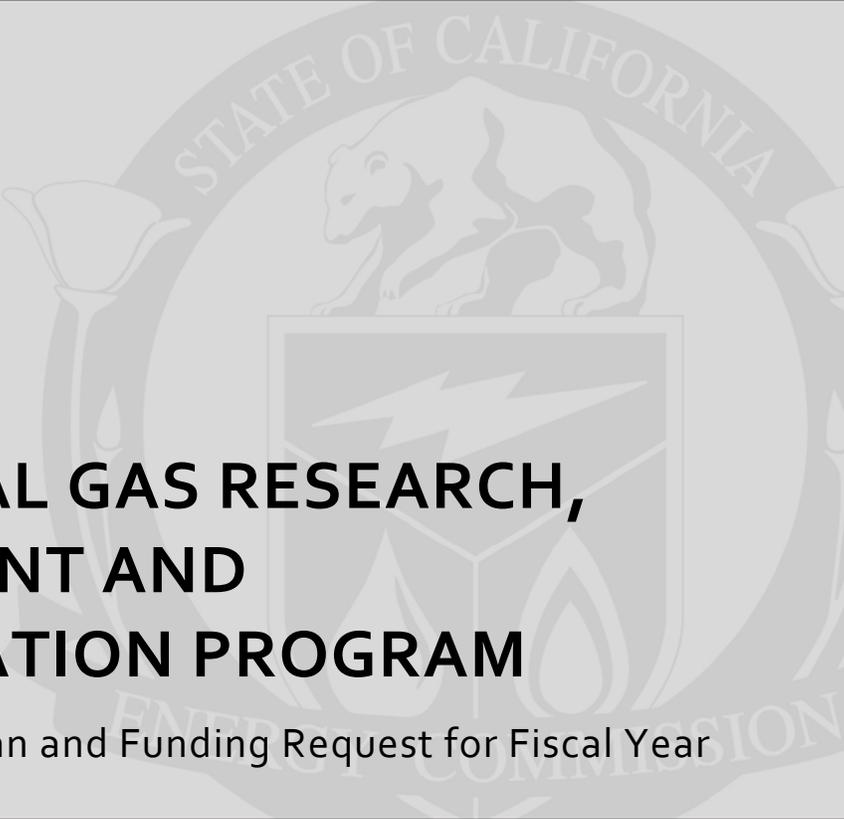


California Energy Commission
STAFF REPORT



**THE NATURAL GAS RESEARCH,
DEVELOPMENT AND
DEMONSTRATION PROGRAM**

Proposed Program Plan and Funding Request for Fiscal Year
2010-11

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Janna Franks
Primary Author

Steve Williams
Senior Technical Editor

Janna Franks
Project Manager

Michael Gravely
Manager
Energy Systems Research Office

Thom Kelly
Deputy Director
Research and Development Division

Melissa Jones
Executive Director

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Energy Research and Development Division

Avtar Bining
Matt Coldwell
Sandra Cushman
David Effross
Guido Franco
Pedro Gomez
Rey Gonzalez
Mike Gravely
Anish Gautam
Virginia Lew
Michael Lozano
Brad Meister
Philip Misemer
Leah Mohney
Marla Mueller
Jamie Patterson
Fernando Pina
Prab Sethi
John Reed
Chris Scruton
Linda Spiegel
Tony Tully
Steve Williams
Brad Worster

Media and Public Communications

ABSTRACT

The California Energy Commission's Public Interest Energy Research (PIER) program was created in 1996 when the state Legislature enacted Assembly Bill 1890 (Brulte, Chapter 854, Statutes of 1996), California's electric utility restructuring legislation. This law shifted the administration of public interest energy-related research, development, and demonstration (RD&D) from California's investor-owned utilities to state government—a major change intended to ensure the continuation of public interest energy research, development and demonstration.

Similar legislation was enacted in 2000 with Assembly Bill 1002 (Wright, Chapter 932, Statutes of 2000), which required the California Public Utilities Commission (CPUC) to impose a surcharge on all natural gas consumed in California to fund public interest research and development activities specific to natural gas. In 2004, the CPUC designated the Energy Commission as the administrator for the natural gas research program over a five-year period beginning in 2005.

The Energy Commission manages the electricity research program and the natural gas research program through its RD&D Division. Countless California stakeholders, research institutions and governmental partners have collaborated on and participated in the Energy Commission's public interest energy research projects. The success of this state research program depends upon this ongoing partnership.

The CPUC requires the Energy Commission to submit an annual proposed program plan and funding request regarding the program's administration. This staff report is the sixth annual proposed plan, which details the current and future areas of research relevant to California's natural gas ratepayers and stakeholders as well as the Energy Commission's strategic vision for future natural gas RD&D needs. The report covers the 12-month fiscal year 2010-11 (July 1, 2010 through June 30, 2011).

Keywords: California Energy Commission, California Public Utilities Commission, Air Resources Board, CPUC, ARB, natural gas research, PIER, energy research, RD&D, energy efficiency, ARRA, climate science, advanced electricity generation, renewable energy, T&D, grid, infrastructure, buildings research, distributed generation, smart grid, carbon sequestration, carbon storage, transportation research

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EXECUTIVE SUMMARY

Background

The Public Interest Energy Research (PIER) program was created in 1996 when the state Legislature enacted Assembly Bill 1890 (Brulte, Chapter 854, Statutes of 1996), California's electric utility restructuring legislation. This law shifted the administration of public interest energy-related research, development, and demonstration (RD&D) from California's investor-owned utilities to state government – a major change intended to ensure the continuation of public interest energy RD&D.

Similar legislation was enacted in 2000 with Assembly Bill 1002 (Wright, Chapter 932, Statutes of 2000), which required the California Public Utilities Commission (CPUC) to impose a surcharge on all natural gas consumed in California to fund public interest research and development activities specific to natural gas. In 2004, the CPUC designated the Energy Commission as the administrator for the natural gas research program for a 5-year period beginning in 2005.¹ The Energy Commission manages the electricity research program and the natural gas research program through its RD&D Division.

The CPUC requires the Energy Commission to submit an annual proposed program plan and funding request regarding the program's administration. This sixth annual proposed plan details the current and future areas of research relevant to California's natural gas ratepayers and stakeholders as well as the Energy Commission's strategic vision for future natural gas RD&D needs. The report covers the Fiscal Year 2010-11 (July 1, 2010 through June 30, 2011).

Research Policy Guidance

The Energy Commission's natural gas research is driven by CPUC energy policies identified in Decision 04-08-010 and *California's Long-Term Energy Efficiency Strategic Plan*, as well as *Energy Action Plans*, *Integrated Energy Policy Reports* (IEPR), and the *State Alternative Fuels Plan*.² Collaborative research efforts between the Energy Commission and the Air Resources Board help to identify technologies that can help reduce greenhouse gas emissions and achieve the policy goals of Assembly Bill 32 (Nunez, Chapter 488, Statutes of 2006). In addition, the Energy Commission sought input from experts in energy and environmental research, research organizations, the state's investor-owned gas utilities and other interested parties during the development of natural gas research priorities.

The Energy Commission integrates its natural gas and electricity research programs to leverage and increase the effectiveness of research for its overall ratepayer-funded RD&D portfolio. This

¹ California Public Utilities Commission, Decision 04-08-010 (August 19, 2004), <http://docs.cpuc.ca.gov/PUBLISHED/FINAL_DECISION/39314.htm> (January 27, 2010).

² *California's Long-Term Energy Efficiency Strategic Plan*, (September 2008), <<http://www.californiaenergyefficiency.com/docs/EEStrategicPlan.pdf>> (January 28, 2010).

State Alternative Fuels Plan, (December 2007), <<http://www.energy.ca.gov/2007publications/CEC-600-2007-011/CEC-600-2007-011-CMF.PDF>> (January 28, 2010).

reduces the potential of duplicative research in areas that impact both gas and electric use, such as windows and insulation. The benefits from the synergistic gas and electric research projects will continue to accumulate over time through subsequent activities undertaken by other research institutions and industry, and through informed policymaking that recognizes the long-term nature of energy research and development.

This synergistic approach also allows for greater funding flexibility. For example, the Energy Commission PIER electricity program is supporting a significant amount of infrastructure research in partnership with California companies receiving *American Recovery and Reinvestment Act of 2009* (ARRA) funding. A key research project is the development of a smart grid control system that will enable management of a growing community level smart grid infrastructure, including the integration of renewable energy resources, energy storage, and energy efficiency measures. Due to significant research efforts already in progress on this and other related projects, the proposed natural gas budget plan reflects no new investments in this area for the upcoming year.

Based on the FY 2009-10 research budget, the California Public Utility Commission staff recommended that the FY 2010-11 natural gas research plan augment research into the use of renewable energy to offset natural gas applications and to provide more direct natural gas ratepayer benefits. The Energy Commission's proposed natural gas research activities reflect this direction.

Highlights of Natural Gas Research Activities in 2009

Managing electricity research and natural gas research together allows projects to capture the complementary and synergistic effects of both energy resources. For example, the Energy Commission has committed \$14 million in PIER electricity program cost-share funds to California companies awarded federal grants through the ARRA, totaling more than \$386 million. These ARRA-funded projects will affect all areas of California's energy systems – natural gas and electricity. Although no PIER natural gas funding has been requested or allocated to any of these ARRA-related efforts, there will be technology advancements and research lessons learned from these California-based projects that will significantly benefit natural gas research and ratepayers and increased future natural gas research opportunities.

Frito-Lay

Through a partnership with Frito-Lay, this Energy Commission project involves using solar thermal technology in commercial food production. This innovative demonstration project harnesses the sun's energy to produce Frito-Lay's snack, Sun Chips®. By using energy efficient parabolic solar collectors that fill the size of two football fields, the sun's rays heat water in parabolic collectors, creating steam to generate electricity that powers a boiler to cook the chips. Frito-Lay saves 15 percent in natural gas costs annually. Additional benefits are the reduction of greenhouse gas emissions and better air quality for the Central Valley. Frito-Lay leads by example and encourages other California industries to adopt this energy-saving technology.

Gills Onion

The Governor's Environmental and Economic Leadership Award was awarded to a PIER project conducted with Gills Onions. The award is California's most prestigious environmental honor, given only to Californian recipients who exemplify exceptional leadership for protecting and enhancing the environment while promoting economic growth. The Gills Onions processing plant combined energy and waste reduction goals into a successful model for sustainable agriculture and food production facilities. It also has an energy sufficiency plan to eliminate all types of outside energy use by 2012, while being carbon and nitrous-oxide negative by using non-food sources for energy.

Solar Tracking

An innovative non-tracking solar collecting system was completed in December 2009 in partnership with California State University, San Diego. Called an external compound parabolic concentrator, this system is able to operate with a solar thermal efficiency of 50 percent at a temperature of 400°F. The new technology generates a renewable heat source for industrial processes that can be substituted for natural gas-fired heat. The external compound parabolic concentrator can be readily manufactured for \$15 to \$18 per square foot – compared to the \$30 per square foot cost of current state-of-the-art solar collecting systems.

High-efficient Burner

An advanced, high-efficient burner, used to melt metals in industrial furnaces, was developed and tested in 2009. Compared to current technology, the new burner significantly improves the smelting process by not introducing combustion gases into the furnace. The field demonstration at a steel mill in Fontana, California, showed that the new burner technology produced a 25 percent improvement in thermal efficiency, resulting in annual natural gas savings of 2 billion British Thermal Units (Btu) – the equivalent of 20,000 therms – at a cost savings of \$20,000. Emissions of nitrogen oxide, carbon monoxide, and carbon dioxide were reduced by approximately 55 percent, 58 percent, and 25 percent, respectively. The new technology has the potential to increase furnace efficiency by 25 percent, thus reducing gas use and production costs while reducing air emissions for the smelting industry in California.

Natural Gas Charbroilers

An innovative new technology for commercial natural gas charbroilers used in restaurants was demonstrated and tested in 2009. The new high-efficiency design uses a hood to retain heat, a thermostat to control burner temperatures, and infrared burners in place of natural gas-fired burners. This design is projected to save 636 therms per year for each unit using the new technology. The current statewide number of charbroilers is estimated at 20,000 units. The new technology is in the process of commercialization.

Hybrid Water Heater

A new hybrid water heater was developed that combines a simplified high-efficiency tankless component with a downsized, buffer-only storage tank component. Compared to current

storage water heaters, the new technology is 20 percent more energy efficient and reduces the use of natural gas. Plumbed to use existing gas lines and vents, the new technology has a strong retrofit potential as a drop-in replacement for conventional storage water heaters. The technology is now stimulating multiple product entries in the marketplace.

Blending Gases for Appliances

Home gas-fired appliances (for example, stoves, ovens, broilers, furnaces, and tankless water heaters) can operate on anticipated future blending of liquefied natural gas and other natural gas fuel substitutes into the residential gas distribution system, according to recent laboratory tests. However for current Northern California line gas, the tests also determined that the use of liquefied natural gas led to a substantial (5 percent or more) increase in pollutant emissions for cooking burners and tankless water heaters while the emission changes were generally insignificant for storage water heaters and furnaces.

Tests on industrial burners fired with multiple blends of natural gas and liquefied natural gas compositions have determined that emissions of nitrous oxides and carbon monoxide can increase, decrease, or be unchanged, depending on the type of burner and operating practice. With reasonable actions, California natural gas can rise to 1385 Wobbe with no increase in nitrogen oxides or carbon monoxide.³ Many industrial burners will require no adjustments for nitrous oxides or carbon monoxide over the range of California natural gases and up to liquefied natural gas adjusted to 1385 wobbe by nitrogen blending. However for other burners, advanced controls will be needed for tuning to avoid emissions increases. Field tests of burners in industrial plants are still needed to determine the best ways to adjust burners for variable gas supplies.

Fiscal Year 2010-2011 Research Plan

The proposed annual FY 2010-11 funding divides primary research activities into the three major objectives identified in the *2008 Energy Action Plan*:

- Improve industrial, commercial, residential, and transportation energy efficiency.
- Accelerate the adoption of clean alternatives to conventional natural gas resources and technologies.
- Reduce the environmental footprint of California's natural gas system.

The research plan follows the state's "loading order" for new energy resources, led by energy efficiency and renewable and clean distributed resources. Table 1 displays by research area the proposed allocation of the FY 2010-11 budget and, for comparison, provides the natural gas research budget approved for FY 2009-10. Differences between each fiscal year's funding requests are due to goal-oriented policy and research adjustments made by Energy Commission staff in conjunction with input from the CPUC.

³ The Wobbe Index indicates the interchangeability of fuel gases and is the best indicator of the similarity between natural gas and a specific propane-air mixture.

Table 1: Natural Gas Budget Plan Summary FY 2009-10 & FY 2010-11

| Budget Item | FY 2009-10 Budget | FY 2010-11 Budget (proposed) |
|--|---------------------|------------------------------|
| Improve Industrial, Commercial, Residential, and Transportation Energy Efficiency | \$9.95 million | \$10.84 million |
| Accelerate the Adoption of Clean Alternatives to Conventional Natural Gas Resources and Technologies | \$4.95 million | \$6.25 million |
| Improve Natural Gas System Infrastructure Performance and Reliability | \$1.7 million | \$0 ⁴ |
| Reduce the Environmental Footprint of California's Natural Gas System | \$3 million | \$3 million |
| Energy Innovation Small Grants | \$1.75 million | \$1.75 million |
| Program Administration | \$2.65 million | \$2.16 million |
| TOTAL | \$24 million | \$24 million |

Source: California Energy Commission

The following sections describe specific research activities proposed for FY 2010-11. Individual projects will be subject to the Energy Commission’s review and approval process for all RD&D research.

