1

Assessment of the National OilHeat Research Alliance Research and Development Program 2001 - 2008

June 16, 2009

Richard Sweetser
President
EXERGY Partners Corp.
12020 Meadowville Court
Herndon, VA 20170
Phone: 703.707.0293
Fax: 703.707.9566
Email: rsweetser@exergypartners.com

Table of Contents

Executive Summary

NORA's Historical Research and Development

NORA's direct and indirect R&D expenditures during 2001 – 2008 were just over $7,000,000 and adding leveraged and influenced R&D to this figure, topped $14,000,000. This level of effort was made during a time where the industry needed to solve fuel handling and storage problems (2001 – 2005), and also during a time of no growth because heating oil was at a price disadvantage (2005 – 2008) and during a time when NORA was suspended awaiting reauthorization (January – August 2005), all of which impacted the research and development effort.

NORA research and development efforts have supported the technology that has resulted in resolving fuel storage and handling problems, fuel tank remediation problems, fuel quality matters, initial bio-blend standards development for combustion-based appliances, five new energy efficient appliances, development of accurate energy evaluations of residential hydronic systems (boiler and hot water heating) and the development of a fuel calculator to provide consumers with real world impact of appliance upgrades. These are significant accomplishments for this short period of time.

The Future of Liquid Fuel Research and Development

Based on a new global perspective on energy efficiency, the environment, climate change and energy security and sustainability, liquid fuels based on clean low sulfur heating oil, bio-blends and advanced liquid fuels have the potential to become a sustainable energy solution for American consumers. The nation will require successful development of all sustainable energy sources to achieve its economic, energy and environmental goals. Liquid fuels can be one key element in the future provided the research already begun is completed. The current liquid fuels research portfolio consists of seven discrete areas of research and development requiring $8.4 million in investment over the next five years. The specific areas of research are: Fuels, Combustion, Heat Transfer, Appliances, Systems & Controls, Venting and Standards.

National Oilheat Research Alliance "NORA"

On November 9, 2000, Congress recognized the need for increased consumer education, technician and dealer training, employee safety, research, development and demonstration (RD&D) to improve heating oil fuels, storage, appliance and applications serving the nation's consumers and businesses, by passing the National Oilheat Research Alliance (NORA) Act of 2000 (*Public Law 106-469,* Title VII, *Section* 701*)* This Act created a national check-off program for the oilheat industry to fund industry programs as directed by the industry itself within the parameters set forth in the Act. The authorizing act established NORA to enhance consumer and employee safety and training, provide research, development, and demonstration of clean and efficient oilheat utilization equipment, and consumer education.

NORA's research and development (R&D) programs provide necessary and important support for the industry, the general economy of the United States and millions of Americans who rely on oilheat for residential and commercial space and water heating.

NORA Research and Development Direct, Indirect and Influenced R&D

Figure 1 provided a visual understanding of the actual NORA expenditures for external R&D projects provided directly through NORA's research committee or through NORA's grants to state oil dealer entities for R&D purposes. Table 1 provides a broader picture of NORA's R&D effort as it includes external and internal R&D expenditures, accrued R&D funds to complete ongoing projects and an estimate for leveraged and influenced R&D. This latter category certainly can be second guessed, however, the industry believes that through its direct efforts, fuel processors, manufacturers and state governments have reacted to competitive pressures, as well as, new governmental policies that have benefitted from NORA's R&D has resulted in a doubling of NORA's direct and indirect support.

