2007 and is further informed by the 2009 London International Workshop on Black Carbon [1] and subsequent discussions with workshop participants.

Black carbon is a solid particle emitted during incomplete combustion. All particle emissions from a combustion source are broadly referred to as particulate matter (PM) and usually delineated by sizes less than 10 micrometers (PM10) or less than 2.5 micrometers (PM2.5). Black carbon is the solid fraction of PM2.5 that strongly absorbs light and converts that energy to heat. When emitted into the atmosphere and deposited on ice or snow, black carbon causes global temperature change, melting of snow and ice, and changes in precipitation patterns.

Fossil fuel combustion in transport; solid biofuel combustion in residential heating and cooking; and open biomass burning from forest fires and controlled agricultural fires are the source of about 85 percent of global black carbon emissions. Maximum feasible reductions in 2030 can capture 2.8 Tg/yr of black carbon, a reduction of 60% from business as usual. Co-emitted pollutants and the location of emission activity will determine the net impact of control strategies on the climate.

Public health protection is already a strong argument for actions that control black carbon. Exposure to PM is responsible for hundreds of thousands of global deaths each year. Actions that reduce PM such as new requirements for exhaust after treatment with lower sulfur fuels, fuel switching and reductions in fuel consumption can reduce a substantial fraction of black carbon emissions. Regardless of the climate protection benefits, there is a strong case for these actions to protect public health.

The climate impacts of black carbon reinforce the public health need for actions to control PM emissions. According to the IPCC, black carbon is the third largest contributor to the positive radiative forcing that causes climate change[2]. One kilogram is about 460 times more potent than an equivalent amount of carbon dioxide over a 100-year time horizon and 1600 times more potent over a 20-year horizon based on unofficial IPCC estimates[3]. IPCC estimates of radiative forcing are conservative compared to others in the published literature.

Controls on black carbon can produce rapid regional and global climate benefits. Like all aerosol particles, black carbon washes out of the atmosphere within a few thousand kilometers from its source, so it produces essentially short-lived radiative forcing. This forcing produces strong regional climate impacts that extend beyond the forcing region and approach a global scale. In the aggregate these regional impacts are a global problem. A climate change mitigation strategy that incorporates short-lived forcing agents like black carbon can more rapidly reduce the positive radiative forcing that causes climate change, especially when rapid action is needed to avert tipping points for large-scale impacts like the loss of Arctic summer sea ice, the Himalayan-Tibetan glaciers, and the Greenland ice sheet.

Black carbon reductions supplement but do not replace actions to control carbon dioxide and other greenhouse gases. A focus of climate change mitigation is to reduce all positive radiative forcing, and carbon dioxide is the largest positive forcing agent, so any delay in CO2 emission reductions extends its climate impacts. Actions that reduce black carbon and carbon dioxide emissions in parallel will more effectively reduce total positive radiative forcing.

Controls on black carbon will reduce both positive and negative radiative forcing, so decisions to act on a climate basis alone should focus on the net effect. Black carbon is emitted with other pollutants that reflect light and offset its positive forcing. These include primary and secondary organic carbon, sulfates, and nitrates produced in amounts that vary with the combustion and fuel type of each source. The net effect of sources is modified by the transport and deposition of its black carbon emissions onto ice and snow, so major sources that produce negative forcing in the atmosphere can still be net positive forcers if they deposit sufficient amounts into the Arctic or atop mountain glaciers.

The highest priority targets strictly from a climate mitigation perspective are sources that cause net positive radiative forcing such as combustion of fossil fuels low in sulfur and deposition of black carbon on ice and snow surfaces. On-road heavy-duty diesel vehicles, off-road agricultural and construction equipment, residential coal combustion, and industrial brick kilns are generally net positive forcers. Open agricultural burning, residential biofuel burning and commercial shipping may be negative forcers, but this can be offset locally if there is black carbon deposition on snow and ice.

SCIENTIFIC ASSESSMENT

Human activities are causing changes in the Earth's climate. Among the most important of these changes is an increase in average global temperatures induced by absorption of long-wave infrared radiation by greenhouse gases and strongly light-absorbing aerosols. Atmospheric scientists call this change a positive radiative forcing. Reflection of energy is a negative forcing associated with cooling. The IPCC estimates that human activities since 1750 are associated with a total net positive radiative forcing of 1.6 Wm^{-2} [0.6 to 2.4], which is associated with a 0.8˚C [± 0.2] increase in average global temperature since the late 1800s.

Black carbon refers to any number of strongly light-absorbing combustion particles, the strongest of which is soot[4]. The particles vary in size but generally they are much smaller than PM2.5 and may not even get as large as PM0.1. Black carbon is always a component of particular matter emitted from combustion sources, but the amount emitted will vary by the type of fuel used, the combustion process, and the performance of any emission control technologies or practices.

Black carbon lasts about one week in the atmosphere, but this can vary by up to a factor of three depending on the combustion process and the location of the emission[5]. Carbon dioxide, on the other hand, produces perturbations that are long lived such that most CO2 emitted today will impact future climate for 30 to 100 years, and some produce impacts for even longer.

Black carbon is an important contributor to the positive radiative forcing that causes climate change. The largest share of this forcing comes from the direct absorption of light energy in the atmosphere. The IPCC estimates that through this effect black carbon is responsible for about 0.34 Wm^{-2} [± 0.25] in globally averaged radiative forcing[6]. Research cited in the IPCC report shows that this warming effect can be magnified when black carbon particles are incorporated within (or mixed with) other particles that scatter light energy such as sulfates[7], but most climate models used by the IPCC did not take this amplification into account. Thus this estimate is probably too low.