Improve Industrial, Commercial, Residential, and Transportation Energy Efficiency

Reflecting the state’s energy loading order, the Energy Commission considers natural gas process and end-use efficiency as its highest priority research objective. Research efforts will identify and develop opportunities to achieve greater energy efficiency benefits with existing or market-ready technologies to provide near-term and long-term benefits for California residents and the state economy.

The proposed budget plan would support research on energy efficiency through seven core areas: improved efficiency of the hot water distribution system; improved efficiency of food service operations; improved efficiency of industrial and institutional natural gas use; demonstration of emerging technologies for industrial applications; development of advanced distribution systems for heating homes; development and demonstration of advanced fuel-

⁴ Given that significant research efforts are already in progress in this research objective, the proposed natural gas budget plan reflects no new investments in this area for the coming year.

efficient transportation technologies and fuel switching strategies that result in cost-effective reduction of on-road and off-road petroleum fuel use in the short-and long-term; and development of next generation models, data sources, and policy and technology analyses to provide an improved understanding of customer behavior and demand for natural gas.

Accelerate the Adoption of Clean Alternatives to Conventional Natural Gas Resources and Technologies

Consistent with the loading order, the proposed budget plan also assigns priority to reducing dependence on imported natural gas by diversifying supplies. An ongoing Energy Commission initiative on the development of renewable, energy-secure communities is building on results from completed research on renewable technologies. The eventual deployment of market-ready renewable natural gas alternatives, which could substantially reduce natural gas demand, is also among the Energy Commission's most prominent research goals.

Key research projects include the development of energy-efficient, cost-effective, safe, clean, durable, and reliable combined heat and power and distributed energy resources technologies; development of gas-fired commercial heating/power systems and cooling solutions, biogas, and biomass gasification systems augmented by renewable resources; and research, development, and deployment of alternative fuels that reduce petroleum consumption and transportation-related greenhouse gas emissions while assisting economic development within the state of California.

Reduce the Environmental Footprint of California's Natural Gas System

To achieve the long-term greenhouse gas emissions reduction targets mandated by Assembly Bill 32, California must establish an environmentally-sound natural gas system. Key targets include efficiency and optimizing the use of natural gas, especially for heating and industrial purposes.

The three core initiatives in this research area include assessing the impacts of global climate change; developing strategies to reduce direct and indirect greenhouse gas emissions associated with natural gas; and developing solutions to reduce the impacts of natural gas production, distribution, storage, and use on air quality, biological diversity, land use, public health, and water quality.

Energy Innovations Small Grants Program

The Energy Commission's Energy Innovations Small Grants Program provides research grants to businesses, nonprofit organizations, individuals, national laboratories, utilities, academic institutions, and other qualifying entities for research that establishes the feasibility of new, innovative natural gas energy concepts. The program currently supports projects that complement larger scale natural gas research projects.

Beginning in FY 2009-10, the Energy Commission created a separate solicitation process for small grants research focused specifically on transportation. These grants will support the Energy Commission's alternative fuels research and complement the natural gas research areas by funding projects that reduce the consumption of petroleum-based fuels by promoting and advancing renewable and non-renewable alternative fuels using innovative tools and methods.

Program Administration

This budget plan proposes allocating 9 percent of the total budget to administrative expenses, which includes personnel expenses and non-research technical support. This proposed allocation, with CPUC staff guidance, represents a decrease from FY 2009-10, in which administrative expenses were 11 percent of the total budget. This change reflects efficiencies gained during the maturation of the program.

Natural Gas Program Benefits from Electricity Program Research

American Reinvestment and Recovery Action of 2009 (ARRA)

Last year the federal government created the *American Reinvestment and Recovery Act of 2009* (ARRA), which included more than \$62 billion in energy-related grants. This federal legislation presented an opportunity to improve California's energy infrastructure faster than would otherwise have been possible using only state funds. To leverage significant amounts of federal funds, the natural gas research portfolio was significantly revised to bring as much ARRA funding to California as possible.

To date, the Energy Commission has committed \$14 million in PIER electricity program cost-share funds to these California companies, resulting in the award of more than \$386 million in U.S. Department of Energy (DOE) federal ARRA funds and leveraging an additional \$283 million in third-party cost-share funding. The state's \$14 million in co-funding is leveraging more than \$669 million in additional federal and private funding, which results in a leveraging ratio greater than 48 to 1 for clean technology implementation in California.

These ARRA-funded projects will affect all areas of California's energy system – both natural gas and electric. Although no PIER natural gas program funding has been requested or allocated to any of these ARRA-related efforts, technology advancements and research lessons are expected to be learned from these California-based projects that will significantly benefit natural gas ratepayers. As the Energy Commission staff manages and coordinates these ARRA-funded electricity research projects, future natural gas research opportunities are expected to evolve from this activity.

Carbon Capture and Storage Research

The West Coast Regional Carbon Sequestration (WESTCARB) partnership, one of seven regional electricity partnerships funded by the U.S. Department of Energy (DOE), is expected to lead to advanced natural gas-fired electricity generation technologies. The partnership consists of more than 80 organizations with the common goal of characterizing regional carbon capture and storage opportunities and conducting technology validation field tests. Carbon dioxide accumulates in the atmosphere before being removed by natural processes. Slowing and ultimately reversing atmospheric carbon dioxide buildup will require deep reductions in man-made carbon dioxide emissions. Carbon capture and storage is one method to reduce these emissions. Due to the current high costs of implementing carbon capture and storage with conventional power generating systems, advanced electricity generation must be developed that will minimize the costs to ratepayers in a carbon-constrained environment. In addition to the PIER electricity program match funding provided by the Commission, the WESTCARB

program is managing more than \$100 million in DOE funding and industry-provided funding for this effort. In 2010, the Commission will initiate research funded by WESTCARB to determine the cost effectiveness of adding carbon capture and storage technologies to existing natural gas power plants.

Long-Term Program Outlook

Looking beyond the next fiscal year, several recently emerged themes in California's energy sector promise to have a profound effect on the Energy Commission's current and proposed natural gas research program. The Energy Commission intends to shape and prioritize its long-term research goals to reflect these themes, which include the Zero Energy Homes and Buildings mandate, customers' behavior impacts on energy use, possible expansion of the state Renewables Portfolio Standards to include direct natural gas use, and the emergence of a California Smart Grid.

The Energy Commission intends to continue to evaluate and calibrate its natural gas research portfolio to best provide benefit to California's natural gas ratepayers. Central to this effort is a renewed focus on quantifying the benefits of the Energy Commission's research activities, as well as identifying and addressing emerging long-term natural gas-related themes and trends that are important to California's energy-smart future.

While the costs and benefits of most commercially-available products and technologies can be quantified, the same cannot be said for pre-market emerging technologies. Calculating benefits associated with energy technology research can be especially challenging because not all benefits are readily quantifiable, such as the environmental impact of greenhouse gas reduction. Nevertheless, the Energy Commission strives to identify and pursue research projects that provide significant and measurable benefits to California's ratepayers.

The Energy Commission is rigorously evaluating its broader research program by examining past projects and then applying these lessons learned to the evaluation and prioritization processes for future programs. The Energy Commission plans to take an integrated approach to evaluating the benefits of its electricity and natural gas research activities. Through this integrated approach between the two research programs, there can be quantified synergistic benefits, enabling more effective research planning.

CHAPTER 1:

Introduction

The Public Interest Energy Research (PIER) program was created in 1996 when the State Legislature enacted Assembly Bill 1890 (Brulte, Chapter 854, Statutes of 1996), California's electric utility restructuring law. Recognizing the benefit of natural gas research to the State of California, Assembly Bill 1002 (Wright, Chapter 932, Statutes of 2000) directed the California Public Utilities Commission (CPUC) to impose a surcharge on all natural gas consumed in California to fund public interest research and development activities specific to natural gas. AB 1002 also required the CPUC to designate an entity to administer the newly created Public Interest Natural Gas Research program. In Decision 04-08-010, the CPUC designated the Energy Commission as the administrator of these research dollars for a five-year period beginning in 2005.

The Energy Commission's natural gas research program has since been updated by two legislative directives: Senate Bill 1250 (Perata, Chapter 512, Statutes of 2006), which changed how the natural gas research funds are encumbered and managed; and Senate Bill 76 (Committee on Budget and Fiscal Review Energy, Chapter 91, Statutes of 2005), which added transportation research as an integral element of natural gas research.

This report is the sixth annual proposed program plan and funding request, which details current and future areas of research relevant to California's natural gas ratepayers and stakeholders as well as the Energy Commission's strategic vision for future natural gas research, development, and demonstration (RD&D) needs in the continuously innovative field of natural gas research. Covering the 12-month period of FY 2010-11, the report complies with the requirements set forth in the CPUC decision and subsequent legislation.

This year's annual budget proposal contains five sections:

- Chapter 1 *Introduction* outlines the history of the Energy Commission's stewardship of ratepayer funded natural gas research and the proposed funding for FY 2010-11.
- Chapter 2 *Research Policy Guidance* highlights the Energy Commission's strategic vision of public interest natural gas research and development. The FY 2010-11 budget proposal is allocated according to this vision.
- Chapter 3 *Fiscal Year 2010-11 Research Plan* details the Energy Commission's proposed research solutions within each natural gas research objective, as well as the funds allocated toward those objectives. Examples of completed and ongoing natural gas projects that support the Energy Commission's research objectives are also provided.
- Chapter 4 *Energy Innovations Small Grants Program (EISG)* establishes the plan for the FY 2010-11 EISG solicitation and summarizes the results of the EISG solicitation from FY 2009-10.

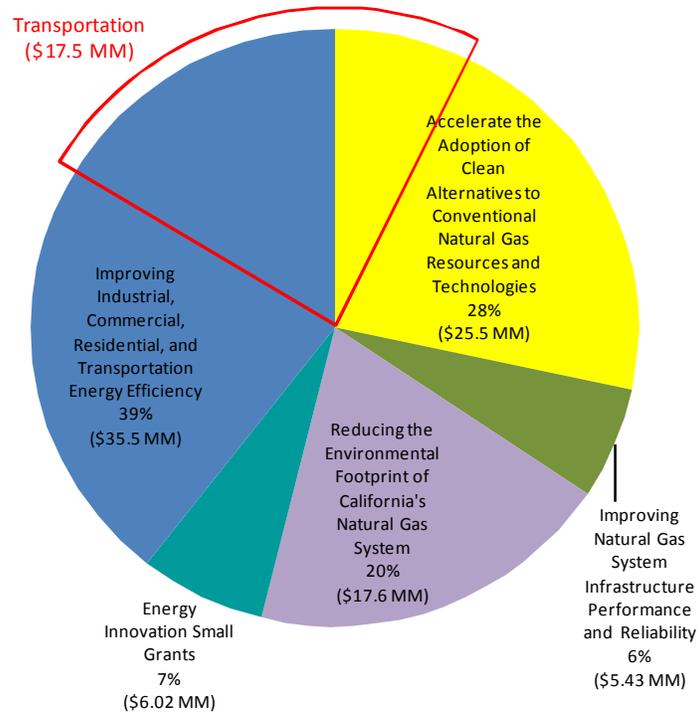
- Chapter 5 *Long-Term Program Outlook* identifies emerging trends in natural gas research and statewide ratepayer benefits created by the Energy Commission as the steward of the CPUC’s natural gas research funds.

Funding Priority Overview

Senate Bill 1250 (Perata, Chapter 512, Statutes of 2006) directs the Energy Commission to meet new research investment goals while performing a full range of RD&D not supported by competitive markets. The natural gas research program includes energy efficiency, advanced electricity generation, renewables, transmission and distribution, transportation and energy, and climate science.⁵

The Energy Commission’s research efforts have remained focused on energy policy priorities since the start of the natural gas program, and throughout the process of updating the reporting structure. Figure 1 summarizes the Energy Commission’s natural gas research expenditures by research objective from January 2005 through June 30, 2009.⁶

Figure 1: Total Natural Gas RD&D Expenditures From January 2005 Through June 30, 2009



⁵ *California Energy Commission Public Interest Energy Research Program 2008 Annual Report: Investing in California’s Future Today*, CEC-500-2009-064-CMF, (March 2009), <<http://www.energy.ca.gov/2009publications/CEC-500-2009-064/CEC-500-2009-064-CMF.PDF>> (January 27, 2010).

⁶ The reporting cycle for the Energy Commission’s natural gas RD&D program switched from a calendar year basis to a fiscal year basis effective December 2006 under CPUC Resolution G-3394 <http://docs.cpuc.ca.gov/PUBLISHED/FINAL_RESOLUTION/63130.htm>.

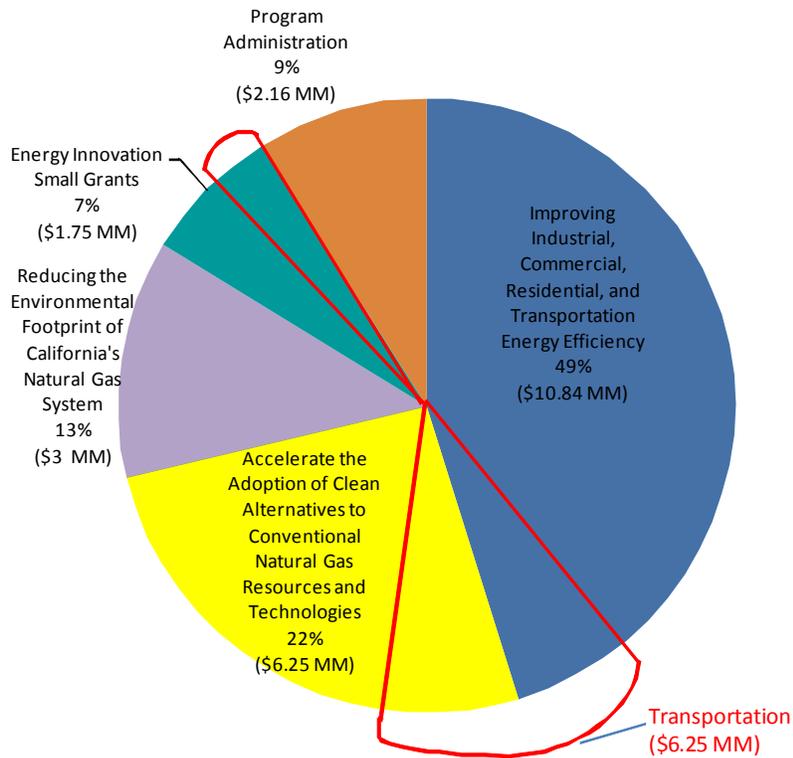
The same is true in this proposed budget. Table 2 and Figure 2 display the proposed allocation of the FY 2010-11 natural gas program budget for each research objective. Transportation-related research funding is highlighted in red as it is embedded in several categories and equals almost one-fifth of the research funding.