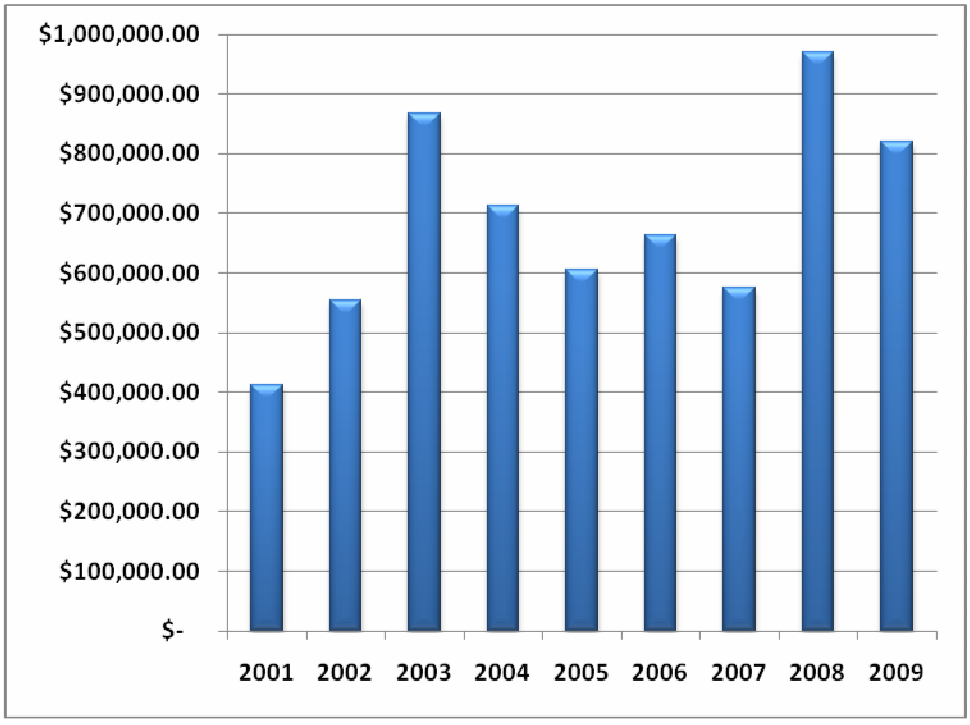


Figure 1 Annual Fuel, Appliance and Application Research, Development and Demonstration Expenditures

Table 1 shows NORA direct and indirect R&D expenditures during 2001 – 2009 at just over $8,000,000 and, adding leveraged and influenced R&D[2] to this figure approaches $11,000,000. This level of effort must be assessed in the context of market drivers and technical issues in real-time. Furthermore, it is equally important to understand the results of this R&D and, given today's energy and political climate, what remains to be done.

Table 1 – NORA's Direct, Indirect and Leveraged R&D 2001 - 2008

	Expenditures	Committed
	2001-2008	2001 - 2009
NORA Direct Project Funding	$ 4,739,516	$ 6,879,642
NORA Funding of state R&D projects	$ 1,161,859	$ 1,161,859
Total Direct NORA Project Funding	$ 5,901,374	$ 8,041,501
Co-funding for Projects	$ 1,362,925	$ 2,762,998
Total Direct and Indirect R&D Funding	$ 7,264,299	$10,804,498

The remainder of this report will cover three elements.

1) NORA's R&D history
2) NORA's R&D Results
3) NORA's R&D Plans

NORA's R&D History

Liquid Fuels

Number 2 heating oil is easily classified as a liquid fuel because at room temperature and atmospheric pressure it is in a liquid state versus coal (a solid) and natural gas (a gas). Liquid fuels are ideal for transportation because of their ability to be stored and their high energy density. Liquid fuels were the first choice for our homes and businesses in the 20th century to improve air quality by moving away from coal and their ease of delivery. Heating oil then lost ground to natural gas, in part, because natural gas was considered largely a domestic commodity and also because large utilities were able to transform markets better than the much smaller oil dealers. However, the future of liquid fuels as an energy source has recently become much brighter because of:

1) the move toward sustainable bio-blends which makes them the lowest greenhouse gas fuel for residential and commercial heating and domestic hot water,
2) the push toward higher efficiency appliances which is yielding potential new appliances like thermal heat pumps providing heating, cooling and domestic hot water out of one single appliance,
3) the shift from end-use CO_{2E} emissions calculations to fuel cycle CO_{2E} emissions calculations,
4) recognition by a growing number of scientists and policy makers that carbon forcers – like methane – are critically important which moves number 2 heating oil lower in CO_{2E} emissions as a fuel, and

[2] NORA leveraged funding refers to industry (independent of NOORA support), state energy offices, federal or manufacturer co-funding of R&D projects. NYSERDA has been a substantial cash co-funder of NORA research, Brookhaven National Laboratory and manufacturers have been substantial in-kind co-funders of NORA R&D. Influenced R&D refers to NORA sponsored R&D that is replicated by others at their cost.

5) the dramatic shift in fuel prices because of the world's financial crisis bring #2 heating oil in line with natural gas for the first time in four years. Furthermore, recent findings in CO_{2E} emissions, low sulfur emissions, bio-blending and energy efficiency should keep liquid fuel cost competitive for a long time.