Some impacts of this direct radiative forcing include not only increases in temperature, but also changes in precipitation and surface visibility. Plumes of emissions can suppress convection and stabilize the atmosphere in ways that obstruct normal precipitation patterns. They dim the Earth's surface, reducing patterns of evaporation that feed the formation of clouds.

Black carbon also produces positive radiative forcing by changing the reflectivity or albedo of bright surfaces like snow and ice. Under pristine conditions these surfaces reflect a high fraction of solar energy back into space, but black carbon particles above or on these surfaces absorb a substantial fraction of this energy and re-emit it as heat. This not only reduces the amount of solar energy reflected, but it can also evaporate clouds and melt snow and ice. This decline in snow and ice surface area produces a feedback loop that can induce additional warming and melting. The IPCC estimates the global albedo effect of black carbon on snow to be 0.1 Wm^{-2} [±0.1].

Given the direct radiative forcing and snow albedo effects estimated by the IPCC, the total radiative forcing of black carbon is estimated to be 0.44 Wm^{-2} [± 0.35] This ranks black carbon as the third most important positive climate-forcing agent after carbon dioxide and methane.

The IPCC appears to provide conservative guidance on black carbon. For example, the definition it adopted is broad and the radiative forcing estimate is at the low end of the possible range. This is due to a situation where the climate science of black carbon is developing rapidly, but the pace of the scientific community in filtering, debating and consolidating this new knowledge is moving slowly.

The IPCC did not quantify the contribution of black carbon to the cooling effect of clouds, which could reduce the estimate of its total radiative forcing. Most models also failed to take into account internal mixing, which could increase the estimate. Greater understanding of internal mixing and contribution to cloud burden will likely be reflected in the next IPCC report due in 2013.

STRATEGIC VALUE

Black carbon reductions will provide substantial public health benefits and stand on their own as a strong reason to reduce emissions. It is clear that black carbon is a fraction of particulate matter emissions that are associated with premature death, disability, and chronic disease. Black carbon may fall into the category of ultrafine particles or PM0.1, which pose a significant health risk. These small particles are emitted primarily from combustion sources. The World Health Organization estimates that in the year 2000 urban air pollution was responsible for 800,000 premature deaths and indoor smoke from solid fuels for 1.6 million premature deaths. Most of these occurred in developing countries.

Targeting black carbon will also achieve more rapid climate benefits than a strategy focused on carbon dioxide alone. Black carbon is one of a small number of climate-forcing agents with short lifetimes, so controls on sustained emissions will produce a relatively rapid decline in atmospheric concentrations. Climate abatement strategies can take advantage of this to quickly reduce the radiative forcing that causes climate change. This strategy can assist in the effort to slow the pace of global climate change and to reduce already committed global warming. But it can also be useful to delay and perhaps avoid some of the greatest regional tipping points such as the loss of Arctic summer sea ice and loss of the Himalayan-Tibetan glaciers. Their loss is developing rapidly, but given strong localized forcing from black carbon, emission controls can have a significant impact.

The policy community should be careful not to trade action on black carbon for action on carbon dioxide. Both produce positive radiative forcing that causes climate change and action on both is necessary to reduce this to achieve climate goals. Actions that reduce the most positive radiative forcing are the most desired, so policies that can simultaneously reduce both black carbon and carbon dioxide can be more effective than simply targeting each one individually.

Black carbon reductions may be required to offset declines in emissions of other short-lived forcing agents One example is the ongoing control of sulfur dioxide emissions. These emissions are declining rapidly around the world as fuel controls are imposed, and there is no question that these actions are necessary to eliminate adverse public health impacts. Since sulfates are strongly light-reflecting, these controls reduce negative radiative forcing, which is equivalent to a positive radiative forcing. And since sulphate precursors are short-lived, this positive forcing occurs relatively rapidly. But black carbon reductions can reduce positive radiative forcing on an equally rapid time frame. Even more, many of the controls necessary to reduce black carbon, such as those used in transportation, are enabled by the same policies to reduce sulfur emissions.

GLOBAL WARMING POTENTIAL

For policy makers convinced by the science and the strategic importance of black carbon controls, a common next step is the application of the global warming potential (GWP) to the full inventory of emissions, an evaluation of the full CO2-equivalent reduction potential of the multi-pollutant "basket" of emissions, and analysis of the most cost-effective control strategies. Black carbon introduces complexity into this process and requires answers first to some fundamental questions: What is the overarching policy goal? Is it necessary to include black carbon in a multi-pollutant basket? If so, how should the metric be designed to compare greenhouse emissions? This guidance is necessary to navigate among the choices inherent in the application of weighting factors.

The GWP is a weighting factor designed to communicate the ratio of the integrated radiative forcing of a greenhouse emission to that of carbon dioxide. Integrated radiative forcing is simply the sum of the radiative forcing that a greenhouse emission produces over a chosen time horizon. For example, the IPCC in its fourth assessment report determined that the GWP for methane on a 100-year time scale is 25. That is, a pulse emission[8] of methane will produce over its lifetime twenty-five times the radiative forcing of the same quantity of carbon dioxide within a 100-year period.