Table 2: Proposed Natural Gas Budget Plan Summary

| Budget Item | FY 10-11 Budget |
|--|---------------------|
| Improve Industrial, Commercial, Residential, and Transportation Energy Efficiency | \$10.84 million |
| Accelerate the Adoption of Clean Alternatives to Conventional Natural Gas Resources and Technologies | \$6.25 million |
| Reduce the Environmental Footprint of California's Natural Gas System | \$3 million |
| Energy Innovation Small Grants | \$1.75 million |
| Program Administration | \$2.16 million |
| TOTAL | \$24 million |

Source: California Energy Commission

Figure 2: Proposed Natural Gas RD&D Budget for FY 2010-11



CHAPTER 2: Research Policy Guidance

Natural Gas Research Vision

The Energy Commission's natural gas research is driven by energy policies identified in the CPUC's Decision 04-08-010 and *California's Long-Term Energy Efficiency Strategic Plan*, as well as *Energy Action Plans, Integrated Energy Policy Reports (IEPR)*, and the *State Alternative Fuels Plan*.⁷ AB 118 recognized the transportation sector as an integral area of natural gas research. The CPUC's Decision 04-08-010 not only authorized the Energy Commission to administer the natural gas program, but also defined public interest gas RD&D activities as those that, "are directed towards developing science or technology, 1) the benefits of which accrue to California citizens and 2) are not adequately addressed by competitive or regulated entities."⁸ The Decision also directs that natural gas RD&D projects meet the following criteria:

- Focus on energy efficiency, renewable technologies, conservation and environmental issues
- Support State Energy policy
- Offer a reasonable probability of providing benefits to the general public, and
- Consider opportunities for collaboration and co-funding opportunities with other entities.

The Energy Commission supports these goals and advocates increasing the energy efficiency of existing building systems, industrial processes and transportation end-uses. Examples include reducing and optimizing hot water use in residential, commercial, and industrial operations, and developing more efficient natural gas-fueled medium- and heavy-duty vehicles. The Energy Commission also is working to develop and advance more energy efficient end use technologies and strategies for unique California conditions and industries. During the development of the Energy Commission's natural gas research priorities and budget plan the Commission sought input from experts in energy and environmental research, research organizations, the state's investor-owned gas utilities, other interested parties, and CPUC staff.

Research Objectives

The Energy Commission believes that the priorities of the state energy "loading order" for new energy resources are reflected in the proposed natural gas projects for energy efficiency, renewable and clean distributed resources. Another research objective has strategic significance for energy-smart growth and is guided by key policy mandates and directives, such as

⁷ *California's Long-Term Energy Efficiency Strategic Plan*, (September 2008), <<http://www.californiaenergyefficiency.com/docs/EEStrategicPlan.pdf>> (January 28, 2010).

State Alternative Fuels Plan, (December 2007), <<http://www.energy.ca.gov/2007publications/CEC-600-2007-011/CEC-600-2007-011-CMF.PDF>> (January 28, 2010).

⁸ CPUC Decision 04-08-010, p.24.

Assembly Bill 32 (Nunez, Chapter 488, Statutes of 2006) and the *State Alternative Fuels Plan*.⁹ The Energy Commission pursues strategic investments in RD&D that recognize the central role natural gas plays in meeting the state's energy needs and helping achieve its emissions reduction targets.

The proposed budget plan identifies three research objectives that support this vision:

1. *Improve Industrial, Commercial, Residential and Transportation Energy Efficiency.* Research in this area seeks to improve the daily energy consumption practices for California natural gas ratepayers by addressing energy efficiency for industrial operations, the commercial food services sector, heating systems in residential and commercial buildings, and the transportation sector. Research will also focus on gaining an improved understanding of residential customer behavior and demand for natural gas.
2. *Accelerate the Adoption of Clean Alternatives to Conventional Natural Gas.* This area includes research that assesses and develops technologies that enable renewable resource-fueled processes to be substituted for natural gas-consuming processes. Relevant technologies include solar thermal cooling, solar process heating, and various biomass and geothermal energy applications that aim to harness California's renewable resources and limit natural gas dependencies.
3. *Reduce the Environmental Footprint of California's Natural Gas System.* This area proposes research aimed at identifying and reducing environmental impacts associated with the use of natural gas, including the development of nonstandard gas supplies (for example, liquefied natural gas and shale gas). The area also includes methodological research to improve analytical methods for measuring pollutants.

These objectives are consistent with direction provided by the CPUC. Upon reviewing and approving the FY 2009-10 proposed research budget, the CPUC staff recommended that future natural gas research plans increase their focus on the use of renewable energy to offset natural gas applications and on direct natural gas ratepayer benefits.

The proposed research objectives also reflect three high-level research objectives established by the Energy Commission: stimulate economic growth in California, identify and achieve long-term natural gas goals, and capture the benefits of integrating electricity and natural gas research. Furthermore, the Energy Commission remains flexible to rapidly changing new and emerging energy technologies. The selection of past projects reflects the core research vision and has resulted in numerous successful results including valuable research that would otherwise not have been funded.

Strategic Partnerships

The Energy Commission relies on strategic partnerships to help carry out its research, development, and demonstration activities. Partnerships are used to avoid duplication, build on successful RD&D work, generate new ideas, leverage public and private investments, and

⁹ <<http://www.energy.ca.gov/2007publications/CEC-600-2007-011/CEC-600-2007-011-CMF.PDF>>

ensure that the RD&D portfolio provides benefits to the state's electric and natural gas customers. Such partnerships facilitate interagency research coordination and cooperation and often include other state agencies, local and regional entities, industry, utilities and researchers. For example, one of the major organizing principles in the creation of the *2007-2011 Natural Gas Research Investment Plan* was that Senate Bill 76 (Committee on Budget and Fiscal Review Energy, Chapter 91, Statutes of 2005) required planning with the California Air Resources Board (ARB) to coordinate energy and environmental research priorities.¹⁰ The investment plan represents co-planning by the ARB and the Energy Commission at the strategic level and represents the forum for achieving consensus between ARB and the Energy Commission on natural gas strategic research issues and their respective priorities. ARB staff plays a key role in implementing the natural gas research program. As with the Energy Commission's electricity research, ARB staff provides advice and insights in workshops, the development of research roadmaps, defining the scope of research projects and in some cases management of specific research projects on behalf of the Energy Commission.

Additionally, the Energy Commission taps into California's diverse and substantial research capabilities at state universities, national laboratories, and high-tech companies.

Creating and sustaining these partnerships helps leverage RD&D investments, and is essential to performing the right research for the greatest benefit to California's ratepayers.

Stimulate Economic Growth in California through Advanced Natural Gas Technologies

Given California's current economic environment, energy research also should focus on projects that help fuel near-term economic growth. For example, projects that directly reduce natural gas costs for end users through efficiency improvements or more economical alternatives allow natural gas ratepayers to reduce consumption and realize cost savings. In addition to projects that address efficient and clean development of California's natural gas system, this budget proposes a high priority for projects that specifically reduce natural gas costs. While the *2009 Integrated Energy Policy Report* recognizes that natural gas prices remain volatile and difficult to predict — due to physical market factors of supply and demand, the influence of financial markets, and future greenhouse gas policies — future research will assess the impact these natural gas market factors have on how California businesses and consumers accept and implement new cost-reduction technologies.

Identify and Achieve Long-Term Natural Gas Goals for California's Energy-Smart Development

The Energy Commission believes that California's natural gas system will be transformed over the next decade as the state pursues its goal of energy-smart and community-oriented development. The Energy Commission envisions the following developments and opportunities for California's natural gas industry: the supply mix will become significantly

¹⁰ *2007-2011 Natural Gas Research Investment Plan*, (August 2006), <<http://www.energy.ca.gov/2006publications/CEC-500-2006-017/CEC-500-2006-017-CMF.PDF>> (January 28, 2010).

diversified using alternatives such as domestic shale gas production, biogas, liquefied natural gas (LNG) and other renewable alternatives; natural gas and clean alternatives will become larger components of California's transportation fuel mix; and the statewide natural gas consumption could be dramatically reduced by implementing community-level natural gas efficiency measures, such as integrated cooling, heating, and power (CHP) systems and district heating and cooling.

Capture Benefits of Integrated Electricity and Natural Gas Research

The Energy Commission strives to identify and capture research opportunities shared by its natural gas and electricity programs. Improving the efficiency of the electricity system will result in significant savings, as natural gas accounts for more than 45 percent of California's electricity generation mix.¹¹ Moreover, greenhouse gas reduction targets outlined in Senate Bill 1368 (Perata, Chapter 598, Statutes of 2006) and AB 32 suggest increasing the use of natural gas to replace higher-carbon fuel sources.

Through administrative and research synergies, the Energy Commission also provides unique benefits to California natural gas ratepayers. Administrative synergies derive from managing the public interest natural gas program within the existing public interest electricity research program using overlapping staff resources. This source cost saving is important and has a much bigger impact on the value of the program by achieving low operating margins over the long term. Research synergies contain even greater benefits and come from several sources:

Scoping Overlap — Stakeholders participating in roadmapping and scoping activities are able to identify both electricity and natural gas research needs where they overlap by program area.

For example, the Industrial Agriculture and Water program identified research areas that applied to electricity, natural gas, and some that applied to both areas during the 2008/2009 Food Processing roadmapping process. The research areas were identified by stakeholders that actively contend with multiple regulatory hurdles and recognize that resource substitution was a viable strategy in many cases. The Energy Commission elicited multiple project ideas while minimizing the potential for resource switching.

Researcher Engagement — Researchers and developers who respond to Requests for Proposals (RFPs) are more likely to be engaged and take part in broader RFP processes rather than more narrow electricity-only or natural gas-only efforts. RFP's written broadly to address both electricity and natural gas issues bring in higher quality responses.

The RD&D Division's new Renewable Energy Secure Communities (RESCO) program provides a good example of efforts to cross-leverage between natural gas and electricity research funding sources. RESCO was launched in 2008 with a solicitation that attracted more than 50 proposals. Most of the proposals awarded applied electricity research funds to address opportunities for

¹¹ 2007 Net System Power Report, April 2008 (<http://www.energy.ca.gov/2008publications/CEC-200-2008-002/CEC-200-2008-002.PDF>)

development of technical integration solutions related to the deployment of community scale renewable energy supply. Natural gas research funds were applied to three specific RD&D projects that enable community energy system integration, i.e., projects targeting cleaner, more efficient ways of exploiting local renewable energy resources that displace natural gas consumption.

RESCO technical integration projects emphasized the broadest possible application of renewable energy in a community energy system context. Both stand alone and integrated renewable sources deliver electricity to buildings in the community, displacing natural gas in building heating and cooling applications. The project specifications require a holistic approach that integrates and optimizes the interplay of renewable energy sources, electricity and natural gas demand response measures, energy efficiency measures, sourcing of bulk energy, and use of community waste streams to generate bio-gas to generate electricity and otherwise displace natural gas consumption in the community.

Interdependent Research Progress — Research, development, and demonstration processes are often non-linear in nature and depend on multiple research elements to bring a successful technology to fruition. Energy Commission staff often is made aware of the need for improvements in natural gas technology via efforts made in the electricity arena, and vice versa.

An example of interdependent research progress can be seen in a project that combined advances in solar-thermal technologies originally intended for the electricity sector with natural gas-specific technology development. Cooling Technologies, Inc., developed, adapted and tested a new dual-fired (gas-solar) generator for its 5-ton ammonia-water air-cooled absorption chiller. The generator is a simple adaptation of the company's standard gas-fired chiller generator, which minimizes the extra cost associated with the solar/gas product. With dual-fire capability, the need for thermal storage or backup systems is eliminated because the cooling system is able to operate on either or both solar energy and natural gas or propane.

Shared Sector Expertise — Expertise developed in a particular area of interest, such as advanced generation technology, is necessary to identify and manage RD&D projects. This spans both electricity and natural gas sectors. Energy Commission staff uses its sector expertise to greatest benefit when research opportunities are not restricted to either electricity or natural gas.

One such instance of shared sector expertise can be seen in the Natural Gas Cofiring in Biomass Fueled Boilers project, which aimed to develop and retrofit low nitrogen oxide gas cofire technology at two biomass fired industrial power boilers at Burney Mountain Power and Fairhaven Power. With biomass, the high fuel moisture level and high fuel quality variability combine to reduce electric competitiveness and increase environmental compliance costs. By firing small amounts of gas, approximately 10 percent of total heat input, operators can control the combustion process and avoid the usual problems that accompany combustion of wet biomass. Cofire offers an independently controlled combustion zone with higher temperatures, resulting in faster load response, better CO and opacity burnout, reductions of carbon in the

ash, and faster, cleaner startup. These benefits are essential for biomass to compete in the volatile deregulated power market that requires greater responsiveness than is now possible.

Research Policy Guidance

Energy Action Plan Loading Order

The *2008 Energy Action Plan Update* articulates a unified approach to meeting California’s electricity and natural gas needs by emphasizing that meeting California’s energy policy goals and mandates “requires the cooperation and teamwork of multiple sectors of the California economy, including the electricity, natural gas, and transportation sectors.”¹²

The *2008 EAP Update* also identifies next steps to guide the Energy Commission’s natural gas research effort and are addressed in the FY 2010-11 research program. These major action areas include:

- Energy efficiency
- Renewable energy
- Climate change

2009 Integrated Energy Policy Report

The Energy Commission’s *2009 Integrated Energy Policy Report (2009 IEPR)* is California’s key energy policy document.¹³ The *2009 IEPR* reflects input from numerous public and private stakeholders, as well as federal, state, and local agencies. The inclusive process included nearly 50 public workshops and hearings and approximately 70 supporting reports.

The *2009 IEPR* details natural gas resource constraints in California and outlines several major issues facing the state’s natural gas sector including growing demand, dependence on imports, price fluctuations, and AB 32 policy goals. Figure 3 displays the state’s growing demand for natural gas. In response, the proposed natural gas research budget addresses energy efficiency, renewable energy resources and greenhouse gas (GHG) emissions reduction targets.

Figure 3: Projected California Demand by Sector 2008-2017



¹² <http://www.energy.ca.gov/2008publications/CEC-100-2008-001/CEC-100-2008-001.PDF>

¹³ http://www.energy.ca.gov/2007_energypolicy/index.html

State Alternative Fuels Plan

The joint Energy Commission and ARB *State Alternative Fuels Plan (Plan)* establishes the following policy goals for California's transportation fuels:¹⁴

- Petroleum reduction
- Greenhouse gas reduction
- In-state biofuels production and use
- Improved air quality

The *Plan* also states that natural gas as a transportation fuel could account for the largest percentage (6.7 percent) of GHG reductions from nine alternative fuels studied.

The transportation research component of the Energy Commission's natural gas research program develops alternative fuels and vehicle technologies to help achieve the goals of the *Plan*.¹⁵ Research results target market implementation through the Alternative and Renewable Fuels and Vehicle Technology Program (ARFVT).¹⁶

Natural Gas Research Program Research Objectives

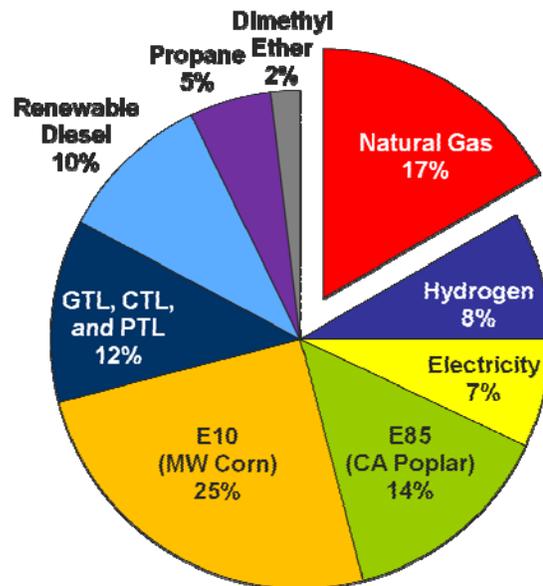
By focusing on the three research objectives, the Energy Commission's natural gas research program supports a range of issues and concerns critical to California's economic growth and the state's effort to meet its natural gas demand in environmentally sensitive ways.

Improve Residential, Commercial, Industrial, and Transportation Energy Efficiency

Natural gas end use and process efficiency is the Energy Commission's highest priority research topic area and one that provides significant near-term benefits to California residents.