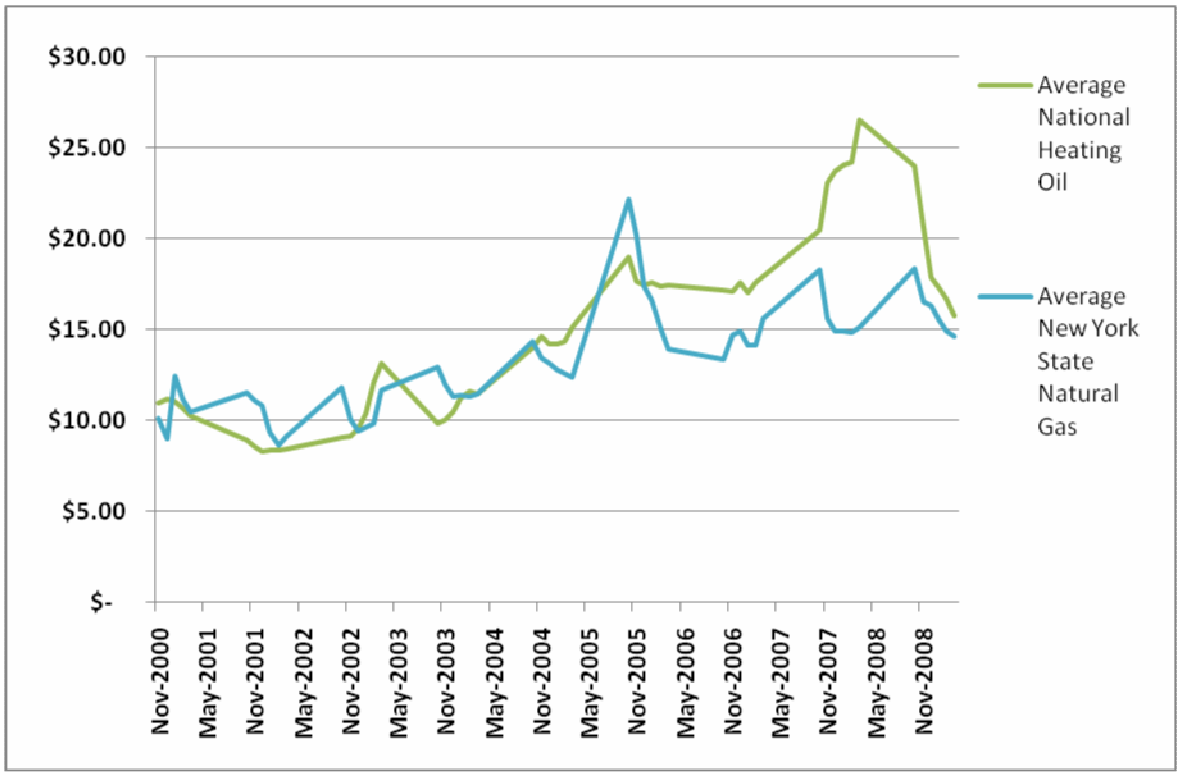


Figure 2 $/MMBTU Residential Retail Price

These key changes, surfacing in the fourth quarter of 2008, have dramatically transformed the liquid fuels market potential for the future. This new energy and climate change environment is just becoming understood by the heating oil industry, and research and development plans have been made that will position liquid fuels as a sustainable source of residential heating, hot water supply and even power generation and cooling in the future. (See Five Year Research Plan section of this document)

Liquid Fuels Market Conditions

The technical issues facing the heating oil industry in 2001, when NORA began, focused on solving a limited number of systemic problems to insure there would be a future for the industry. In 2001, NORA established its operating principles and began focusing and understanding its near-term research agenda. No direct project related research or development money was spent in 2001, however, a great deal of focus, time and effort was expended on:

1) determining the R&D path forward
2) working closely with States like New York on their established liquid fuels R&D,
3) working with the state oil dealer organizations on their respective R&D projects, and
4) working with the Department of Energy (DOE) on their liquid fuels R&D projects.

Figure 2 provides an overview of direct NORA external R&D project funding[3] for 2002 through 2008. During the 2002 – 2005 timeframe the principle R&D issues to be resolved were fuel quality, handling and storage. There was a limited amount of energy efficient appliance work, but this was not a significant focus as problems needed to be resolved before an industry future could be effectively planned. Simply put, the research funds supported the industry's need to resolve problems which required significantly more education and training dollars at that time.