The IPCC provides 20-year, 100-year and 500-year GWP values for every major greenhouse gas. In every application of the GWP this choice of time horizon is necessary. With black carbon this choice can appear difficult since the time horizon produces large variation in GWP values. This variation is explained by the differences between the time-dependent impacts of short and long-lived forcing agents. With black carbon, for example, a short time horizon like 20 years will capture all of its radiative forcing, but only a fraction of the forcing of carbon dioxide, a longer-lived agent. A longer time horizon like 100 years will still capture all of the forcing of black carbon, but it will also capture a greater fraction of carbon dioxide forcing, so the differences between their total forcing grows smaller over longer time horizons. This explains why the 100-year GWP for black carbon is much lower than the 20-year GWP.

But the selection of time scale should depend not on the greenhouse emissions being evaluated. It should depend on the overarching policy goal. If the goal is to avert global impacts to occur within 100 years, then the 100-year GWP (GWP100) is the appropriate metric. Global impacts expected within 20-years require the 20-year GWP (GWP20). The parties to the Kyoto Protocol chose to use primarily the 100-year time frame in calculating their emission inventories, which shows a preference for long term impacts and therefore, long-lived greenhouse gases. The choice of the shorter 20-year time scale would have indicated a concern for short-term climate impacts and placed greater emphasis on the role of black carbon and other short-lived forcing agents.

Black carbon is a very potent climate-forcing agent indicated by its GWP. Although the IPCC has never explicitly provided a GWP for black carbon, the information provided in the Fourth Assessment Report did provide a graphic representation of this GWP in Figure 2.22 located on page 206 of Forster et al (2007). In addition, information provided in Table 2.5 on page 164 of the same report provides the information necessary to estimate this value. The formula for the GWP is provided on page 210 is the following,

$$GWP_i \equiv \frac{\int_0^{TH} RF_i(t)\,dt}{\int_0^{TH} RF_r(t)\,dt} = \frac{\int_0^{TH} a_i \cdot [C_i(t)]\,dt}{\int_0^{TH} a_r \cdot [C_r(t)]\,dt}$$

where GWP_i is the time-integrated global mean radiative forcing of a pulse emission of 1 kilogram of compound *i* relative to that of the reference gas CO2. *TH* is the time horizon, a_i is the radiative efficiency of component *i*, and $[C_i(t)]$ is the time-dependent abundance of *i*. The numerator and the denominator are each referred to as the absolute global warming potential (AGWP). The AGWP values of CO2 for 20-years, 100-years and 500-years are found on page 211 of the report.

Since the average lifetime of black carbon is less than 1 year, the annual average radiative forcing is equal to the integrated radiative forcing for any time horizon (20, 100, or 500 years). And if the annual emissions are known for any average RF estimate, then the ratio of the two provides the integrated RF per Kg of emissions, which is equivalent to the AGWP. This method was applied to each AEROCOM study presented in Table 2.5 to produce a separate GWP, then each of these GWPs were averaged. Results are shown in Table 1. This approach is conservative since it provides only the GWP for the direct effect of black carbon and does not include the semi-direct, indirect or snow albedo effects.

Table 1. Global Warming Potentials (GWP) drawn from the IPCC 4th Assessment Report

	GWP20	GWP100	GWP500
Black carbon	**1600**	**460**	**140**
Methane	72	25	7.6
Nitrous oxide	289	298	153
Sulfur oxides	-140	-40	-12
Organic carbon	-240	-69	-21
Carbon dioxide	1	1	1

Note: The methodology used for black carbon was also used for organic carbon and sulfur oxides. Values for black carbon, organic carbon and sulfur oxides were not published by the IPCC and are not official estimates.

Application of the GWP assumes that the emissions being compared produce radiative forcing that is evenly spread across the globe, so any two emissions produce equivalent radiative forcing regardless of their location. But since black carbon is short-lived and its radiative forcing is regionally concentrated, this assumption does not hold. Short-lived aerosols travel short distances, producing strong regional radiative forcing sometimes referred to as "hot spots". The location and duration of this forcing will vary with local conditions that influence their lifetime and transport. Therefore, no two emissions of black carbon weighted by GWP can be expected to produce an equivalent radiative forcing. This suggests that black carbon emissions weighted by the GWP do not necessarily represent a CO2-equivalent value.

The IPCC acknowledged the limitations of the GWP in its application to short-lived forcing agents and called for a new metric for short-lived emissions in its 2007 report. It said "*To assess the possible climate impacts of short-lived species and compare those with impacts of the LLGHGs [long-lived greenhouse gases], a metric is needed.*"[9]. In 2009 it re-affirmed the GWP as the standard metric but opened the way for alternative approaches in its Fifth Assessment Report due in 2013[10].

Despite this, regional radiative forcing of black carbon produces climate impacts that are both regional and global in scale. Radiative forcing causes warming that extends beyond the forcing region. In the aggregate, the multiple forcing regions are a global problem.

An alternative metric to the GWP is the Global Temperature Change Potential (GTP). It is the ratio of temperature change from a pulse emission of a climate species to a pulse emission of carbon dioxide. Long-lived and short-lived pollutants that are equivalent in terms of GTP-weighted emissions will produce an equivalent global mean temperature response for a chosen year. This is to say that the GTP will produce a more accurate representation of the CO2-equivalent impacts of black carbon than will the GWP. However, policy makers will still need to choose a time period over which the metric will be calculated[11].

While the IPCC mentions the GTP in its most recent report, it does not provide values. A recent paper in press co-authored by leading scientists who drafted pieces of the IPCC report provides the estimates in Table 2.