Approximately one-third of California's natural gas consumption today is on-site gas used for water heating, space heating, and cooking, and another 30 percent is used for electricity generation for residential and commercial buildings. In total, annual energy consumption in California's residential and commercial buildings accounts for more than 60 percent of the total

Figure 4: State Alternative Fuels Plan Projection of Alternative Fuel Breakdown in 2022 (total volume = 5.3 billion gal. of gasoline equivalent, natural gas-derived solutions in red)



¹⁴ (CEC-600-2007-011-CTD)

¹⁵ Excluding electric drive technology the Energy Commission's electricity RD&D program will support electric drive RD&D.

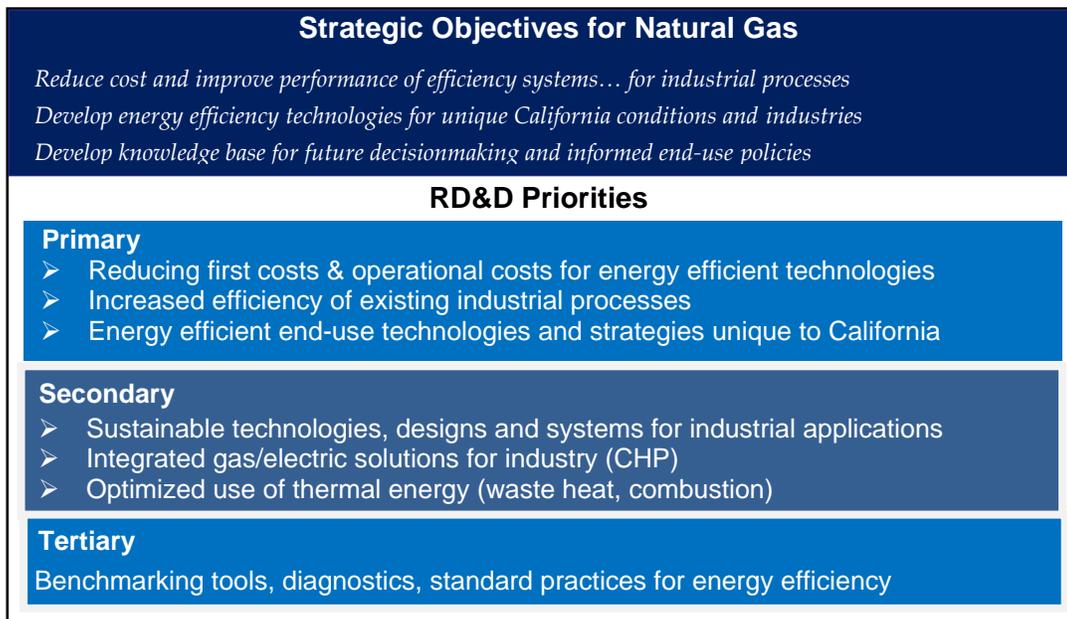
¹⁶ <http://www.energy.ca.gov/proceedings/2008-ALT-1/>

natural gas consumed in the state. The Energy Commission’s buildings research program focuses on improving the energy efficiency of residential and commercial buildings, encompassing both natural gas and electric savings. Natural gas is saved by improving the efficiency of building envelopes, thermal distribution systems, and food service equipment, but this also contributes to improved electric efficiency by reducing cooling and ventilation requirements.

On-site natural gas use in the industrial sector accounts for one-fourth of the state’s natural gas consumption. The Energy Commission’s Industrial, Agriculture, and Water research program focuses on improving energy efficiency in the natural gas sector and ensuring the availability of reliable energy supplies. The industrial sector, in particular, is a major energy consumer and one of the largest users of natural gas in the state, accounting for approximately 24 percent of total use in 2007. Consequently, industry represents a logical target for improving the efficiency of natural gas use through the adoption of new technologies and improved energy management practices.

Recognizing the importance of industrial end uses in reducing natural gas demand, the research program has defined strategic objectives that directly affect these sectors (Figure 5). Preliminary solutions identified as being relevant to the industrial sector range from reducing first costs and operational costs for energy efficiency technologies, to unique and innovative technology development and sustainable processes.

Figure 5: Strategic Objectives for Natural Gas



Source: California Energy Commission

Natural gas use in the transportation sector, currently a small portion of total demand, is expected to increase significantly following implementation of the *State Alternative Fuels Plan*, AB 32, and other policies. SB 76, the legislation that led to the formation of the Energy Commission’s Transportation Research Area, provides guidance on determining the areas of

transportation research that are appropriate for public interest funding. This law requires that public interest research done for transportation also provide benefits to California's natural gas and electricity ratepayers. SB 76 further lays out broad areas of ratepayer benefits to be realized by transportation research, summarized as:

1. Direct benefits specific to making gas or electrical service:
 - Safer, more reliable
 - or
 - Less costly
2. Activities that benefit ratepayers and that promote ALL of the following:
 - Energy efficiency
 - Reduction of health and environmental impacts from air pollution
 - Reduction of greenhouse gas emissions related to natural gas and electricity production and use
 - Increased use of alternative fuels

The Energy Commission's methodology for making investments in transportation energy research ensures that the research investments comply with SB 76, account for energy system linkages, address transportation energy policy priorities, and provide ratepayer benefits. This methodology:

1. Incorporates the requirements of statutes governing public interest energy research, including SB 76.
2. Uses energy system linkages to better understand how transportation research impacts electric and natural gas ratepayers.
3. Uses California transportation policy in combination with statutes and system linkages to identify strong, moderate, or weak ratepayer benefit potential of research initiatives.

A more complete discussion of the methodology can be found in the *Public Interest Energy Research Program 2007 – 2011 Natural Gas Research Investment Plan*.¹⁷

The 2007 IEPR further highlights California's dependency on gasoline and points out that transportation is the single largest contributor to greenhouse gas contributions because of its almost complete reliance on gasoline and diesel fuels. It also makes several recommendations for future policy and research supporting alternative fuels. To reduce petroleum fuels use and greenhouse gas emissions, the 2007 IEPR and *State Alternative Fuels Plan* (Assembly Bill 1007, Pavley, Chapter 371, Statutes of 2005) set goals to increase alternative fuels use to 9 percent by 2012, 11 percent by 2017, and 26 percent by 2022.¹⁸ The plan notes that natural gas use in heavy-duty vehicles alone could represent about 36 percent of the freight and off-road vehicle fuel use by 2050. Significant investment in this research area is necessary if California plans to

¹⁷ <http://www.energy.ca.gov/2006publications/CEC-500-2006-017/CEC-500-2006-017-CMF.PDF>

¹⁸ <http://www.leginfo.ca.gov/bilinfo.html>

meet such emission targets. Moreover, the *2008 EAP Update* defined transportation fuels and vehicles as a priority natural gas research area for the Energy Commission's Transportation research program and the Alternative and Renewable Fuels and Vehicle Technology program (Assembly Bill 118, Nunez, Chapter 750, Statutes of 2007) take strategic guidance from the plan, so that technology development direction for the research is coordinated with the deployment abilities of the ARFVT.

Accelerate the Adoption of Clean Alternatives to Conventional Natural Gas Resources and Technologies

The Energy Commission believes renewable natural gas alternatives, and highly efficient applications of natural gas, such as cooling, heating, and power (CHP) systems, require immediate and continued research to ensure significant long-term benefits for California's natural gas ratepayers. The demand for natural gas for electricity generation and commercial and residential heating applications, as well as for industrial processing and transportation-related uses, is increasing and expected to rise. Renewable technologies and resources that could displace conventional natural gas are abundantly available in California, although many of these options require long-term research to support their development and market entry. The transportation sector, which is expected to rely more on natural gas for important niche applications, benefits from research into renewable alternative fuels and technologies that could substitute for conventional natural gas.

California energy policies and directives place a high priority on reducing the state's dependence on imported natural gas through diversification of its gas supplies. For instance, the *2008 EAP Update* recognizes the need for additional research to establish or improve the viability of these natural gas alternatives, including solar thermal technologies. Similarly, the *2009 IEPR* encourages utility preference for low-carbon fuels, including various renewables for electricity generation and alternative resources that directly displace natural gas, such as solar for water and space heating, industrial process heating and cooling, or pipeline-quality injected biogas. Already working to expand the market acceptance of CHP and combined cooling, heating, and power (CCHP) systems to reduce the natural gas and electricity costs, the Energy Commission proposes pursuing research that will reduce the cost and improve the performance of solar thermal, biogas, biomass gasification technologies and geothermal technologies. Another important research initiative is the development of renewable natural gas alternatives, such as fuel produced from landfill gas, wastewater treatment systems, and anaerobic digesters.

Reduce the Environmental Footprint of California's Natural Gas System

The Energy Commission believes research efforts that reduce the environmental footprint of California's natural gas system are critical to the successful adoption of emerging natural gas technologies. California's natural gas system must be expanded and improved in compliance with state and federal regulations that protect natural resources and minimize environmental, health and safety hazards. The use of clean fossil-fueled sources such as natural gas is high in the loading order priorities. Established by CPUC Decision 07-01-039, the Power Plant Green House Gas Emissions Performance Standards heightens the importance of natural gas in meeting the state energy policy goals. An environmentally sound natural gas system is crucial

for California to achieve the long-term GHG emissions reductions target mandated by AB 32 (Figure 6).¹⁹

The 2008 EAP Update supports collaboration among the CPUC, the Energy Commission and the Air Resources Board to determine how electricity and natural gas sectors should be included in AB 32

framework. The Proposed Final Opinion on Greenhouse Gas Regulatory Strategies provides directions and priorities on how to achieve these AB 32 reduction goals.²⁰ AB 32 places reducing greenhouse gas emissions at the center of California's government and business agendas, and highlights additional research needs that must be addressed to meet its goals.

Furthermore, the Energy Commission's natural gas research program is

evaluating and characterizing the impact of California's natural gas system on the climate and other environmental impacts associated with various natural gas technologies, such as environmental concerns with the development of shale gas deposits.

Figure 6: State GHG Emissions Projection and Needed Reductions to Meet AB 32



Stakeholder Outreach

Energy policies provide guiding principles for stakeholders during the creation of collaborative roadmaps. Natural gas roadmaps are a planning mechanism and communication tool that establishes a clear link between the priorities of natural gas research and key California energy policy goals. The Energy Commission's *Research Development and Demonstration Roadmap* (RD&D Roadmap), which includes energy resources and technologies that deal directly with natural gas replacement with renewable energy, was developed through internal workshops with RD&D Division staff, meetings with other Energy Commission program staff, and extensive interviews with external stakeholders from government, utilities, industry companies, advocacy groups, and research organizations.²¹ External stakeholders include the U.S. Department of Energy, California Department of Food and Agriculture, Lawrence Berkeley National Laboratory, UC Davis, Pacific Gas & Electric, Sacramento Municipal Utility District and Southern California Edison.

¹⁹ http://docs.cpuc.ca.gov/published/FINAL_DECISION/64072.htm

²⁰ <http://www.energy.ca.gov/2008publications/CEC-100-2008-007/CEC-100-2008-007-D.PDF>

²¹ *PIER Renewable Energy Technology Program: Research Development and Demonstration Roadmap*. August 2007. CEC-500-2007-035. <<http://www.energy.ca.gov/2007publications/CEC-500-2007-035/CEC-500-2007-035.PDF>>

The Energy Commission's *Natural Gas Vehicle Research Roadmap* (NGV Roadmap) identifies initiatives and projects that research, develop, demonstrate, and deploy advanced fuel-efficient natural gas powered transportation technologies and fuel switching strategies that result in a cost-effective reduction of on-road and off-road petroleum fuel use in the short and long term.²² The NGV Roadmap represents a broad range of views, with the participation by over 100 stakeholders in the natural gas vehicle market. More than 35 in-depth interviews were conducted with stakeholders representing the interests of the natural gas vehicle industry, government, advocacy groups, fleet users, and utilities. The interviewed representatives and other stakeholders also provided feedback on drafts of the NGV Roadmap. Finally, at the Roadmap Asilomar Workshop, stakeholders were asked to review, refine and prioritize the many natural gas vehicle RD&D ideas collected during the process. The results of the workshop were offered to a wide group of stakeholders for comment.

Energy Commission staff and external stakeholders participating in roadmapping activities also have the chance to identify both electricity and natural gas research needs where they overlap by program area. Collaborative thinking about energy solutions that cut across policy boundaries is integral to maximizing the research dollar value to the ratepayer. The end users of electricity and natural gas face a complex array of regulatory issues in which savings from one energy source is often offset by increased usage from other sources. Bringing natural gas and electricity stakeholders together in the roadmapping process minimizes resource shifting, encourages innovation and yields outcomes that are more likely to successfully address challenges that involve both areas.

²² *Natural Gas Vehicle Research Roadmap*. May 2008. CEC-500-2008-044-D.
<<http://www.energy.ca.gov/2008publications/CEC-500-2008-044/CEC-500-2008-044-D.PDF>>

CHAPTER 3: Fiscal Year 2010-11 Research Plan

Overview

The Energy Commission’s *Proposed Program Plan and Funding Request for Fiscal Year 2010-11 (Natural Gas Budget Plan)* reflects current state energy policy, particularly the loading order introduced in the *2008 EAP Update*. The three major research areas developed by the Energy Commission to carry out these goals address energy efficiency, renewables and clean alternatives, and the science of energy and climate. Policy guidance for these initiatives extends from the loading order, the *State Alternative Fuels Plan*, CPUC Decision 04-08-010 and AB 32.

The \$24 million *Natural Gas Budget Plan* includes research project funding, small grants, and program administration. Approximately \$20.09 million is proposed to spend on specific research areas, \$2.16 million on program administration (a reduction of nearly \$500,000 from last year’s allocation), and \$1.75 million would be allocated for Energy Innovations Small Grants, which funds feasibility studies for emerging natural gas technologies. Table 3 displays a summary of the *Natural Gas Budget Plan*.

Table 3: FY 2010-11 Natural Gas Budget Plan Summary

| Research Objectives | Proposed Budget |
|---|---------------------|
| Improve Residential, Commercial, Industrial, and Transportation Energy Efficiency | \$10.84 million |
| Accelerate the Adoption of Clean Alternatives to Conventional Natural Gas System and Infrastructure Performance and Reliability | \$6.25 million |
| Reduce the Environmental Footprint of California’s Natural Gas System | \$3 million |
| Energy Innovation Small Grants Program | \$1.75 million |
| Program Administration | \$2.16 million |
| TOTAL | \$24 million |

Source: California Energy Commission

Proposed Research Solutions

Improve Industrial, Commercial, Residential and Transportation Energy Efficiency

The *2008 EAP Update* states that energy efficiency is the first priority under the state energy loading order. Efficiency improvements through improved building codes, appliance standards, utility energy efficiency programs, and smart growth strategies account for nearly one-quarter of the emissions reductions identified in the *California Climate Action Team Report*.²³

Transportation energy efficiency will be increasingly necessary to achieve proposed carbon dioxide emissions reductions. The Energy Commission proposes to focus heavily on natural

²³ http://www.climatechange.ca.gov/climate_action_team/reports/index.html

gas RD&D that will improve energy efficiency in California’s industrial, commercial, residential, and transportation sectors.

In FY 2010-11, the Energy Commission proposes to leverage knowledge gained from its past and ongoing research to target energy efficiency opportunities with strong potential for significant natural gas savings. In conjunction with input from the CPUC, this budget includes an additional \$0.89 million in funding for natural gas energy efficiency over last year’s budget because of increased opportunities for innovation in this area. Table 4 provides the energy efficiency budget for FY 2010-11.