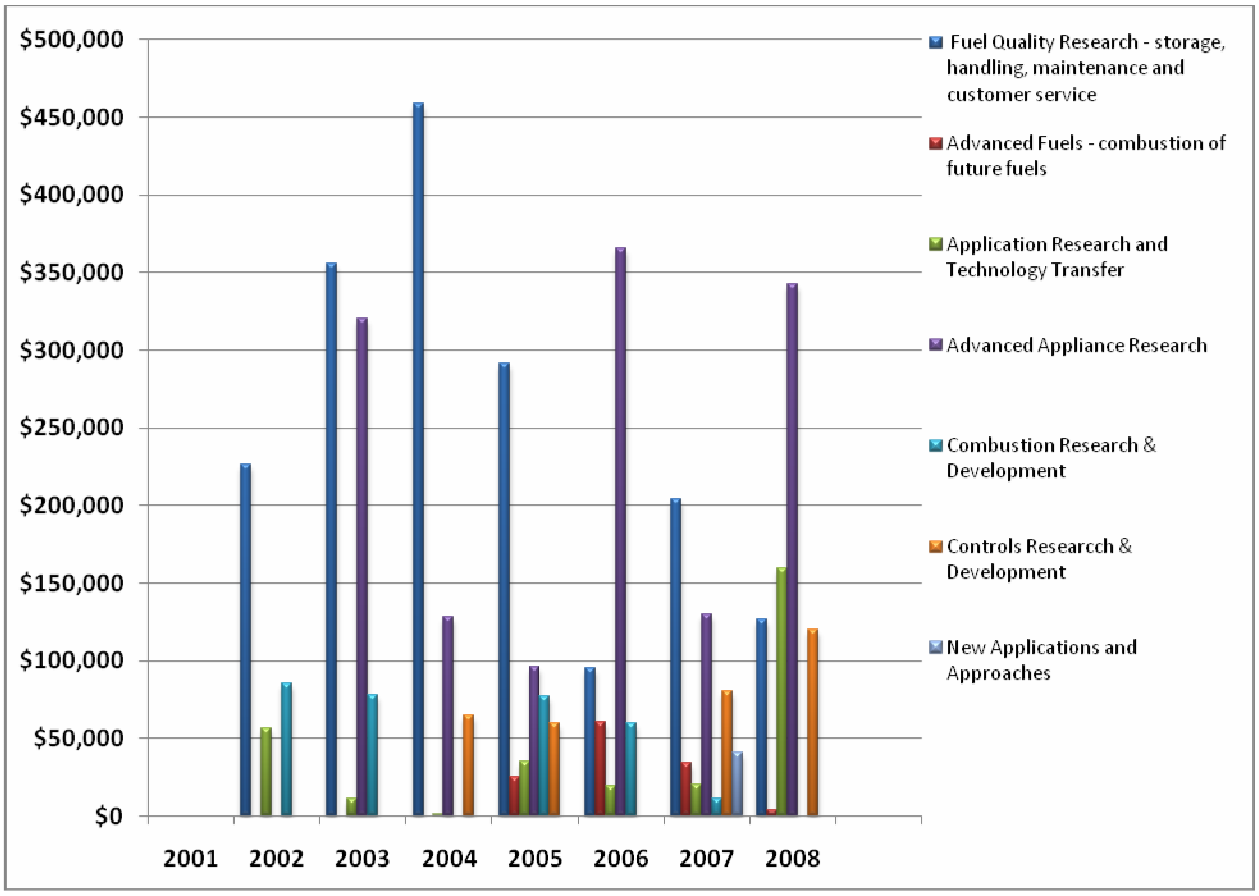


Figure 3 NORA Externally Funded NORA R&D Projects[1]

In early 2005, NORA suspended operations because of the sunset provision of the enabling federal legislation that created the Alliance in 2000. The hiatus in NORA's authorized operating status proved to be seven months through August 8, 2005, when a five year extension for the Alliance was signed into law.

Soon after NORA was reauthorized, the research program was reconstituted. The industry's prior work eventually resolved important fuel handling and storage issues, determined the role of sulfur in fuel and began to assess biofuel quality and management issues. The industry had also developed a condensing furnace and began to understand the role of condensing appliances. In 2006, fuel oil prices started to diverge (Figure 2) causing further erosion of the home oil heating market. At that time, NORA solicited research and development ideas from the industry and began to develop a series of high efficiency

[3] These figures exclude internal staff research and development activities, pro bono industry contributions, leveraged federal research laboratory work, oilheat industry state-based funding and State energy office co-funding.

appliance concepts, began investigating improved combustion mechanisms, explored system operating efficiencies and control strategies and an novel appliances that could use advanced liquid fuels (low sulfur heating oils and bio-blends). The idea behind this limited R&D work during this period of high oil prices was to understand the R&D pathways moving forward, should heating oil close the gap with natural gas sometime in the future.

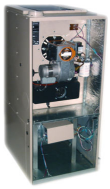
The current convergence of residential heating oil and natural gas today is expected to last for several years based simply on supply/demand and this current technical/political climate (see Liquid Fuels section). This will likely mean that this close relationship will remain for the foreseeable future. The heating oil industry has concluded that now is the time to increase its investment in R&D.

NORA's R&D Results

NORA has worked with industry, manufacturers, the U.S. DOE, state research organization like NYSERDA and international research organizations like IWO Institut für wirtschaftliche in Germany and the Petroleum Energy Center of Japan. NORA's research and development efforts during the 2001 – 2008 timeframe have resulted in the development of advanced energy efficient products, components and application knowledge. Ongoing research and development work will expand fuel performance, add critical new appliances and broaden applications and deliver real consumer value, as well as, reducing the dependence of foreign resources, reducing carbon emissions and securing domestic jobs.

The following accomplishments resulted from NORA R&D and including the current ongoing projects provide a remarkable success story as to the effectiveness of this research.

Advanced and Integrated Appliances



The Adams Condensing Furnace Stainless steel heat exchanger with molded pyro-ceramic combustion chamber designed to heat instantly on fire-up 50,000 through 250,000 BTU with 35% more heat with matching fuel savings. The Adams Condensing Furnace was first of its kind on the market to earn ground breaking AFUE rating.

Bock 20-Gallon Oil Fired Water Heater. Bock has had a very positive response to the 20 gallon unit which serves to meet a wide range of niche situations where a small, responsive capacity has made the unit commercially available. Note this compact water heater received GAMA's (now AHRI) highest energy efficiency rating.