The GTP uses an impact parameter that is further down the cause-effect chain and closer to the impacts on society; however, additional uncertainties are introduced: it varies with estimates of climate sensitivity and climate response time. As these estimates improve, the GTP for specific emissions will need to be recalculated. Like the

Table 2. Global Temperature Change Potentials (GTP) for black carbon and other pollutants

	GTP20	GTP100
Black carbon	**470**	**64**
Methane	57	4
Nitrous oxide	303	265
Organic carbon	-71	-10
Sulfur oxides	-41	-5.7
Carbon dioxide	1	1

Source: Fuglestvedt, J., K. Shine, T. Berntsen, et al. (2009) Transport impacts on Atmosphere and Climate: Metrics. *Atmos Environ* In press.

GWP it will vary with estimates of background conditions, and it does not quantify precipitation or snow melt impacts that may be important when analyzing black carbon aerosols. Nonetheless the GTP is a likely alternative to the GWP.

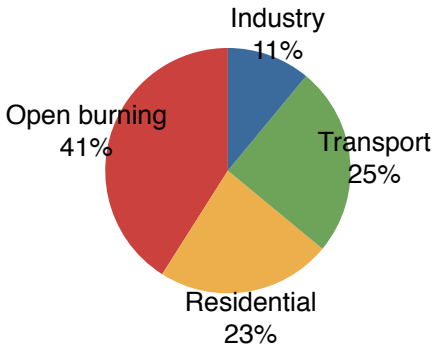
Without a common yardstick to compare short- and long-lived climate forcers, one option could be to exclude black carbon from multi-pollutant analyses, and establish separate objectives for its mitigation.

SOURCES AND TARGETS

The most recent inventory data show that the major sources of black carbon are fossil fuel combustion in industry, power generation, transportation and residential activities. Also significant is residential biofuel burning, agricultural fires, and forest fires.

Since black carbon is always emitted with a collection of aerosols, including some that are light-reflecting, it is necessary when identifying the highest priority targets to evaluate not only the inventory of emissions, but also the net absorption or reflection of those emissions and the magnitude of this effect. Organic carbon and sulphates are light-reflecting, so emissions that produce the lowest ratio of these components in relation to black carbon will cause the most positive forcing. This analysis should also take into account estimates of transport and deposition of black carbon onto ice and snow. Emissions that place the most black carbon onto these surfaces will produce the largest positive forcing at the surface. The exact threshold from negative to positive forcing for major sources is a subject of ongoing research.

Figure 1. Share of global black carbon emissions from all sources in 2000



Source: Bond, T.. (2009) Black carbon: Emission sources and prioritization. Presentation at the 2009 International Workshop on Black Carbon. 5-6 Jan 2009. London, UK.

Based on what we know about the composition of emissions from the major sources of black carbon, combustion of fossil fuels low in sulfur cause net positive radiative forcing, while residential biofuel burning, combustion of fossil fuels high in sulfur, and open burning can cause net negative forcing; however, when these sources are in close proximity to ice and snow, they can cause local positive forcing, the magnitude of which is unknown, but which may offset in whole or in part any negative forcing. Table 3 describes the priority source targets for black carbon based on this approach and Table 4 provides estimated maximum feasible reductions by major source category.

Table 3. "No-regret" targets to mitigate the climate impacts of black carbon

I. Diesel combustion in ...
A. on- road heavy-duty vehicles
B. off-road agricultural, construction and other vehicles
II. Near-Arctic emissions of ...
C. biomass burning from forest fires and controlled agricultural fires
D. diesel combustion in commercial shipping
III. Near-glacier emissions of ...
E. biofuel burning in residential heating and cooking
IV. Low-sulfur coal combustion in ...
F. residential heating and cooking
G. industrial brick kilns

Table 4. Maximum feasible reductions from baseline emissions in 2030 (Gg/yr)

	Black carbon	Organic carbon	Sulfur oxides
Industry	621	502	457
Open burning	373	1,177	166
Transportation	1,032	397	1,950
Residential	750	2,404	2,043
Total	2,776	4,480	4,616

Source: Adapted from estimates by the International Institute for Applied Systems Analysis (IIASA); Michael Walsh, International Consultant; and Corbett & Winebrake, Energy and Environmental Research Associates (EERA).

Note: Estimates of carbon-equivalent emissions require a weighting factor like the GWP or GTP. For example, the CO2-equivalent black carbon emissions for industry in 2030 using the 20-year GWP are 621*1600=993,600 MMTCO2-eq(GWP20).

MITIGATION STRATEGIES

On-road transportation

Stringent emissions controls in highly motorized industrialized countries like the United States and the European Union are producing a global decline in transportation-related black carbon emissions, however, the global vehicle fleet is set to triple by 2050.[12] If no action is taken, then these emissions are predicted to rise again and reach levels 20 percent above year 2000 levels by 2050. High-polluting heavy-duty diesel vehicles are expected to remain the primary transportation-related source of BC emissions over this time, but motorcycles, light-duty gasoline vehicles and light-duty diesel vehicles should also be targeted.

The primary, most effective emission reduction strategy is installation of the wall-flow filter (also called the diesel particulate filter) on diesel vehicles. This can practically eliminate black carbon emissions when used with ultra-low sulfur fuel at 15 parts per million (ppm) or less, and these benefits are possible immediately after installation of the device.

Appropriate policy interventions can include emission standards for new vehicles that require diesel particulate filters and low sulfur fuels; measures to encourage or require retrofit of in-use vehicles with particulate filters; effective verification and enforcement regimes; and early scrappage of high polluting older vehicles. All of these strategies have been implemented successfully in several countries, and they will produce substantial local air quality and public health benefits.