Table 4: Budget Breakdown for Improving Industrial, Commercial, Residential, and Transportation Energy Efficiency

| Research Solution | Budget |
|--|-------------------------|
| Natural Gas Efficiency Research for Industrial Use | \$2.42 million |
| Energy Efficient Food Service Operations | \$1.8 million |
| Energy Efficient Hot Water Generation and Distribution | \$1.6 million |
| Advanced Energy-Efficient Heating Systems and Building Envelopes | \$2.02 million |
| Fuel-Efficient Transportation Technologies | \$3 million |
| TOTAL | \$ 10.84 million |

Source: California Energy Commission

Natural Gas Efficiency Research for Industrial Use

Nearly every industrial sector in California relies on natural gas. The use of natural gas in California industry is dominated, however, by a relatively small set of industrial sectors. The largest users include food processing, printing, and manufacture of electronics, transportation equipment, fabricated metals, furniture, chemicals, plastics, and machinery. These sectors represent prime areas of opportunity for reducing industrial natural gas use.

Current PIER industrial research roadmaps have identified the following general areas of interest:

Heat Recovery. Research opportunities include very low-grade (-40 to 250 degrees F) heat recovery, low-grade (250 to 500 degrees F) heat recovery, mid- to high-grade (500 to 1400 degrees F and higher) heat recovery, heat loss reduction, enhanced heat transfer, combustion systems improvement, advanced natural gas burners, and fuel flexibility.

Process Measurement, Diagnostics, and Optimization. Research opportunities include optimization of energy management technologies, energy metering and monitoring, energy efficiency assessment and analysis tools, financial analysis tools, process/product innovation and optimization, advanced controls, innovative processes, and non-thermal energy alternatives.

Renewable Energy for Greenhouse Gas Reduction. Research opportunities include renewable energy sources, alternative fuels, solar and other renewables.

The Energy Commission proposes to fund technologies such as high-efficiency, low emission burner designs; burners with integrated heat recovery systems; components to optimize heat recovery (valves, intelligent cycling system); combustion control systems; flexible fuel boilers; fuel switching, mixing and use without adversely affecting process performance; new techniques for process heating; renewable resources to displace natural gas; and software tools for process optimization and monitoring. The following projects exemplify research in these areas.

Waste Heat Recovery Through the Recovery of Condensate Water (DOME Technology). The DOME technology is a distillation vessel that uses waste heat to evaporate waste-water from the associated process. The distillation vessel is designed so that the clean condensed water created by the vessel is drawn down by gravity and creates a slight vacuum in the vessel space behind it. This lowers the boiling point of the wastewater in the DOME device and improves the efficiency of the distillation process.

DOME technology has potential in California's food processing industry. This \$50 billion a year industry is an important, diverse, and dynamic sector of California's economy. The food processing industry is the third largest industrial energy user in the State annually, consuming an estimated 590 million therms of natural gas, 3,700 million kilowatt-hours (kWh) of electricity, and 36,000 million gallons of water. As a large consumer of water and energy, the food processing industry naturally generates large amounts of waste heat and wastewater, which significantly reduces the energy efficiency of the operations and increases costs. Over the past decades urbanization, regulations, higher costs for water, global competition, and limitations on effluents have motivated the food processing industry to search for ways to reduce energy and water use. The commercial market, however, offers limited technologies to this industry for waste heat and wastewater recovery.

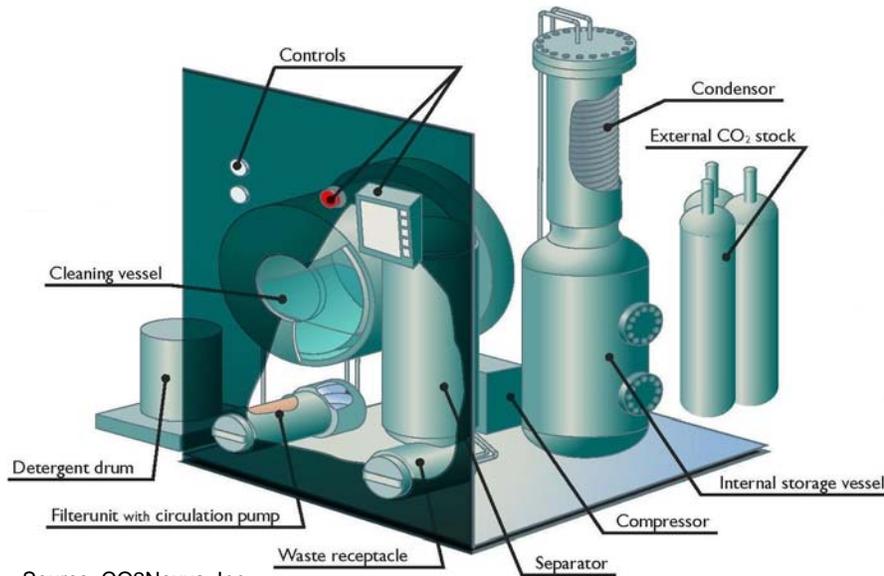
The proposed research will develop and demonstrate the cost-effective and efficient DOME technology, which is based on a concept of integrated waste heat and wastewater recovery, utilization, and/or reuse in an optimal combination of processes using well-established off-the-shelf hardware components.

Demonstration of Supercritical Carbon Dioxide-Based Laundry System. Commercial/industrial laundry has long been one of the major water consumers and uses billions of gallons of potable water each year. While the industry has implemented water efficiency measures, there have been no outright substitute solvents introduced that offer environmental, performance, and cost benefits as compared to water. The environmental impacts of implementing technology that does not use water as a cleaning solvent are enormous. CO₂Nexus has developed a commercial prototype of a supercritical carbon dioxide-based laundry system for industrial/ commercial laundry facilities that will reduce water consumption and significantly reduce energy usage through the elimination of the associated dryers.

For market acceptance, the technical and commercial feasibility of a supercritical-carbon dioxide textile cleaning and disinfection machine must be demonstrated with independent verification of the energy and water savings. The PIER Industrial, Agriculture, and Water Program plans to

fund this demonstration effort under the Emerging Technology Demonstration Program. For this project, Southern California Gas Company and Los Angeles Department of Water and Power will measure and verify of energy and water savings, with the possibility of offering rebates in the future for this technology.

Figure 7: Supercritical CO₂ Laundry Machine



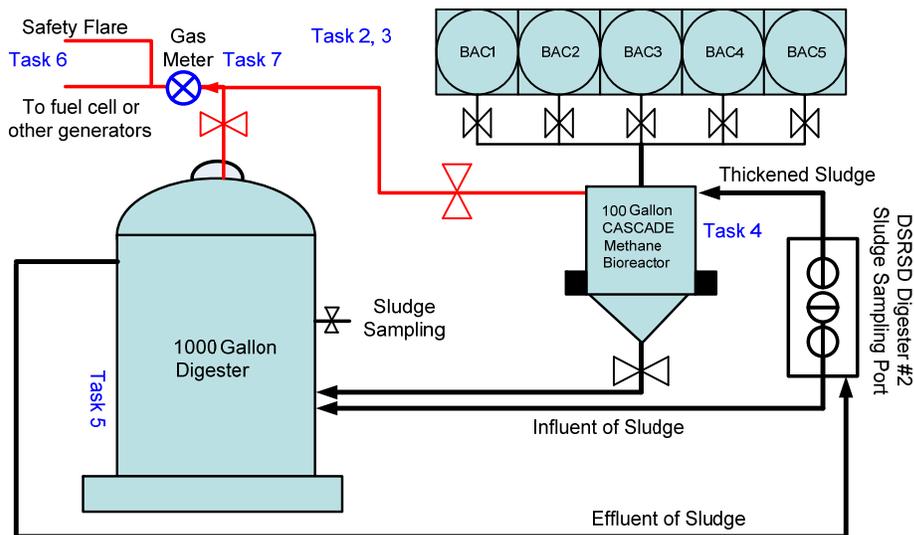
Source: CO2Nexus, Inc.

Demonstration of the CASCADE Clean Energy System. Wastewater treatment uses 5 to 7 percent of U.S. annual electrical output. Currently, however, only 1 percent of U.S. treatment facilities recover energy from wastewater. The CASCADE (Computer Assisted Strain Construction and Development Engineering) Clean Energy System allows for the selection of microorganisms based on different wastewater contents from different wastewater treatment facilities or at different times of the year under different climatic conditions. This project will demonstrate that a 100-gallon CASCADE methane bioreactor with a 1,000-gallon digester at a Dublin San Ramon Service District (DSRSD) facility can improve digester efficiency by 30 percent.

This scaled-up demonstration project will provide the industry with proven technical and performance data along with the economics of the system. The project will yield a functioning digester, design of the strain incubator and bioreactor, and the methane production rate.

The Energy Commission plans to fund CASCADE Clean Energy in the amount of \$400,000 for this demonstration effort under the Emerging Technology Demonstration Program. For this project, DSRSD is committed to providing assistance for the evaluation, documentation, and confirming the performance of the CASCADE Clean Energy System.

Figure 8: CASCADE Clean Energy System Diagram



Source: CASCADE Clean Energy, Inc.

Advanced Software for Demand and Energy Reduction in California Pipelines. This project will demonstrate the energy savings possible with use of pump optimization software and use of drag-reducing agents (DRA). It involves retooling existing pump optimization software to provide an integrated software solution to determine:

- Optimal pump selection and sequence for specific fluid.
- Optimal DRA concentration profile based on fluid transported.
- Optimal schedules to reduce periods of high pipeline flow and energy use while maintaining throughput requirements.

This technology has the potential California-wide energy savings of 5 million therms per year in gas use reduction.

Fluid pipelines operating in California transport gasoline, fuel oil, jet fuel, crude, other hydrocarbons, and water, all vital to California's economy. These pipelines are also significant users of energy, in the form of electricity and natural gas used to run the pumps necessary for pipeline operation. In addition to significant baseline energy consumption, pipelines require additional energy usage to respond to pipeline schedule requirements.

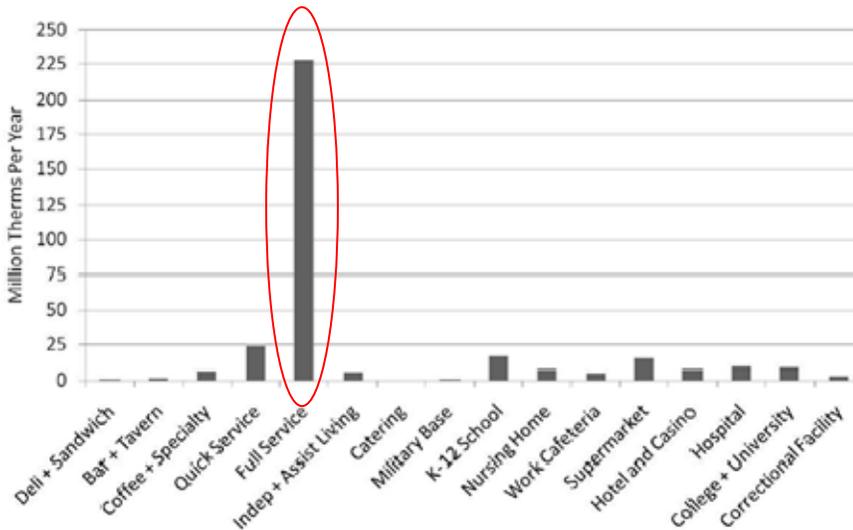
Improving pipeline technologies would help maximize the efficiency of natural gas pipelines as well as carbon dioxide pipelines for carbon capture. Maximizing the efficiency of existing pipelines could postpone the need for future pipeline construction.

Energy Efficient Food Service Operations

Gas use in full-service commercial food facilities has been identified as an area that could benefit significantly from efficiency improvements. Full-service facilities in California collectively account for more than 60 percent of natural gas use by all of the state's food service facilities, including hospitals, universities, and hotels (see Figure 9). Much of the potential

efficiency gain would come from improvements in hot water heating and range-top cooking. On a daily basis, each of California’s 34,400 full-service facilities uses an average of 2,000 gallons of hot water. As much as 90 percent of the energy used to heat water literally goes down the drain.

Figure 9: Annual Food Sector Gas Load by Service Facility Types (full service facilities in red)



Source: California Energy Commission

Potential research opportunities in the commercial food service industry include commercial dishwashers; commercial range tops; restaurant-specific, refrigeration heat-recovery systems; and tankless and high-efficiency condensing water heaters.

One technology with high potential for increased energy efficiency is dishwashers. Research opportunities include the development of a water-to-water and air-to-water heat exchangers for dishwashers (preheating domestic water using energy from gray water and exhaust air). The energy from the heated wastewater can be used to preheat the incoming cold water used by the dishwasher. Research is needed to develop an integrated heat recovery system that could reduce the gas used for heating water for the dishwasher by an estimated 50 percent, assuming daily dishwasher usage of four hours. This results in estimated annual energy savings of nearly 50 million therms, or approximately \$50 million in annual cost savings to the food service industry.

The range top is one of the most widely used pieces of equipment in commercial kitchens. Typically, a range-top configuration consists of six open gas burners, with a standard oven incorporated underneath. The development of a super-advanced (sealed or open top) gas-burner range with a target efficiency of at least 70 percent is a significant area of potential savings.

A typical gas-fired range top has a cooking energy efficiency of 30-40 percent. Range tops are generally controlled by the operator and are not amenable to advanced controls. If the burners

are continuously left on, as frequently the case in busy kitchens, real-world cooking energy efficiencies are closer to 10 percent. As a result, range tops are one of the more energy-intensive appliances in a commercial kitchen. Range tops open to the kitchen radiate heat, thereby requiring higher exhaust rates and more mechanical cooling of the kitchen. Research is needed to develop an advanced gas-fired range top that will meet the real-world needs of both end users and manufacturers, significantly surpassing the performance of existing range tops (in efficiency and user comfort), and provide benefits to food service operators.

Research is needed to develop a restaurant-specific, refrigeration heat recovery (de-superheating) system and demonstrate its energy efficiency potential for preheating domestic water. The research would quantify the reduction of gas used for heating domestic water and the associated reduction in compressor energy. There is the need to characterize the performance of such equipment under different operating conditions, combining both laboratory and field testing experiences. A key deliverable would be a design application guideline for this technology in commercial foodservice.

Another area of promising research is the testing of tankless and high-efficiency condensing water heaters, to determine potential problems in restaurant applications. For full service and institutional commercial restaurants, high-efficiency condensing water heaters may be better suited than tankless water heaters. There is a need to determine hot water loads in commercial restaurants and to test water heaters in commercial restaurant applications and laboratory environments. This research will increase the identification of potential problems with both tankless and high efficiency condensing water heaters and their technical and economic applications in commercial restaurants.

Energy-Efficient Hot Water Generation and Distribution

The Energy Commission has found through past natural gas research efforts that heat loss in water distribution systems is one of the biggest inefficiencies in California's residential and commercial water heating systems. Various studies suggest that improvements in hot water distribution system design could improve efficiency by up to 50 percent while reducing hot water delivery time. In particular, the Energy Commission proposes to support the field assessment of tankless water heaters in both residential new construction and retrofit applications; test heat exchangers that use second-story shower grey water to preheat incoming cold shower water; and assess flow, pressure, and customer satisfaction of a range of showerheads currently available to consumers.

Solar water heating for both domestic hot water and space heating applications also is an important research area. Improvements in solar hot water systems could reduce equipment and operating costs and increase implementation rates. Potential research includes hybrid integrated solar systems; roof-integrated solar hot water systems; drainback optimized controls; freezable open-loop collectors for solar hot water systems in regions with subzero temperatures; and ground-source heat pump research.