ThermoPride Two-Stage Furnace. Fuel savings by running on low-fire most of the time, but on extremely cold days the burner will run on high-fire automatically. The ECM blower provides additional electrical efficiency.

Kerr Heating Products Paradigm condensing oil-fired, warm-air furnace is equipped with an integrated corrosion-resistant, tertiary heat exchanger into their oil-fired, warm-air furnace to condense flue gases. This condensing warm-air furnace represents the next generation of oil-fired heat appliances. This furnace achieves an AFUE in the mid 90 percent range. Additionally, an electronically commutated blower motor is used to reduce the electrical energy consumption of the furnace.

ThermoPride combination heating and air conditioning unit provides year-round comfort for your customer's home. This product provides a low cost solution to deliver energy efficient heating and cooling. Since all mechanical functions and the combustion process are outdoors, its operation is remarkably quiet.

PB Heat's Pinnacle Oil Condensing Oil Boiler is a direct vent, sealed combustion boiler and is 93%+ efficient*, earning it the ENERGY STAR® rating. The boiler is equipped with a Beckett AFG burner fueled with standard commercial grade #2 fuel oil and operates at two firing rates with inputs of 70,000 and 84,000 BTU/HR respectively. An insulated acoustic shroud and boiler jacket promotes quiet operation and reduces heat loss.

Energy-Kinetics High Efficiency Combo Heat & Hot Water System is under development. This is a combined heat and hot water condensing oil boiler application that has progressed with new spiral stainless steel secondary condensing unit. Research is nearing completion and field testing is expected in 2009.

Heat Transfer Research and Development

New York State Energy Research and Development Authority (NYSERDA) have co-funded NORA research to develop advanced plastic heat exchangers for condensing appliances. Condensing boilers achieve very high efficiency levels by recovering heat from the flue gas before it is discarded. The recovery of latent heat from the water vapor in the humid gas is a very important part of the total heat recovery but the condensate formed is corrosive – leading to the need for expensive alloys in the heat exchanger. This project is focused on the potential replacement of these alloys in the condensing section of home heating boilers with polymers. While the work will focus on conventional heating oil, this concept will also be applicable to low sulfur heating oil, and biodiesel although these are considered to be the least all challenging environments. This project is scheduled for 2010.

Advanced and Integrated Appliances Research and Development

Brookhaven National Lab's (BNL) initial success in developing and testing a liquid-fueled burner/combustion chamber for the Robur heat-pump (5 RT cooling and 120,000 Btuh heating) has second generation burner and combustion chamber testing with complete unit testing expected in mid-2009 and full product development later in the year. Development of this unit would allow heating efficiencies to exceed 100 percent, and enable liquid-fuels to reduce electric demand and take pressure off the electrical grid. This advanced thermal heat-pump offers very high heating efficiency potential (fuel COPs > 1.4). Product R&D is expected to continue through 2010.

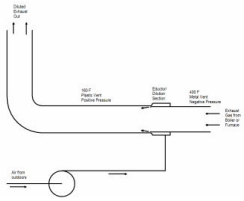
NYSERDA is co-funding NORA to develop a self-powered thermo-photovoltaic TPV liquid-fueled technology to operate in residential hydronic boiler applications that will be designed to generate sufficient electricity to enable operation of the heating system without electric utility power. This work is expected to begin in 2009.

Systems and Controls Research and Development

Carlin Sentinel Advanced Primary Combustion Controller: 100 field test controls have been installed and performance of the UV Cell has been brought up to expectations. Reporting features of tank level and fuel consumption data are undergoing testing and the manufacturer is actively working to line features with back office programs. When the Sentinel is commercialized in the fall of 2009 it will enable a fuel dealer to have access to smart data about combustion, burner operations, fuel use, storage level, and other information relayed to the dealer's computer system. Extend service intervals while insuring safe, reliable and clean burner operation.

Research on the efficiency of oil- and gas-fired hydronic home heating systems that provide both heat and hot water through baseboard radiators was conducted at BNL under a NORA and NYSERDA joint project. The data from this recent research forms the basis of a web-based fuel-oil savings analysis calculator for consumers. (FSA Calculator)

Advanced Venting Systems and Technology Research and Development



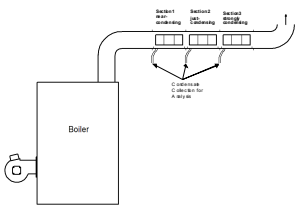
NYSERDA is co-funding NORA to develop an advanced venting solution. The problems of condensation in ventilation systems at high efficiency levels can be avoided through the use of dilution venting. With this approach, flue gas is diluted with ambient air, reducing its temperature and then the mixture is vented using low cost, condensate-resistant plastic pipe. With the addition of the ambient air, dewpoint is lowered relative to the mix temperature, and potential for downstream condensation is lowered. The application of dilution venting to oil-fired boilers and furnaces, could resolve venting problems that exist even with conventional equipment and promote higher efficiency appliances with lower system cost and safer venting. The project is scheduled to begin in the fall of 2009.