Approaches that also deserve consideration are those that produce black carbon reductions and carbon dioxide reductions in tandem. These include low carbon fuels, higher efficiency engines, lighter-weight and more aerodynamic vehicles, and even zero carbon modes. For simultaneous and effective action on BC and CO2 emissions, it is important to enable rapid transition towards advanced emission control technologies and to advance renewable energy sources in all sectors to minimize trade offs and achieve climate goals in all regions. Also important are changes in transportation demand and travel behavior to reduce polluting activities. These are brought about by investments in infrastructure to support greater use of mass transit, bicycling, walking, telecommuting, and other alternative means of mobility. It is also supported by changes to land use and economic policy to encourage and facilitate these shifts without compromising mobility needs or undermining economic development. All of these approaches move transportation systems towards greater efficiency, lower cost, and fewer emissions.

Off-road transportation

Marine shipping, locomotives, agricultural vehicles, construction equipment and other commercial off-road vehicles fall under the category of off-road transportation. Emissions from these sources are less certain and likewise tend to be less stringently regulated than on-road emissions. The quality of off-road fuel also tends to be poorer. Strategies for controlling off-road emissions are similar to strategies for on-road sources, including after-treatment technologies like particulate filters enabled by lower sulfur fuel. Strategies for ships may also include operational measures like speed controls, shore-power electrification in port, and others. Marine bunker fuel used in ships contains much higher levels of sulfur than on-road fuels, however newly implemented regulations intend to reduce this by more than 80 percent by 2020. As the current suite of sulfur reduction policies improve fuel quality, concomitant reductions in black carbon are absolutely necessary to offset any potential warming impact these reductions may produce.

Residential coal and biofuel

The world's residential coal and biofuel stoves are a no-regrets target from a public health perspective, and the potential climate impacts of emissions re-enforce the need for cleaner burning stoves. Higher efficiency stoves linked with cleaner burning fuels are being developed. But strategies to address this source category face challenges in meeting local heating and cooking needs from available fuel sources with appropriate technologies. Clean and advanced renewables over the long term are particularly important in the household sector to avoid massive fossil fuel based grid expansion.

Targeted industrial sources

Unfortunately BC industrial emissions are one of the weakest parts of global emission inventories given the

absence of robust field measurements. Nevertheless experts have suggested that brick kilns are the most important industrial source of BC given their predominant use of coal. BC emissions from diesel generators are captured in the off-road category of global inventories, but it is worth recognizing as well their role in industrial activities. Emissions controls will largely take place by replacing high-emitting brick kilns with alternative technologies.

Open biomass burning near snow and ice

Open burning is a high emitter of organic carbon, so its direct effect is probably cooling; however, black carbon emissions that reach snow and ice surfaces during vulnerable melt times can produce strong regional warming and melting effects. Strategies to avoid these may include the enforcement of seasonal bans on agricultural burning and other fire control practices.

RESEARCH NEEDS

Inventory measurements

Estimates of aggregate black carbon emissions such as those in the IPCC AR4 are highly uncertain. The quality of emissions information for certain source sub-groups is also poor. Ongoing inventory refinements include improvements to activity data and targeted measurements to confirm aerosol composition and quantities. This will support improved target selection and analysis.

Global warming potential

Research is needed on how the metric design depends on the formulation of climate policy. Also needed is research into the potential to expand multi-gas policies to include short-lived substances, either in the same "basket" as the long-lived forcing agents, or in a separate basket.

Climate impacts of control strategies

The net climate impact of an emission control strategy on the collection of aerosols emitted from a source is more policy relevant than the impacts of individual pollutants viewed without this context. Source-specific and geography-specific analysis of the net impacts of control strategies is needed to strengthen the case for their implementation.

Radiative forcing uncertainty

The estimate of radiative forcing since pre-industrial times given by the IPCC and more recent estimates given in the peer-reviewed literature differ by a factor of three. An explanation of this difference and consensus on the proper value would improve our understanding of the relative contribution of black carbon to global climate change.

Acknowledgements

This document was first begun in January 2009 with the input of the various speakers at the London workshop. From there, we did a full review of the IPCC Fourth assessment report and identified every mention of black carbon. All the relevant information there has been distilled and incorporated here. We also received much help and guidance from Jan Fuglestvedt and Terje Berntsen on the issue of GWPs and metrics generally. Tami Bond has been patient and generous with her time and provided substantial comments on multiple drafts. The first and subsequent drafts have been through three full rounds of comments, which amount to about 18 full sets of separate comments in track changes. They include comments from Martin Williams, Alan Lloyd, Michael Walsh, Tami Bond, Catherine Witherspoon, Mark Jacoboson, Olivier Boucher, Ellen Baum, John Guy, Jan Fuglestvedt, Drew Shindell, Elisa Dumitrescu, staff at the United Nations Environment Programme, Anumita Roy Chowdhury, Ben DeAngelo, and Kate Blumberg. Thanks go to all of them.

Notes

[1] The 2009 International Workshop on Black Carbon was organized by the International Council on Clean Transportation (ICCT) and occurred in London, UK on January 5-6. The agenda, list of speakers, and presentations are available online at http://www.theicct.org.

[2] Refers to cumulative radiative forcing on a global scale since pre-industrial times (1750-2005). Climate impacts are a consequence of radiative forcing.

[3] Refers to integrated radiative forcing, also known as the global warming potential (GWP), which is evaluated according to various forwarding-looking time horizons. The IPCC did not publish GWP values for black carbon and called for an alternative metric for short-lived forcing agents. Nevertheless it did publish the data needed to derive GWP values, which were calculated for this paper. A full discussion is given in the section on global warming potentials.