Residential Testing of Tankless Water Heaters, to Better Understand Potential Technical Problems, in Both New Construction and Retrofit Applications. Tankless water heaters may

have difficulty supplying enough hot water for simultaneous uses such as showers and laundry and have the problem of a cold water sandwich. A cold water “sandwich” occurs where a section of piping has hot water that has cooled off. This cold water is “sandwiched” between the initial hot water from the tap and the hot water that comes after the cold water. If there is no modulating temperature control, the water temperature could fluctuate at different flow rates and water pressure. Research is needed to identify potential solutions to these technical problems.

Showerhead Research to Include Broad Areas Such as Height of Showerhead, Water Pattern, Pressure. Research is needed on the performance and energy benefits associated with pressure compensating and non-pressure compensating showerheads. By reducing the amount of water, these showerheads can reduce the energy used for heating hot water. The research will evaluate customer or end-user satisfaction regarding minimum acceptable performance over a range of flowing pressures and the effect of flow rate on temperature control. Performance parameters would include: flow rate, force, spray area or pattern, temperature, efficiency (For example, removing shampoo from hair), thermal shock (hot and cold), and other end-user-defined parameters.

Hybrid-Integrated Solar Systems for Hot Water Production and Space Heating. Research is needed to determine the performance and technical potential of a hybrid solar system that could provide both water and space heating in residential applications. The research will also develop more accurate residential hot water use profiles based on real-life California data.

Roof-Integrated Solar Hot Water systems. Research is needed to investigate ways to lower the cost associated with integrating solar hot water systems in a variety of roof configurations.

Drainback Optimized Controls. Most of the current controls for solar hot water systems are not optimized for drainback systems. Research is needed to provide data to support drainback optimized controls and the resulting increase in energy efficiency.

Freezable Open-Loop Collector. Open-loop active solar hot water system design is efficient and lowers operating costs but is not currently appropriate in regions with subzero temperatures. Research is needed to design an open loop collector for areas with subzero temperatures.

Advanced Energy-Efficient Heating Systems and Building Envelopes

Space heating, particularly in residential and small commercial buildings, represents a significant end use for natural gas. The Energy Commission intends to fund advanced research on hydronic radiant space heating for use in floor systems, radiators, fan coil units and fin-tube baseboard convectors. Hydronic heating includes all types of hot water heating. Hot water heat can be delivered to a room through a radiant floor, radiators, fan-coil heaters, fin-tube baseboard convectors, or a combination of any of these devices. There are a wide variety of possible applications using each of these methods. For instance radiant heat can be delivered through a floor, wall, or a ceiling. Hydronic heating can provide a high degree of temperature control within the heated area. Research can also improve the performance of more

conventional gas furnaces, which will comprise the largest share of heating equipment for the near term.

Hydronic Radiant Heating Systems. Homeowners with radiant-floor heating are likely to be more comfortable at lower air temperatures than conventional forced air systems. Since the floor is warm, it makes occupants in the room feel warmer than conventional forced-air heating systems. People with radiant-floor heating can keep their thermostats lower and thus realize significant energy savings, resulting in combined natural gas energy and fan electrical energy costs by 10-40 percent. Research is needed to better understand barriers and identification of cost effective solutions.

Reducing the First Cost of Highly Efficient Natural Gas Furnaces. Because conventional gas furnaces represent the most common method of space heating for the near term, finding cost-effective ways to improve their efficiency to condensing levels will be the quickest way to save gas in this end use sector. Efficiency can be improved both by improving heat transfer characteristics on the combustion side and by reducing resistance to air flow on the air handler fan side of the furnace. Developing less expensive ways for heat exchangers to resist corrosive products of combustion are also important to achieving cost-effective condensing natural gas furnaces.

Ground Loop research. Ground-source heat pumps (sometimes called geothermal heat pumps) are more efficient than air-source heat pumps, but are prohibitively expensive. Research is needed to investigate ways to lower the costs associated with these systems and improve their cost effectiveness, such as development and analysis of innovative polymer heat exchangers that have the potential to reduce ground loop materials and installation costs. Additional research will focus on the cost effectiveness of coupling solar heating system with ground source heat pumps to provide seasonal heat storage for residential and commercial buildings. Using the ground loop to inject heat from rooftop collectors throughout the summer, it may be possible to satisfy 100 percent of space and water heating loads in the winter.

Improving the Performance of Building Envelopes. A key to reducing the use of natural gas for heating buildings is improving the performance of the shell, or envelope, of buildings. Because most buildings have significant air leakage to the outside and also serious deficiencies in insulation, natural gas use for heating these buildings is much higher than it needs to be. Discovering, developing and publicizing the benefit of better construction techniques are an important potential source of natural gas savings. An additional important benefit of this work is that comfort of such buildings is substantially improved due to elimination of drafts and cold spots. Another important area of needed research is measuring and quantifying the performance of building envelopes, both new and existing. Because the majority of building stock already exists, developing cost-effective envelope retrofits for these buildings is also very important to reduce natural gas use.

Fuel-Efficient Transportation Technologies

The *State Alternative Fuels Plan* (also part of the 2007 IEPR) provides findings for natural gas and several alternative fuels. The plan, the basis of the Energy Commission's Alternative and Renewable Fuels and Vehicle Technology Program, analyzed the penetration of various

alternative fuels into the transportation fuel sector using the best available full fuel cycle analysis methodology. PIER Transportation also provided gaps analysis for natural gas vehicle deployment used in the plan. A moderately aggressive case showed that ambitious but realistic goals for displacing traditional gasoline and diesel can be achieved. These goals, expressed on a gallon of gasoline-equivalent basis, are:

- 9 percent in 2012
- 11 percent in 2017
- 26 percent in 2022

These goals accelerate the growth of alternative fuels, displacing more than 4 billion gasoline gallon-equivalents (20 percent) in 2020. This could grow to at least 30 percent by 2030. By 2050, alternative fuels could provide more than half the energy needed to power California's transportation system.

The plan also concludes that biodiesel and renewable diesel, natural gas, propane, and electric drive technologies are primary options to displace diesel fuel in specific markets, such as transit buses, school buses, delivery vans, truck refrigeration units, and port vehicles. Natural gas use in heavy-duty vehicles alone could represent about 36 percent of the freight and off-road vehicle fuel use by 2050.

Natural gas vehicle research will comply with ratepayer benefit requirements of SB 76 by implementing natural gas vehicle technologies that improve efficiency, improve air quality and reduce vehicle carbon emissions.

The Energy Commission believes that natural gas vehicles will continue to play an important role in realizing California's goals for cleaner transportation. The Energy Commission will continue efforts to pursue research opportunities that address barriers preventing a broader range of natural gas vehicles. The economic drivers for growing the Light-Duty Vehicle compressed natural gas (CNG) market will likely be strengthened as natural gas pricing continues its delinking to the price of petroleum. *The Natural Gas Vehicle Research Roadmap* identifies RD&D barriers to natural gas vehicle market viability (Figure 10).²⁴ As focused research into natural gas engine development continues to progress, the barriers to deployment and demonstration will hinge on certification of these engines into vehicle chassis.

²⁴ CEC-500-2008-044-F

Figure 10: Recommended Funding Priorities From the Natural Gas Vehicle Research Roadmap (Issues addressed by FY 2010-11 research circled in red)

| | | Top Priorities | Second-Tier Priorities | Longer-Term Priorities |
|-------------|--|---|--|-------------------------------------|
| Near Term | Engine Development and Vehicle Integration | More heavy- and medium-duty engine/vehicle integration | More line haul heavy-duty engine/vehicle choices | Light-duty vehicle choice expansion |
| | | More heavy-duty and medium-duty engine sizes | Certification of new models | Continued engine refinements |
| | | Existing heavy-duty and medium-duty engine improvements | | HCNG and HCCI engines/verifications |
| | | | Determine and develop the controls for emissions due to fuel variability and stricter GHG (i.e., methane) standards. | |
| Longer-Term | | | | |

Source: California Energy Commission

Expanding Availability of Natural Gas Engines and Vehicles. The Natural Gas Vehicle Research Roadmap identifies key areas of research interest that can expand the availability of natural gas engines and vehicles. The Energy Commission proposes continuing research to enhance the viability of the natural gas vehicle market in California for vehicles that extend from Medium-Duty to Heavy-Duty Vehicle platforms. The proposed research will target expanding natural gas engine and vehicle availability by addressing second tier research roadmap priorities. The Energy Commission intends to support natural gas vehicle demonstration and deployment research efforts to enable more chassis options for existing or near term natural gas engines. Examples of projects include research opportunities to support vehicle integration, production planning, market strategy, testing, field demonstrations, and certification of new natural gas engines.

Accelerate the Adoption of Clean Alternatives to Conventional Natural Gas Resources and Technologies

The state loading order ascribes the second highest priority to renewable resources and other clean alternatives, including cooling, heating, and power (CHP) systems. California’s Renewables Portfolio Standard assigns a high priority to reducing the state’s dependence on imported natural gas by diversifying its gas supplies. The availability and stability of natural gas supply affect prices and price volatility. The demand for natural gas is increasing for electricity generation, commercial and residential heating applications, and transportation end uses.

Renewable resources that could directly displace conventional natural gas are abundantly available in California. The Energy Commission believes renewable natural gas alternatives, as well as highly efficient applications of natural gas, such as CHP, require immediate and continued research in order for these resources to result in significant long-term benefit to

California’s natural gas ratepayers. Proposed research in this topic area addresses the following 2009 IEPR recommendations:

- Support to displace natural gas with renewable sources to generate electricity and alternatives such as solar for water and space heating.
- Address technical and infrastructure barriers to deployment of emerging renewable heating and cooling technologies and to assess their current and future cost trajectories as well as how to strengthen the market for commercially mature technologies.
- Develop natural gas alternatives and substitutes for use within transportation applications, ideally using existing infrastructure and vehicles.

In supporting these recommendations, the Energy Commission proposes targeting three areas: buildings-scale implementation, community-scale implementation, and alternative transportation fuels. The Energy Commission is requesting an increase of \$300,000 over last year’s funding for this area to reflect revised policy goals developed with the CPUC. Table 5 provides the proposed budget breakdown for FY 2010-11 for this research area.

Table 5: Budget Breakdown for Accelerate the Adoption of Clean Alternatives to Conventional Natural Gas Resources and Technologies

| Research Solution | Budget |
|---|-----------------------|
| Develop Low-Cost and Thermally Efficient Renewable Industrial Heating and Cooling. | \$1 million |
| Develop Energy-Efficient and Low-Emission Technologies for Distributed Energy Resources (DER) and Combined Heat and Power (CHP)/Combined Cooling, Heating and Power (CCHP)/Industrial Cogeneration Applications | \$2 million |
| Research, Develop, and Deploy Alternative Fuels that Reduce Petroleum Consumption and Transportation related GHG Emissions, While Assisting Economic Development Within the State of California. | \$3.25 million |
| TOTAL | \$6.25 million |

Source: California Energy Commission

Develop Low-Cost and Thermally Efficient Renewable Industrial Heating and Cooling

Potential research opportunities within this area include:

- Water preheating in a multitude of industries using waste heat or renewable energy.
- Modular renewable electric heating to replace natural gas dryers and other heaters while also reducing grid electrical needs.
- Solar/thermal augmentation/replacement of existing natural gas-fired boilers.

Solar-Assisted Gas Hot Water Heating for Food Processing Industry. California has more than 1,100 wineries that ship more than 500 million gallons of wine per year, contributing \$30 billion to the state’s economy. The industry consumes more than 400 GWh of electricity annually and, after fruit and vegetable processing, is the second largest electricity-consuming food industry in California. In addition to electricity, the industry also consumes annually approximately 23 million therms of natural gas. Much of the electricity used in winemaking goes to refrigeration

for cooling and cold storage. Hot water is essential for sanitizing barrels, bottles, and equipment; for maintaining tank temperature during red wine fermentation; and for yeast generation.

Solar-assisted natural gas-fired hot water heating technology is appropriate for small wineries that use conventional storage tanks smaller than 199 gallons. At 200 gallons the storage tank must be an approved pressure vessel, which adds significantly to the initial cost. In smaller wineries, investments in equipment are kept low by purchasing readily available commercial hot water heaters, small boilers, and conventional storage tanks. The opportunity for substantial energy costs savings in smaller wineries, however, comes at a higher initial purchase cost and longer payback. By reducing the purchase cost and increasing the potential savings, quicker paybacks can be realized. An improved solar-assisted natural gas -fired boiler may realize such a payback.

The proposed research is to develop and demonstrate a solar-assisted natural gas-fired water heating system for small food processors. The proposed system combines a low maintenance closed-loop solar water heat with high efficiency heat exchanger and supplemental tankless gas fired water heater. Such a system has the potential for energy cost savings of 40 percent.

This project aims to provide an environmentally sound, safe, reliable, and affordable energy product while satisfying the unique California requirement of smog mitigation through reduction in nitrous oxides. Solar-assisted systems added to natural gas-fired equipment would decrease natural gas demand during the summer when the wineries demand for hot water is the highest.

If the solar-assisted natural gas-fired water heating system were adopted by 40 percent of the California wineries which utilize small tanks, the potential natural gas savings is projected to be 16 percent of annual use – saving 3.7 million therms out of the 23 million therms used annually by the wine industry. The corresponding carbon dioxide production would be reduced by 44 million pounds per year. This project will result in lower energy costs through the more efficient use of natural gas, increase California's competitive position in global markets, and improve environmental quality.

Develop Energy Efficient and Low-Emission Technologies for Distributed Energy Resources and Combined Heat and Power/Combined Cooling, Heating and Power Industrial Cogeneration Applications

A major deterrent for reciprocating or internal combustion engines for Combined Heat and Power (CHP) and Combined Cooling, Heating and Power (CCHP) industrial co-generation applications in California is the poor emissions performance coupled with the world's most stringent distributed generation emission standards in California.

Reciprocating engines are the most commonly used prime movers for distributed energy resources and CHP/CCHP applications. The 2009 IEPR recognized CHP/CCHP as an end-use efficiency measure for commercial, industrial and institutional facilities with identified potential "as high as 22,000 MW." Since 2003, California's energy policy has defined energy efficiency as the first priority in the loading order of resource additions to meet California's growing energy

demand. Therefore, energy efficient CHP/CCHP is a preferred resource in California's loading order.

Energy-efficient, durable, and reliable distributed energy resource systems are a promising solution to California's need for cost-effective, safe, and clean energy technologies. In particular, CHP/CCHP offers high system efficiency (thermal and electricity) and will be a critical technology solution going forward. However, many perceived CHP/CCHP benefits (including greenhouse gas emission reductions) remain largely unrealized in California.

The RD&D in this area will address hardware development of low-emission technologies for CHP/CCHP applications that are market ready or close to commercialization. In particular, this RD&D will use alternative fuels with low carbon intensity, including biogas, natural gas and otherwise wasted fuels, such as flared gas. In addition, as a part of its advanced generation research, low-emission technology will be developed for CHP/CCHP applications with inverter-based power and renewable intermittency and grid connectivity technology solutions capable of distributed energy resource aggregation. This effort will also address grid connectivity and distributed energy resource aggregation issues associated with CHP/CCHP/cogeneration units and will involve design, testing, field evaluation, and monitoring.