Fuels Research and Development

Brookhaven National Laboratory (BNL): Ultra-Low Sulfur for Space Heaters. Tests using ULSD were performed on Monitor and Toyatomi space heaters, neither of which experienced any burner related problems over the one month testing period. Based on results, it's assumed that spaced heaters that specify use of No. 2 oil should not see any undue coking within ULSD, whereas others may likely require at least annual service of the combustion chamber. All work on this project has been completed and a final project report is being prepared.

Brookhaven National Laboratory (BNL): Advanced Synthetic Coal to Liquid Fuels (CTL) for Oil-Fired Burners. BNL has located a source for CTL test fuel. The target fuel is a diesel-like product produced by a Fischer-Tropsch process from gasified coal (CTL). NORA is working on contract arrangements with the fuel supplier. An alternative is the same product produced by a Fisher-Tropsch process from natural gas (GTL). Development of this fuel and its production in the United States would lead to a virtual

limitless supply of clean burning, no sulfur fuel produced in the United States. President Elect Obama has been a strong advocate of this fuel and the heating oil industry has worked with him to develop this important domestic resource.



New York State Energy Research and Development Authority (NYSERDA)has co-funded NORA research on the impact of reducing heating oil sulfur levels to low (500 ppm) and ultralow (15-100 ppm) levels on appliance operation and design and is just getting started. These levels may present manufacturers with new opportunities to develop and market very high efficiency appliances for oil, with reduced cost. This research project will begin in 2009.

Combustion Research and Development

Heat Wise 2-Stage Oil Burner for energy efficiency is currently being applies with a warm-air furnace. This burner is currently UL listed and consumes only 80 watts of running power. The Two-stage Burner will offer increases to efficiency to existing oil-fired equipment at low cost. The design will fire both fuel oil and Biodiesel blends.

Carlin Econox burner has been applied with four appliances (Bock, Buderus, Olsen and Thermodynamics). Cycle testing and formatting of the cycles have been modified to fully test any possible field condition. This new residential oil burner is capable of two positions, 50 percent turndown, step modulation (lo-hi-lo) mode of operation and will provide significant gains in seasonal energy efficiency. Field testing is well underway, UL certification is nearing completion and this product is expected to enter the market this fall.