[4] The IPCC defines black carbon to include soot, charcoal and refractory organic matter, but these last two absorb from five to ten times less light per mass than soot and would have lower GWP values.

[5] Table 2.5 in Forster, P., V. Ramaswamy, P. Artaxo, et al. (2007) Changes in Atmospheric Constituents and in Radiative Forcing. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

[6] Ibid Table 2.13 p 207

[7]The radiative properties of black carbon depend on its mixing state. This describes whether black carbon is incorporated within other particles (internally mixed) or separate from them (externally mixed). Model simulations and lab studies show that black carbon is predominantly internally mixed, which is associated with larger positive radiative forcing than external mixing.

[8] A pulse emission gives an instantaneous increase in the atmospheric concentration of a climate-forcing gas or aerosol.

[9] Forster et al (2007) p 211

[10] Summary report of the IPCC Expert Meeting on the Science of Alternative Metrics, 18-20 March 2009, Oslo, Norway.

[11] The time period should be oriented toward a policy goal, such as the EU target of avoiding warming greater than 2 degrees C or avoidance of tipping points like the loss of Arctic summer sea ice.

[12] International Energy Agency Energy Technology Perspectives 2008 report. Available online at http://www.iea.org/Textbase/techno/etp/index.asp

Appendix V - Glossary

AB 32	California Global Warming Solutions Act of 2006
ARRA	American Recovery and Reinvestment Act of 2008
BC	Black Carbon
BEV	Battery Electric Vehicle
BLM	US Bureau of Land Management
Cal-EPA	California Environmental Protection Agency
CARB	California Air Resources Board
CalISO	California Independent System Operator
CEC	California Energy Commission
CEQA	California Environmental Quality Act
CO_2	Carbon Dioxide
CPUC	California Public Utilities Commission
DG	Distributed Generation
DOE	United States Department of Energy
DWR	California Department of Water Resources
EAAC	Economic and Allocation Advisory Committee
EJAC	Environmental Justice Advisory Committee
ESA	Energy Services Agreement
ESP	Energy Service Provider
ESCO	Energy Services Company
ETAAC	Economic and Technology Advancement Advisory Committee
FCEV	Fuel cell electric vehicle
GHG	Greenhouse Gases
GWP	Global Warming Potential
HAN	Home Area Network
IOU	Investor-Owned Utility
LCFS	Low Carbon Fuel Standard
LED	Light Emitting Diode
MMTCO2E	Million Metric Tons Carbon Dioxide Equivalent
MPR	Market Price Referent
MSW	Municipal Solid Waste
MW	Megawatts
MWh (or MWhr)	Megawatt-hours
NOx	Oxides of Nitrogen ($NO + NO_2$)
NEPA	National Environmental Policy Act
OBF	On-Bill Financing
PHEV	Plug-in Hybrid Electric Vehicle
PIER	Public Interest Energy Research
PM10	Particulate Air Emissions less than 10-microns in diameter
POU	Publicly Owned Utility
PPA	Power Purchase Agreement
PV	Photovoltaic
R&D	Research and Development
RD&D	Research Development and Demonstration

RECs	Renewable Energy Credits
REO	Real Estate Owned
RETI	Renewable Energy Transmission Initiative
RPS	Renewable Portfolio Standard
RTU	Rooftop Unit
SEER	Seasonal Energy Efficiency Rating
SOx	Sulfur Oxides (SO_2 + SO_3)
ZNE	Zero Net Energy

California Environmental Protection Agency

Air Resources Board

Economic and Technology Advancement Advisory Committee Members

Alan Lloyd (Chair)
Dr. Lloyd is the President of the International Council on Clean Transportation. He served as the Secretary of the California Environmental Protection Agency from 2004 through February 2006 and as the Chairman of the California Air Resources Board from 1999 to 2004. Prior to joining ARB, Dr. Lloyd was the Executive Director of the Energy and Environmental Engineering Center for the Desert Research Institute at the University and Community College System of Nevada, Reno, and the Chief Scientist at the South Coast Air Quality Management District until 1996. Dr. Lloyd's work focuses on the viable future of advanced technology and renewable fuels, with attention to urban air quality issues and global climate change. A proponent of alternate fuels, electric drive and fuel cell vehicles eventually leading to a hydrogen economy, he was the 2003 Chairman of the California Fuel Cell Partnership and is a co-founder of the California Stationary Fuel Cell collaborative. He earned both his B.S. in Chemistry and Ph.D. in Gas Kinetics at the University College of Wales, Aberystwyth, U.K.

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Mr. Adler is President of the California Clean Energy Fund (CalCEF), a nonprofit venture capital fund created to accelerate investment in California's clean energy economy. CalCEF Fund I is invested as a fund-of-funds in 40 companies covering the full range of clean energy technologies. In 2006 CalCEF founded the nation's first university center on energy efficiency, the Energy Efficiency Center at U.C. Davis, and in 2008 launched the CalCEF Clean Energy Angel Fund and an affiliated public policy and market intelligence organization, CalCEF Innovations. Mr. Adler has a B.A. in Political Science from U.C. Berkeley and an M.A. in Public Policy from Harvard University.

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Dr. Weyant is Professor of Management Science and Engineering, a Senior Fellow in the Institute for International Studies, and Director of the Energy Modeling Forum (EMF) at Stanford University. Established in 1976, the EMF conducts model comparison studies on major energy/environmental policy issues by convening international working groups of leading experts on mathematical modeling and policy development. Prof. Weyant earned a B.S./M.S. in Aeronautical Engineering and Astronautics, M.S. degrees in Engineering Management and in Operations Research and Statistics all from Rensselaer Polytechnic Institute, and a Ph.D. in Management Science with minors in Economics, Operations Research, and Organization Theory from University of California at Berkeley. Dr. Weyant was also a National Science Foundation Post-Doctoral Fellow at Harvard's Kennedy School of Government. His current research focuses on analysis of global climate change policy options, energy technology assessment, and models for strategic planning.