Research, Develop and Deploy Alternative Fuels that Reduce Petroleum Consumption and Transportation-related Greenhouse Gas Emissions, while Assisting Economic Development within the State of California

Proposed alternative fuels research will comply with the public benefits requirements of SB 76. Among these benefits are those that increase the use of alternative fuels, while improving air quality and reducing emissions of carbon dioxide in the transportation sector. An alternative Fuels Research Roadmap is being developed that will define initiatives to remove barriers to deploying alternative fuel technology and infrastructure within three areas:

- Resources and upstream research
- Fuel processing and conversion
- Distribution and fuel infrastructure

In addition to coordinating research with the ARB, this research will leverage federal efforts that address California's fuel issues. For example, the new federal policy document on biofuels, *Growing America's Fuel*, advocates a "strong focus on accelerating third generation (drop-in) biofuels development – gasoline, diesel, aviation fuels, and industrial feedstocks."²⁵ California also has its own particular and unique transportation fuels concerns regarding carbon balances, greenhouse gas emissions, energy independence and energy security, business development, and job creation. The *Alternative Fuels Research Roadmap* is addressing these concerns in a California-specific context.

²⁵http://www.whitehouse.gov/sites/default/files/rss_viewer/growing_americas_fuels.PDF

The alternative fuels research investment strategy is to advance nascent technologies toward stages that attract private sector capital and ultimately commercialization. This approach not only supports needed technological innovation, but also serves the twin purposes of ensuring California's preeminence in the increasingly vital alternative energy industry and creating new "green collar" jobs within the state. SB 1250 mandates that a time-balanced approach to the transportation RD&D portfolio. Near-, mid-, and long-term solutions are equally weighted. Thus we are pursuing a range of alternative fuel technologies, such as biomethane (already viable in niche applications), and electrofuels utilizing extremophile organisms to create fuel through photosynthesis (a very early stage technology).

Alternative fuels funding priorities in the short-to-medium term focus on drop-in, or fungible, fuels. These fuels are designed for compatibility with existing infrastructure and vehicle technology, thus avoiding the necessities of both vehicle modification and the massive and costly reengineering of bulk fuels transportation, storage, and distribution systems. Research investments will be directed at promising technologies currently under development in California, and include microbial (such as: bacteria and yeast) and thermochemical fuel paths. Many of these fungible fuels may generate significant positive externalities as well, from valuable co-products to organic waste treatment/disposal to carbon dioxide recycling.

Reducing the Environmental Footprint of California's Natural Gas System

Reduction of greenhouse gas (GHG) emissions is one of the most significant policy mandates for California today. Most importantly, AB 32 places a direct statewide cap on GHG emissions and requires California to reduce its GHG emissions to 1990 levels by 2020. This legislation includes emissions associated with California's natural gas system and will require substantial efficiency and optimization of natural gas end uses, especially those that burn natural gas for heating and various industrial processes. Furthermore, urban development and pressures of a growing economy and population affect sensitive habitats, air quality, and water quality. Applying existing regulations and any new environmental protection regulations will have impacts on energy infrastructure constraints, energy prices, and protection of the environment, public health, safety, and environmental justice. These policy and regulatory directives require that further development of California's natural gas systems will not increase its environmental footprint. The Energy Commission proposes supporting research projects that support energy-smart development of California's natural gas system without significantly impacting the state's environment and climate. Table 6 provides the budget breakdown for FY 2010-11 for this research objective.

Table 6: Budget Breakdown for Reducing the Environmental Footprint of California’s Natural Gas System

| Research Solution | Budget |
|---|--------------------|
| Air Quality | \$0.8 million |
| Environmental Effects from Geological Sequestration | \$1.2 million |
| Climate Science | \$1 million |
| TOTAL | \$3 million |

Source: California Energy Commission

Air Quality

Sensors for the Detection of Ultra-Low NOx Emissions. This project will develop nitrogen oxide (NOx) sensors and controls for stationary power to meet the needs of future near-zero-emission power systems. The researchers will apply their experience developing technology for low cost, high-sensitivity sensors for the detection of NOx in automotive (diesel) exhaust gas that have been designed for a response time of a few seconds or less, sensitivity in the range of 1-50 parts per million (ppm) with an accuracy of 1 ppm, and no cross-sensitivity to oxygen or water vapor. While the chemical environment, temperature, and other operating conditions will be different in stationary power than automotive applications, this sensor has shown promise in meeting the sensitivity, response time, durability, and other requirements necessary for this new application.

Since most of the fossil fuel-based power plants in California burn natural gas, this sensor will be tailored to natural gas power stations. On this project the RD&D Division is partnering with the Energy Commission’s Facility Siting Division, Air Resources Board, and local air districts.

Sustainable Urban Energy Planning. Buildings have significant environmental and energy footprints. The California Energy Commission has the authority to set building efficiency standards to minimize these effects and recently received the authority to adopt retrofit standards. Since its introduction in 1978, California's building and appliance efficiency standards have saved more than \$56 billion in electricity and natural gas costs. New standards effective in 2010 are predicted to save an additional \$23 billion by 2013.

In addition to cost savings, the need for less power production results in fewer smog-forming pollutants released into the atmosphere, resulting in benefits to the regional air quality. Some of these benefits, however, are indirect and difficult to quantify. There is a need for research that identifies these benefits (cost, efficiency, and emissions) under various situations to support the use of these regulatory mandates, as well as the implementation of voluntary and local time-of-sale energy-efficiency upgrade mandates throughout the state.

This project will research the environmental, economic, and equity costs and benefits to local governments of mandates and voluntary energy efficiency programs for new buildings. Additionally, comparative empirical studies will be conducted to evaluate the direct and indirect benefits of high-performance, energy-efficient buildings to owners and tenants. On this project the Environmental research team is partnering with the Buildings and Appliance

research team and the Energy Efficiency Research Office. A 50 percent match funding will be produced from the FY 2010-11 electricity research budget.

Environmental Effects From Geological Sequestration

This topic area would examine the potential risks to California's groundwater from geologic sequestration or underground capture of greenhouse gas emissions associated with industrial natural gas combustion. As a source of more than 78 million tons of carbon dioxide annually, natural gas combustion is a major source of California-based GHG emissions. The *AB 32 Scoping Plan* specifically identifies the reduction of GHG emission from natural gas combustion as an area of significant concern.²⁶ To address these concerns, the Energy Commission will support research projects to identify best management practices for addressing direct and GHG emissions from natural gas usage, with a specific focus on carbon sequestration. The *AB 32 Scoping Plan* has identified carbon sequestration as a strategy that holds significant potential for GHG emissions reduction. At present, there are few established guidelines for maximizing benefits from sequestration. The projects in this category would help to develop feasible, high-value strategies to help reduce natural gas-associated GHG emissions.

Potential Water Quality Impacts From Carbon Dioxide Contamination of Groundwater. Carbon dioxide sequestered in underground salt deposits may escape and migrate upward along different pathways, such as faults or abandoned wells, to reach shallow groundwater bodies used for municipal or agricultural water supplies. This carbon dioxide can partially or completely dissolve into the groundwater, altering the water's pH balance and potentially dissolving many minerals in the water. These dissolved minerals may contain hazardous components such as arsenic or lead that are released into the water. The lowered water pH may also mobilize contaminants that have been bound by the surrounding sediment into the water.

The proposed study will leverage an existing U.S. Environmental Protection Agency study by expanding that study to include freshwater aquifers in areas of California that are potential candidates for geologic carbon sequestration. Specifically, the study would assess mineral and metal associations in typical freshwater aquifers, assess the most probable mechanisms of metal mobilization by dissolved carbon dioxide, and use this information to develop and test geochemical models to improve the assessment of risk associated with geologic carbon sequestration.

On this project the Energy Commission Environmental research team is partnering with the Department of Conservation/Division of Oil, Gas, Geothermal Resources, the U.S. Environmental Protection Agency, the U.S. Department of Energy, and the West Coast Carbon Sequestration Partnership (WESTCARB).

Potential Seismic Effects of Geological Sequestration: An Initial Evaluation. Another concern of geologic sequestration of carbon dioxide in California is the potential to trigger earthquakes. It has been documented since the 1960s that deep well injection can induce seismic activity in geologic unstable areas. This event has been documented at hazardous waste disposal wells,

²⁶ <http://www.arb.ca.gov/cc/scopingplan/scopingplan.htm>

underground natural gas storage facilities, and oil fields. Although the vast majority of these events are of relatively low intensity, more significant earthquake events have also been documented. The geologic sequestration of carbon dioxide will lead to an increase in subsurface pressure, which may trigger an earthquake along an existing fault. Another concern is that seismic activity may reduce the integrity of the confining strata or rupture the well casing, allowing the carbon dioxide to migrate to the surface. To date, little research has been completed in this area.

The study would include evaluating the Department of Oil and Gas information on seismic/earthquake occurrences related to oil and gas operations and a preliminary characterization of regional seismic activities in areas within California that are suitable for carbon dioxide injection activities. The Energy Commission is partnering with the Department of Conservation/Division of Oil, Gas, and Geothermal Resources, the U.S. Environmental Protection Agency, the U.S. Department of Energy, and WESTCARB.

Climate Science

Understanding the impacts of global climate change on a local level will help develop efficient mitigation strategies and will help focus on technologies that have concrete applicability. California's unique climate and geography create an ideal laboratory to study specific climate phenomena and their effect on key state sectors. The Energy Commission intends to use targeted research to better understand the impacts of global climate change on the local California environment.

Reducing Fugitive Natural Gas Methane Emissions. California has a large natural gas industry producing approximately 325 billion cubic feet of natural gas in 2005, extracted from more than 1,500 gas wells and thousands of oil wells. A vast network of pipelines and associated equipment transport the natural gas produced in California, as well as imported gas, to consumers, which include power plants, industrial facilities, commercial buildings and residential homes. Aside from the transportation sector, natural gas is the fuel of choice in California.

The Air Resources Board's (ARB) *AB 32 Scoping Plan* includes a measure designed to reduce fugitive methane emissions from the oil and natural gas systems in California. The emissions from the natural gas system come from wells, leaks in transmission and distribution lines, process equipment (e.g., natural gas-fired dehydrators), control equipment (e.g., pneumatic devices such as air powered tools), and from the venting of natural gas during maintenance and repair operations.

ARB and the Energy Commission are coordinating a research project designed to develop improved emission factors to estimate fugitive methane emissions from the different components of the natural gas system. The current emission estimates are believed to be highly uncertain mainly due to two reasons: 1) the existing emission factors were developed from a study conducted in 1996 and they may not apply to existing systems and practices, and 2) most of the tests conducted for the 1996 study were done outside California. Only a very small sample of components in the natural gas system will be tested under the ongoing project.

Under this follow-up project, with the Energy Commission partnering with ARB, local districts, and natural gas utilities researchers will develop proposed controlled strategies using the improved emissions estimates developed in the original research project. Additional measurements may be necessary. Given the lack of uniformity in regulatory requirements in different regions in California, the proposed strategies will be designed by regions in California (for example, an area under the jurisdiction of the Sacramento Air Quality Management District) and, perhaps, by utility territory. The control measures will include estimated costs, overall level of control, cost effectiveness (dollars per ton of methane reduced), and an estimate of the economic impact to the natural gas industry and its ratepayers.

Vulnerability of the Natural Gas System to Potential Climate Change Impacts: a Scoping Study. In February 2008, the U.S. Climate Change Science Program released a Synthesis and Assessment Product, *Effects of Climate Change on Energy Production and Use in the United States*. The Energy Commission's research was heavily cited in this report and used as an example of what should be done for other states. At the same time, the report revealed several areas of research on energy impacts that need attention, including the following: potential decrease of power plants' generation efficiency due to high ambient temperatures; potential reductions of generating capacity due to increased temperatures of cooling medium (e.g., water from rivers) used in the cooling part of the power cycle; potential decrease of capacity of transmission lines; and potential disruptions of the supply of energy (e.g., natural gas) from outside sources that would be affected by climate change (e.g., the natural gas platforms in the Gulf region of the United States due to the potential increase of hurricane activity). In addition, other potential effects of climate change on energy infrastructures include the catastrophic failures of the levee system in the Sacramento-San Joaquin Delta where underground natural storage facilities and other important energy infrastructures are located, and the impacts of sea level rise on coastal power plants.

Although an ongoing project with the Lawrence Berkeley National Laboratory is investigating the vulnerability of the electricity system, the vulnerability of the natural gas system has not been assessed. Under a proposed project, a scoping study will be undertaken to determine if in-depth studies are needed for the natural gas sector. The information gathered during the scoping study would be used for a follow-up study, if warranted. On this project the Energy Commission is partnering with ARB, local air districts, and natural gas utilities.

CHAPTER 4: Energy Innovations Small Grants Program

Planned FY 2010-11 EISG Solicitation

Some of the most important discoveries, advances and inventions have emerged from small, innovative projects. The Energy Commission proposes allocating \$1.75 million of its proposed budget for a cross-cutting natural gas research grant program to complement ongoing core research for the Energy Commission’s natural gas research program. This year’s funding for small grants research would be divided into two main parts: transportation-related natural gas research (\$750,000) and other natural gas research (\$1 million).

These solicitations would fall under the existing Energy Innovations Small Grant (EISG) program, a successful program with the objective of providing opportunities for supporting feasibility studies. Since 2006, EISG has included emerging and promising natural gas technologies. The EISG is administered by the San Diego State University Research Foundation.

Through EISG, the Energy Commission carries out one solicitation every fiscal year for grant awards for natural gas projects. Table 7 describes the major activities and preliminary deadlines for the \$1 million solicitation for non-transportation natural gas research.

Table 7: EISG FY 2010-11 Non-Transportation Solicitation Deadlines

| Deadline | Date |
|--|---|
| Pre-proposal Abstracts Accepted (optional) | Summer 2010 |
| Grant Applications Received | Summer/Fall 2010 |
| Energy Commission Approval of Awards | Approx. 20 weeks from cutoff date |
| Notification of Awards | Within 5 business days (email & web site) |
| Begin Executing Agreements | Winter 2010 |

Source: California Energy Commission

The additional \$750,000 would fund a grant solicitation program to target feasibility research projects with specific focus on transportation-related energy topics. Table 8 describes the major activities and preliminary deadlines for the \$750,000 solicitation for transportation-related energy research.

Table 8: EISG FY 2010-11 Transportation Solicitation Deadlines

| Deadline | Date |
|---|---|
| Pre-proposal Abstracts ccepted (optional) | Summer 2010 |
| Grant Applications Received | Summer/Fall 2010 |
| Energy Commission Approval of Awards | Approx. 20 weeks from cutoff date |
| Notification of Awards | Within 5 business days (email & web site) |
| Begin Executing Agreements | Winter 2010 |

Source: California Energy Commission

These grants would support the Energy Commission’s alternative fuels research and complement the overarching natural gas research areas by funding projects that aim to reduce the consumption of petroleum-based fuels by promoting and advancing renewable and non-renewable alternative fuels using innovative tools and methods. Research examples include:

Resources and upstream research for cost effective production technologies for viable transportation fuels.

Distribution and fuel infrastructure research for cost effective technologies and strategies that solve both technical and social issues related to the introduction of new fuels.

Transportation small grants that would continue to support PIER vehicle technologies research by funding projects that reduce vehicle energy consumption through improved vehicle efficiency, reduced greenhouse gas emissions and enhanced viability of alternatively fueled vehicles. Many of these projects would indirectly support natural gas goals regarding fuel efficiency.

These projects would benefit ratepayers by reducing natural gas consumption, lowering carbon dioxide and other air pollutants, and lowering natural gas prices. These grants would be designed to assess “proof of concept,” with successful projects considered for substantive research funding in subsequent years. The program has already proven to be a valuable tool for engaging the larger research community, capturing new ideas, and thus ensuring the highest value research is identified and supported by the natural gas program.

Summary of the FY 2009-10 EISG Solicitation Results

The EISG Natural Gas Solicitation for FY 2009-10 (#09-01G) resulted in nine proposals being accepted. The initial screening, conducted by technical reviewers with recognized expertise in the subject area, resulted in four eligible proposals that were reviewed by the Program Technical Review Board. After its review, the Program Technical Review Board recommended funding four of the proposals (listed below in Table 9).