Research Project Financial Information

Project Number	Research partners	Research Projects	2001	2002	2003	2004	2005	2006	2007	2008	2009	Total Spent	Total Project
Fuel Quality Research focused on maintenance cost and customer service issues associated with fuel quality													
8150	NYSERDA & Brookhaven National Laboratory	Fuel quality study 1		$ -	$ -	$ 11,772	$ 36	$ -	$ 540	$ -	$ -	$ 12,408	$ 12,408
8510	NYSERDA & Brookhaven National Laboratory	Fuel quality study 2		$ 211,343	$ 136,219	$ 143,450	$ 320	$ -	$ 4,640	$ 50,637	$ 20,085	$ 626,752	$ 626,752
8550	Brookhaven National Laboratory	Studies on equipment and avail of low sulfur		$ 15,253	$ 11,375	$ 31,422	$ 8,342	$ -	$ 100	$ -	$ -	$ 67,693	$ 67,693
8622	Brookhaven National Laboratory	Study on ultra low sulfur availability		$ -	$ -	$ -	$ -	$ -	$ -	$ 36,500	$ -	$ 36,500	$ 36,500
8630	Allegra & Brookhaven National Laboratory, Hart Energy	Ultra low sulfur study		$ -	$ -	$ 28,488	$ 45,000	$ -	$ -	$ -	$ -	$ 73,488	$ 73,488
Total Fuel Quality Research				$ 226,596	$ 208,194	$ 215,132	$ 54,358	$ -	$ 5,280	$ 87,197	$ 20,085	$ 816,841	$ 816,841
Co-funding and leveraged effort				$ 267,932	$ 248,267	$ 209,005	$ 14,005	$ -	$ 6,500	$ 72,496	$ 25,106	$ 843,371	$ 798,950
Advanced Fuels focused on storage, handling, and combustion of future fuels such as sustainable biodiesel blends													
8636	Brookhaven National Laboratory	Space Heater performance on low sulfur fuel	$ -	$ -	$ -	$ -	$ -	$ 20,000	$ 2,372	$ -	$ -	$ 22,372	$ 22,372
8637	Brookhaven National Laboratory	Coal to liquids study	$ -	$ -	$ -	$ -	$ -	$ 40,347	$ 86	$ -	$ -	$ 40,433	$ 76,000
8688	Brookhaven National Laboratory	Bio in tanks - biodiesel compatibility	$ -	$ -	$ -	$ -	$ -	$ -	$ 11,000	$ 4,000	$ -	$ 15,000	$ 15,000
8691	NEFI, BNL, National Biodiesel Board	Research on biodiesel	$ -	$ -	$ -	$ -	$ -	$ -	$ 20,000	$ -	$ -	$ 20,000	$ 20,000
8700	Consumer Energy Council of America	Case study on fuel	$ -	$ -	$ -	$ -	$ 25,000	$ -	$ -	$ -	$ -	$ 25,000	$ 25,000
8580	Sage Environmental	Study on tanks and technology improvements	$ -	$ -	$ 14,336	$ 56,819	$ 43,438	$ 16,200	$ 5,218	$ -	$ -	$ 142,011	$ 142,011
8585	Petroleum Equipment Contractors Association	Develop alternative leak detection	$ -	$ -	$ -	$ -	$ 7,500	$ 7,500	$ 10,188	$ -	$ -	$ 25,188	$ 25,188
8586	Petroleum Equipment Contractors Association	Cleanup technologies	$ -	$ -	$ -	$ -	$ -	$ 71,457	$ 69,423	$ 10,948	$ -	$ 151,828	$ 151,828
8589	Benfield	Leak detection, cleanup - tanks insurance	$ -	$ -	$ -	$ 150,000	$ 150,000	$ -	$ 113,956	$ 8,456	$ -	$ 422,412	$ 422,412
8627	Petroleum Equipment Contractors Association	Study on leak detection	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 20,000	$ -	$ 20,000	$ 20,000
8590	Consumer Energy Council of America	Technology transfer work on tanks	$ -	$ -	$ 133,000	$ 36,469	$ 30,000	$ -	$ -	$ -	$ -	$ 199,469	$ 199,469
Total Advanced Fuels Research			$ -	$ -	$ 147,336	$ 243,288	$ 261,938	$ 155,504	$ 232,842	$ 43,404	$ -	$ 1,084,312	$ 1,119,879
Co-funding and leveraged effort			$ -	$ -	$ -	$ -	$ -	$ 15,087	$ 3,514	$ 1,000	$ -	$ 19,601	$ 28,493
Application Research and Technology Transfer													
8520.00	IWO Institut für wirtschaftliche in Germany	Interface support and conference	$ -	$ 8,043	$ 11,255	$ 328	$ 7,365	$ 6,700	$ 8,431	$ 12,830	$ -	$ 56,271	$ 56,271
8540.00	Consumer Energy Council of America	Developing research agenda	$ -	$ 48,500	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 48,500	$ 48,500
8630.00	Brookhaven National Laboratory	Boiler & DHW Testing - including 8639	$ -	$ -	$ -	$ -	$ 26,763	$ 12,314	$ 11,581	$ 82,367	$ 23,013	$ 156,039	$ 156,039
8535.00	Brookhaven National Laboratory	Energy Savings Calculator	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 54,450	$ -	$ 54,450	$ 54,450
8537.00	NYSERDA & Brookhaven National Laboratory	FSA Calculator develop web based system	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 3,945	$ -	$ 3,945	$ 3,945
Total Application Research and Technology Transfer Research			$ -	$ 56,543	$ 11,255	$ 328	$ 34,128	$ 19,014	$ 20,072	$ 153,651	$ 23,013	$ 325,205	$ 325,205
Co-funding and leveraged effort			$ -	$ -	$ -	$ -	$ 6,691	$ 3,079	$ 2,895	$ 46,635	$ 5,753	$ 65,053	$ 65,053
Advanced Appliance Research													
8610	Adams	Condensing Furnace	$ -	$ -	$ 265,000	$ -	$ -	$ -	$ -	$ -	$ -	$ 265,000	$ 265,000