Rick Zalesky
Mr. Zalesky is Vice President of the Biofuels and Hydrogen business for Chevron Technology Ventures Company, LLC. In this role, he has responsibility for the commercialization of infrastructure development, production and supply, as well as all current technology initiatives. Mr. Zalesky joined the company in 1978 holding a variety of management positions of increasing responsibility in the downstream in refining, marketing, and technology. He is Chevron's representative on the Fuel Operations Group of the FreedomCAR and Fuel Program of the Department of Energy and a member of the UC Davis External Research Advisory Board. Mr. Zalesky is a graduate of the Georgia Institute of Technology, with a bachelor's degree in Civil Engineering.

APPENDIX VII

U.S. Department of Energy Table

data from http://www.energy.gov/recovery/documents/recoveryactfunding.xls

see above website for updates, project descriptions, and list of individual awardees

Data is as of October 16, 2009

Program Office	Project	Authorized/ Appropriation (in $1000)	Awarded/ Obligation (in $1000)	Spent/ Outlay (in $1000)
ARPA-E	Program Funding Level	388,856	SEE BELOW	SEE BELOW
	Advanced Research Projects Agency - Energy (ARPA-E)	see program funding line	2,741	474
	Program Direction - ARPA -E	see program funding line	215	202
ARPA-E Sum:		**388,856**	**2,956**	**676**
DA	Program Funding Level	42,000	SEE BELOW	SEE BELOW
	Departmental Administration	see program funding line	20,454	3,653
	Working Capital Fund	see program funding line	0	0
DA Sum:		**42,000**	**20,454**	**3,653**
EERE	Program Funding Level	16,771,907	SEE BELOW	SEE BELOW
	Advanced Building Systems	0	0	0
	Advanced Materials RD&D in Support of EERE Needs to Advance Clean Energy Technologies and Energy-Intensive Process R&D	see program funding line	29,950	329
	Battery Manufacturing	see program funding line	168,600	0
	Buildings and Appliance Market Transformation	see program funding line	2,899	740
	Clean Cities AFV Grant Program	see program funding line	0	0
	Combined Heat and Power (CHP), District Energy Systems, Waste Heat Recovery Implementation and Deployment of Efficient Industrial Equipment	see program funding line	0	0
	Commercial Scale Biorefinery Projects	see program funding line	841	0
	Commercial Vehicle Integration (SuperTruck) and Advanced Combustion Engine R&D	see program funding line	5,500	0
	Community Renewable Energy Deployment	see program funding line	527	10
	Concentrating Solar Power	see program funding line	19,733	0
	EE Appliance Rebate Programs	see program funding line	32,100	23
	EE Conservation Block Grant Program	see program funding line	1,627,056	12,305
	EGS Technology R&D	see program funding line	13,917	46
	Enabling Fuel Cell Market Transformation	see program funding line	34,460	4,420
	Energy, Water & Emissions Reporting and Tracking System	see program funding line	4,000	48
	Enhance and Accelerate FEMP Service Functions to the Federal Government	see program funding line	13,696	178
	Fundamental Research in Key Program Areas	see program funding line	5,096	4
	Geothermal Demonstrations	see program funding line	1,500	0
	Ground Source Heat Pumps	see program funding line	0	0
	High-Penetration Solar Deployment	see program funding line	7,700	0
	Hydroelectric Facility Modernization Program	see program funding line	0	0

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	Improved Energy Efficiency for Information and Communication Technology	see program funding line	0	0
	Industrial Assessment Centers and Plant Best Practices	see program funding line	1,225	0
	Integrated Biorefinery Research Expansion	see program funding line	13,433	0
	Investigation of intermediate ethanol blends, optimization of E-85 engines, and development of transportation infrastructure	see program funding line	11,578	220
	Lab Call for Facilities and Equipment	see program funding line	0	0
	Large Wind Turbine Blade Testing Facility	see program funding line	24,753	0
	Management and Oversight (EE Program Direction)	see program funding line	33,352	13,388
	Modify Integrated Biorefinery Solicitation Program for Pilot and Demonstration Scale Biorefineries	see program funding line	5,146	1,037
	NWTC Upgrades	see program funding line	9,950	0
	National Accounts Acceleration in Support of the Commercial Buildings Initiative	see program funding line	0	0
	National Geothermal Database, Resource Assessment and Classification System	see program funding line	2,569	0
	PV Systems Development	see program funding line	32,400	1,634
	Renewable Energy and Supporting Site Infrastructure	see program funding line	86,660	11
	Residential Buildings (Building America, Builders' Challenge, and Existing Home Retrofits)	see program funding line	0	0
	Solid State Lighting	see program funding line	0	0
	State Energy Program	see program funding line	3,076,750	18,550
	Transportation Electrification	see program funding line	141,500	0
	Validation of Innovative Exploration Technologies	see program funding line	0	0
	Weatherization Assistance Program	see program funding line	4,747,431	198,854
	Weatherization Innovation Pilot Program	see program funding line	0	0
	Wind Energy Consortia between Institutions of Higher Learning and Industry	see program funding line	0	0
	Wind Energy Technology R&D and Testing	see program funding line	0	0
	Wind Turbine Drivetrain Testing Facility	see program funding line	0	0
EERE Sum:		**16,771,907**	**10,154,321**	**251,797**
EM	Program Funding Level	6,000,000	SEE BELOW	SEE BELOW
	ANL Recovery Act Project	see program funding line	79,000	2,432
	BNL Recovery Act Project	see program funding line	42,355	10,528
	ETEC Recovery Act Project	see program funding line	54,162	38,541
	Hanford Central Plateau D&D Recovery Act Project	see program funding line	740,120	86,653
	Hanford Central Plateau Soil and Groundwater Recovery Act Project	see program funding line	145,780	11,737