The Program and Technical Review Board is composed of a group of 10 to 14 individuals with recognized energy expertise and includes representatives from the Energy Commission, California State University, the University of California, private industry, and investor-owned utility companies. The Program and Technical Review Board is responsible for final scoring and

preparing a ranking of the grant applications funding for consideration in a public meeting by the Energy Commission.

Table 9: Approved Grant Proposals FY 09-10 (Cycle 09-01G Proposals)

| Organization | Project Title and Descriptions |
|-----------------------------|--|
| Stone Mountain Technologies | <p>Residential Gas-Fired Heat Pump Water Heater</p> <p>Project proposes to prove the feasibility of a gas-fired residential heat pump water heater with primary fuel efficiency higher than conventional gas storage water heaters and higher than electric heat pump water heaters.</p> |
| Colorado State University | <p>Advanced Control Techniques and Sensors for Gas Engines With Non Selective Catalytic Reduction (NSCR)</p> <p>Project proposes to prove the feasibility of using a control system and sensors to control the air-to-fuel ratio in NSCR systems for industrial natural gas engines. The air-to-fuel ratio must be controlled to comply with emissions requirements.</p> |
| MAHLE Powertrain, LLC | <p>Advanced Low Temperature Natural Gas Combustion Using Turbulent Jet Ignition</p> <p>Project proposes to prove the feasibility of an advanced turbulent jet ignition for natural gas engines.</p> |
| Duke University | <p>Novel Bioprocess for the Conversion of Natural Gas to Methanol</p> <p>Project proposes to prove the feasibility of modifying methane-degrading bacteria with a gene silencing technique so that methanol is not further degraded to carbon dioxide.</p> |

Source: California Energy Commission

Future Funding Strategies

To increase the success of the Energy Innovations Small Grant (EISG) natural gas research program, new strategies will be implemented that mirror successful strategies that have been used in the Energy Commission’s electricity research program. The underlying goal of these strategies is to attract a maximum number of quality applications to the natural gas research program.

The EISG program allows applicants to submit the same research proposal up to three times. First submittals often lack something minor that can easily be addressed by the applicant. Starting in 2009-2010, EISG has released multiple natural gas research solicitations to allow applicants to resubmit their research proposals that, although failing to succeed in the first

solicitation, could easily qualify for the second or third solicitation with minor revisions. This policy is particularly helpful for individual researchers with innovative ideas but who lack the full administrative support of a larger company.

The second 2009-2010 natural gas research solicitation closed in February 2010. As of this report, the results have not been reported. More than 80 percent of projects receiving EISG funding are either second or third submittals. This multiple-solicitation strategy will increase the quality of project proposals and ultimately result in more successful projects.

The EISG program will increase the exposure of its natural gas research program by releasing non-transportation and transportation natural gas research solicitations in parallel. This strategy will allow EISG to target a larger applicant pool because the two solicitations together will attract more diverse candidates. Additionally, this will allow EISG staff to spend less time on administrative-related work and more time on promoting the EISG program and encouraging applicants to respond.

CHAPTER 5: Long-Term Program Outlook

The Energy Commission intends to continue to evaluate and calibrate its natural gas research portfolio to benefit California's natural gas ratepayers and other stakeholders. Central to this effort is a renewed focus on quantifying the benefits of the Energy Commission's research activities, as well as identifying and addressing emerging long-term natural gas-related themes and trends that are critically relevant to California's energy-smart future.

The Natural Gas Research Program Benefits by Leveraging PIER Electricity-Funded Research

The Energy Commission manages research efforts for both electricity and natural gas. One substantial value of melding these two programs is the ability to leverage research activities that have value to both electricity and natural gas rate payers. While the majority of this budget plan addresses how the FY 2010-11 natural gas funds are requested to be spent, the plan also highlights areas where the Energy Commission is funding electricity research that will benefit both electricity and natural gas rate-payers.

American Recovery and Reinvestment Act Research Opportunities

As first reported in the Energy Commission's *2009 PIER Annual Report to the Legislature*, the federal government created the federal *American Reinvestment and Recovery Act of 2009* (ARRA), which included more than \$62 billion in energy-related grants. This federal legislation presented an opportunity to improve California's energy infrastructure faster than would otherwise have been possible using only state funds. Although not initially included in the PIER electricity research portfolio for FY 2009-2010, the portfolio was significantly revised to bring as much ARRA funding to California as possible. The Energy Commission recognized the opportunity to use ARRA funding to expand the job opportunities in California; allow California companies to highlight their products, skills, and expertise throughout the nation and the world; and help the state become the center of the oncoming clean technology revolution.

To date, the Energy Commission has committed \$14 million in PIER electricity program cost-share funds to California companies, resulting in the award of more than \$386 million in U.S. Department of Energy (DOE) federal ARRA funds and an additional \$283 million in third-party cost-share funding (see Table 10). The state's \$14 million in co-funding is leveraging more than \$669 million in additional federal and private funding, which results in a leveraging ratio greater than 48 to 1 for clean technology implementation in California.

Table 10: ARRA-Leveraged Funding

| | PIER Program Funds | DOE ARRA Funds Into California | Third-Party Cost-Share Funds for California Projects | TOTAL |
|---|--------------------|--------------------------------|--|-----------------------------------|
| Approved or Awarded Grants | \$14 million | \$386 million | \$283 million | \$683 million |
| | | \$669 million | | |
| Potential Awards for Future ARRA Federal Grants | \$20 million | \$500 million-\$800 million | \$200 million-\$500 million | \$720 million-1320 million |

Source: California Energy Commission

Through this effort, PIER has connected with companies working across the state. Figure 11 shows the locations of the ARRA and Commission co-funded projects in California, which have been announced to date, and a list of the key organizations involved in their development.

Figure 11: Location Map of ARRA Projects in California and List of Project Participants



Total Project Value to CA – more than \$1.3 Billion

- City of Glendale Water & Power
- Modesto Irrigation District
- Burbank Water & Power
- City of Anaheim
- Electric Power Group (WECC subcontractor)
- Pacific Gas and Electric (WECC subcontractor)
- Sacramento Municipal Utility District
- San Diego Gas & Electric
- Honeywell International, Inc.
- Los Angeles Department of Water & Power
- Southern California Edison
- Boeing
- Waukesha Electric Systems
- Primus Power
- SEEO Inc.
- Southern California Edison
- Pacific Gas & Electric
- Amber Kinetics
- Ktech Corp.
- Sacramento Municipal Utility District
- University of California, San Diego
- Potter Drilling
- Porifera
- C6 Resources, LLC

Source: California Energy Commission

The Commission continues to work with California-based ARRA applicants. Anticipating that California applicants may receive additional ARRA awards for already-submitted projects, the

Commission has set aside an additional \$20 million in electricity research co-funding for these California projects.

ARRA is Accelerating Technology

ARRA-funded projects accelerate advancements in technology and manufacturing that otherwise may not have taken place until the next decade or later. The Commission will monitor progress, share technical knowledge, and ensure that the ARRA technologies are properly coordinated and applied throughout the state.

Successfully awarded ARRA projects encompass technologies from electricity generation level to end-use applications. Technologies include the following:

- Smart meters
- Electric vehicle charging stations
- Energy storage technologies including flywheels, lithium-ion batteries, zinc-chloride batteries, reduction-oxidation flow batteries, and underground compressed air
- Cybersecurity
- Synchrophasors for electric transmission lines
- Renewable energy generation
- High-penetration solar deployment
- Geothermal drilling
- Carbon sequestration (capture and storage)
- Energy-efficient building technologies
- Workforce training development

These ARRA-funded projects will affect all areas of California's energy system – both natural gas and electric. Although no PIER natural gas funding has been requested or allocated to any of these ARRA-related efforts, there clearly will be technology advancements and research lessons learned from these California-based projects that will significantly benefit the natural gas ratepayers. As the Energy Commission staff manages and coordinates these ARRA-funded electricity research projects, future natural gas research opportunities will most definitely evolve from this activity.

Carbon Capture and Storage Research

The Commission manages the West Coast Regional Carbon Sequestration (WESTCARB) partnership, one of seven regional partnerships funded by the U.S. Department of Energy (DOE). The partnership consists of more than 80 organizations. WESTCARB's goals are to characterize regional carbon capture and storage (CCS) opportunities and to conduct technology validation field tests.

Carbon dioxide accumulates in the atmosphere before being removed by natural processes. Slowing and ultimately reversing atmospheric carbon dioxide buildup will require deep

reductions in man-made carbon dioxide emissions. CCS is one method to reduce these emissions. Due to the current high costs of implementing CCS with conventional power generating systems, advanced electricity generation must be developed that will minimize the costs to ratepayers in a carbon-constrained environment. In addition to the electricity research program match funding provided by the Commission, the WESTCARB program is managing more than \$100 million in DOE funding and industry-provided funding for this effort.

The WESTCARB team is programmed to demonstrate small-scale carbon dioxide injections in both Arizona and California in the next two years. The results of this research will provide valuable information to help the state and the nation determine the value of CCS in future state greenhouse gas reductions policies and plans. The WESTCARB efforts will make a vital contribution to the scientific, technical, and institutional knowledge necessary to establish frameworks for the development of commercial carbon sequestration projects in California. It will also inform policy makers and stakeholders in the development of public policy instruments addressing carbon dioxide emission reductions.

In 2010, the Commission will initiate research funded by WESTCARB to determine the cost effectiveness of adding CCS technologies to existing natural gas power plants. This effort will research different carbon dioxide capture technologies and develop a proposed pilot demonstration using the most cost-effective and appropriate carbon dioxide capture technology integrated onto a natural gas-fired power plant based in Northern California. Again, as with the ARRA-related research, this effort does not use any PIER natural gas research funds but provides substantial benefits to the California natural gas ratepayers.

Quantifying Natural Gas Research Benefits

While the costs and benefits of commercially available products and technologies can be readily quantified, the same statement cannot be said for pre-market emerging technologies. Calculating benefits associated with energy technology research can be especially challenging given that some benefits are not readily quantifiable, such as the environmental impact of greenhouse mitigation and reduction. Nevertheless, the Energy Commission strives to identify and pursue research projects that provide significant and measurable benefit to California's electricity and natural gas ratepayers. The Energy Commission is rigorously evaluating its broader research program by first examining past projects and then applying these lessons learned to the evaluation and prioritization processes for future programs.

Other Emerging Themes and Trends

Looking beyond the coming fiscal year, several recently emerged themes in California's energy sector promise to have a profound effect on the Energy Commission's current and proposed natural gas research program. The Energy Commission intends to shape and prioritize its long-term research goals to reflect these themes, which include the Zero Energy Homes and Buildings policy mandate, customer behavior's effect on energy use, and the emergence of a California Smart Grid. In addition, the Energy Commission would develop new and rigorous

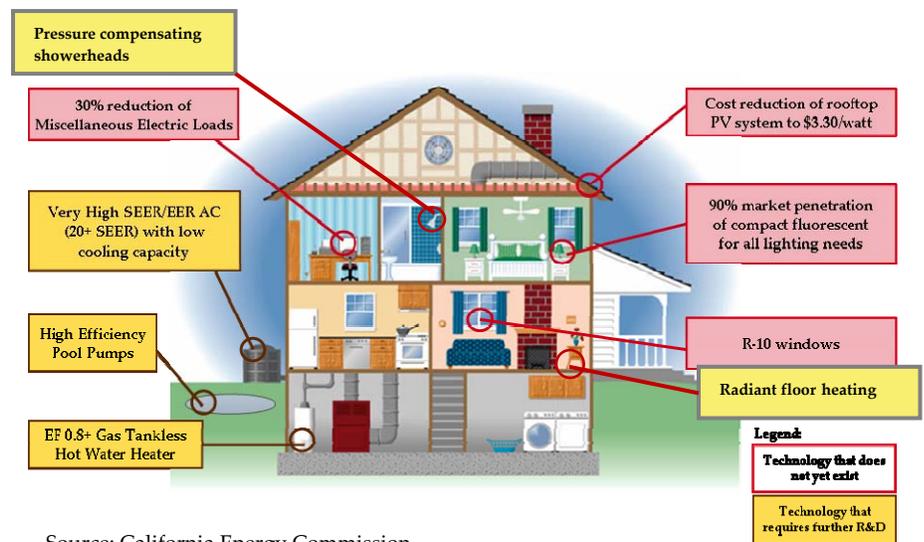
approaches to evaluate the costs and benefits of its research program to create a feedback loop that would promote future program planning.

Zero Energy Buildings and Communities

CPUC Decision 07-10-032 mandates that all new residential construction in California be zero net energy by 2020 and new commercial construction by 2030.²⁷ In addition, the 2008 IEPR Update brings additional policy attention to the goal of zero net energy communities. Achieving net-zero energy in California quickly will require concerted research effort on both the natural gas and the electricity sides of the state’s energy system (Figure 12).

Natural gas research must enable wide-scale adoption of energy efficiency and renewable thermal energy solutions, while electricity research will be required to reduce the cost of technology options to improve the viability of zero net energy buildings and communities. The Energy Commission’s natural gas research proposes focusing on technology solutions that would enable the state to successfully meet the zero net energy buildings targets.

Figure 12: RD&D Needs for California’s Zero Energy Residential Homes



Source: California Energy Commission

Research issues pertaining to zero net energy buildings and communities would be addressed through projects in Research Area 1 – *Improve Residential, Commercial and Industrial Energy Efficiency*.

Natural Gas Renewable Portfolio Standards

There are active discussions taking place on the possibility of expanding the scope of California’s Renewables Portfolio Standard applicable to publicly owned utilities. As California continues to lead other state in its renewable energy mandates, some statement of RPS goals for direct use of natural gas is plausible in the future. The Energy Commission would continue to focus on research projects that promote accelerated introduction and adoption of renewable thermal resources to replace conventional natural gas use at the end-use level.

²⁷ http://docs.cpuc.ca.gov/word_pdf/FINAL_DECISION/74107.PDF

Research issues pertaining to renewable alternatives to natural gas would be addressed through projects in Research Area 2 –*Accelerate Adoption of Alternatives to Conventional Natural Gas*.

Glossary

| | |
|---------|---|
| ARB | Air Resources Board |
| ARFVT | Alternative and Renewable Fuels and Vehicle Technology Program |
| ARRA | American Recovery and Reinvestment Act of 2009 |
| Btu | British Thermal Units |
| CALMIM | California Landfill Methane Inventory Model |
| CASCADE | Computer Assisted Strain Construction and Development Engineering |
| CCHP | Combined Cooling, Heating and Power |
| CCS | Carbon Capture and Storage |
| CHP | Combined Heat and Power |
| CNG | Compressed Natural Gas |
| CO2 | Carbon Dioxide |
| CPUC | California Public Utilities Commission |
| DOE | United States Department of Energy |
| DSRSD | Dublin San Ramon Service District |
| EAP | Energy Action Plan |
| EISG | Energy Innovations Small Grant |
| FY | Fiscal Year |
| GHG | Greenhouse Gas |
| IAW | Industrial, Agriculture, and Water Program |
| IEPR | Integrated Energy Policy Reports |
| LNG | Liquefied Natural Gas |
| NASA | National Aeronautics and Space Administration |

| | |
|----------|--|
| NGV | Natural Gas Vehicle |
| PIER | Public Interest Energy Research |
| RD&D | Research, Development, and Demonstration |
| USDA | United States Department of Agriculture |
| WESTCARB | West Coast Regional Carbon Sequestration |
| XCPC | External Compound Parabolic Concentrator |