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Program Office	Project	Authorized/ Appropriation (in $1000)	Awarded/ Obligation (in $1000)	Spent/ Outlay (in $1000)
	Hanford River Corridor D&D Recovery Act Project	see program funding line	442,265	31,000
	Hanford River Corridor Soil and Groundwater Recovery Act Project	see program funding line	77,815	2,913
	Hanford TRU Waste Recovery Act Project	see program funding line	228,520	27,526
	INL Buried Waste Recovery Act Project	see program funding line	119,300	13,830
	INL D&D Recovery Act Project	see program funding line	217,875	33,923
	INL TRU Waste Recovery Act Project	see program funding line	130,000	31,613
	LANL Defense D&D Recovery Act Project	see program funding line	64,200	1,676
	LANL Defense Soil and Groundwater Recovery Act Project	see program funding line	132,800	3,542
	LANL Non-Defense Recovery Act Project	see program funding line	14,775	845
	Liquid Waste Tank Infrastructure	see program funding line	200,000	206
	Moab Recovery Act Project	see program funding line	108,350	6,365
	Mound Operable Unit 1 Recovery Act Project	see program funding line	19,700	0
	NTS Recovery Act Project	see program funding line	44,325	8,151
	ORP Recovery Act Project	see program funding line	326,035	28,359
	Oak Ridge Defense ORNL D&D Recovery Act Project	see program funding line	111,363	7,957
	Oak Ridge Defense TRU Waste Recovery Act Project	see program funding line	78,000	5,572
	Oak Ridge Defense Y-12 D&D Recovery Act Project	see program funding line	325,000	24,840
	Oak Ridge Non-Defense Recovery Act Project	see program funding line	20,281	1,819
	Oak Ridge UE D&D Funded Recovery Act Project	see program funding line	118,200	8,421
	Paducah Recovery Act Project	see program funding line	78,800	1,333
	Portsmouth Recovery Act Project	see program funding line	118,200	5,582
	Program Direction - EM - Defense Environmental Management	see program funding line	9,020	2,214
	Program Direction - EM - Non-Defense Environmental Management	see program funding line	1,030	195
	Program Direction - EM - Uranium Enrichment D&D Fund	see program funding line	682	7
	SLAC Recovery Act Project	see program funding line	7,925	1,326
	SPRU Recovery Act Project	see program funding line	51,775	562
	SRS D&D M & D Areas Recovery Act Project	see program funding line	104,000	2,429
	SRS D&D P & R Areas Recovery Act Project	see program funding line	478,400	35,013
	SRS D&D, Soil & Groundwater Activities Site-wide Recovery Act Project	see program funding line	292,000	52,293
	SRS TRU & Solid Waste Recovery Act Project	see program funding line	541,000	133,862
	Title X Uranium/Thorium Reimbursement Program	see program funding line	32,271	31,871
	WIPP Recovery Act Project	see program funding line	172,375	20,278
	West Valley Recovery Act Project	see program funding line	73,875	5,435
EM Sum:		**6,000,000**	**5,801,574**	**680,851**

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FE	Program Funding Level	3,398,607	SEE BELOW	SEE BELOW
	Carbon Capture and Storage	see program funding line	0	0
	Expand and Extend Clean Coal Power Initiative Round III	see program funding line	50,390	1
	Geologic Sequestration Site Characterization	see program funding line	58	3
	Geologic Sequestration Training and Research Grant Program	see program funding line	208	5
	Industrial Carbon Capture and Storage Applications	see program funding line	59,269	268
	Program Direction - FE	see program funding line	1,572	1,354
FE Sum:		**3,398,607**	**111,497**	**1,631**
LGPO	Program Funding Level	3,970,000	SEE BELOW	SEE BELOW
	ATVM Administrative Fees Transfer	see program funding line	8,117	1,584
	Administrative Fees Section 1705	see program funding line	4,585	538
	LGPO	see program funding line	40,500	4,898
LGPO Sum:		**3,970,000**	**53,202**	**7,019**
OE	Program Funding Level	4,495,712	0	0
	Enhancing State and Local Governments Energy Assurance	see program funding line	43,387	11
	Interconnection Transmission Planning and Analysis	see program funding line	0	0
	Interoperability Standards and Framework (EISA 1305)	see program funding line	10,000	10,000
	Program Direction - OE	see program funding line	1,961	918
	Smart Grid Investment Grant Program (EISA 1306)	see program funding line	7,520	265
	Smart Grid Regional and Energy Storage Demonstration Project (EISA 1304)	see program funding line	47,651	649
	State Assistance on Electricity Policies	see program funding line	0	0
	Workforce Development	see program funding line	0	0

Authorized/ Appropriation ($K): Funds made available to DOE in the Recovery Act.
Awarded/ Obligation ($K): Funding commitments from DOE that will likely result in payments.
Spent/ Outlay ($K): Amount of awarded/obligated funds that have been paid.