8621	Kerr	Condensing Furnace, also 8707 added in 2003	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 126,155	$ 31,435	$ 217,650	$ 323,456
8600	Thermopride	Two Stage & Heat Pak	$ -	$ -	$ 55,355	$ 77,497	$ -	$ -	$ -	$ 132,894	$ -	$ 265,746	$ 459,464
8652	Energy Kinetics	High Efficiency Heating & Hot H20 Sys	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 25,000	$ -	$ 25,000	$ 143,000
8675	Bock Water Heater	Small water heater development	$ -	$ -	$ -	$ -	$ -	$ 37,344	$ 87,134	$ -	$ -	$ 124,478	$ 124,478
8670	Brookhaven National Laboratory	2 Stage Condensing Wall Hung Boiler	$ -	$ -	$ -	$ 50,636	$ 54,659	$ 72,470	$ 16,894	$ 28,585	$ -	$ 223,245	$ 223,245
8693	Heat Wise	Wall Hung Boiler	$ -	$ -	$ -	$ -	$ -	$ -	$ 25,474	$ 29,420	$ -	$ 54,894	$ 54,894
8695	P B Heat LLC	Near Condensing	$ -	$ -	$ -	$ -	$ -	$ 147,125	$ -	$ -	$ -	$ 147,125	$ 147,125
8720	Confidential	Condensing Boiler	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
8721	Peerless Pinnacle	Condensing Boiler	$ -	$ -	$ -	$ -	$ 41,000	$ 109,000	$ -	$ -	$ -	$ 150,000	$ 150,000
Total Advanced Appliance Research			$ -	$ -	$ 320,355	$ 128,133	$ 95,659	$ 365,939	$ 129,502	$ 342,054	$ 31,435	$ 1,473,137	$ 1,830,661
Co-funding and leveraged effort			$ -	$ -	$ 13,839	$ 32,033	$ 23,964	$ 91,617	$ 34,498	$ 104,824	$ 24,892	$ 325,667	$ 498,817
Combustion Research & Development													
8560	Bacharach	develop electronic smoke tester	$ -	$ 85,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 85,000	$ 85,000
8570	Testo	develop electronic smoke tester	$ -	$ -	$ 78,000	$ -	$ -	$ -	$ -	$ -	$ -	$ 78,000	$ 78,000
8635	Carlin	2 stage burner	$ -	$ -	$ -	$ -	$ -	$ 60,000	$ -	$ -	$ -	$ 60,000	$ 440,000
8650	Beckett	White flame burner	$ -	$ -	$ -	$ -	$ 77,000	$ -	$ -	$ -	$ -	$ 77,000	$ 77,000
8680	Heat Wise	2 stage burner	$ -	$ -	$ -	$ -	$ -	$ -	$ 11,210	$ -	$ -	$ 11,210	$ 11,210
Total Combustion Research			$ -	$ 85,000	$ 78,000	$ -	$ 77,000	$ 60,000	$ 11,210	$ -	$ -	$ 311,210	$ 691,210
Co-funding and leveraged effort			$ -	$ -	$ -	$ -	$ -	$ 59,232	$ -	$ -	$ -	$ 59,232	$ 434,371
Controls Research & Development													
8620	Honeywell	Smart controls	$ -	$ -	$ -	$ 65,000	$ 60,000	$ -	$ -	$ -	$ -	$ 125,000	$ 125,000
8632	Carlin Combustion Technologies	Field test 100 smart controls	$ -	$ -	$ -	$ -	$ -	$ -	$ 80,000	$ 120,000	$ -	$ 200,000	$ 260,000
in process	State of Pennsylvania	Controls efficiency project	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 30,000
Total Controls Research			$ -	$ -	$ -	$ 65,000	$ 60,000	$ -	$ 80,000	$ 120,000	$ -	$ 325,000	$ 415,000
Co-funding and leveraged effort			$ -	$ -	$ -	$ -	$ -	$ -	$ 20,000	$ 30,000	$ -	$ 50,000	$ 65,000
New Applications and Approaches													
8638	Brookhaven National Laboratory	Robur Heat Pump	$ -	$ -	$ -	$ -	$ -	$ -	$ 40,389	$ -	$ -	$ 40,389	$ 40,389
in process	NYSERDA & Brookhaven National Laboratory	Self Powered, Oil-Fired Heating System Based on TPV-	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 119,921
in process	NYSERDA & Brookhaven National Laboratory	Advanced Venting Solution	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 150,000
in process	NYSERDA & Brookhaven National Laboratory	Reduced Sulfur Content for Boiler and Furnace Design	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 70,000
in process	NYSERDA & Brookhaven National Laboratory	Plastic Heat Exchanger research	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 100,000
Total New Applications and Approaches Research			$ -	$ -	$ -	$ -	$ -	$ -	$ 40,389	$ -	$ -	$ 40,389	$ 480,310
Co-funding and leveraged effort			$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 872,313
Internal NORA R&D 2002 - 2008												$ 363,421	$ 363,421
New 2009 R&D Funding to be committed for in process and internal R&D											$ 777,114	$ -	$ 777,114
Total NORA Project Funding			$ -	$ 368,140	$ 765,140	$ 652,481	$ 583,683	$ 600,457	$ 519,295	$ 752,307	$ 911,707	$ 4,739,516	$ 6,879,642
NORA Funding of state R&D projects			$ 412,024	$ 185,870	$ 101,105	$ 60,759	$ 22,387	$ 63,035	$ 55,563	$ 217,631	$ 43,425	$ 1,161,859	$ 1,161,859
Total Direct NORA Project Funding			$ 412,024	$ 554,010	$ 866,245	$ 713,241	$ 606,070	$ 663,492	$ 574,858	$ 969,938	$ 955,131	$ 5,901,374	$ 8,041,501
Co-funding and leveraged effort			$ -	$ 267,932	$ 262,106	$ 241,038	$ 44,660	$ 169,014	$ 67,408	$ 254,955	$ 55,752	$ 1,362,925	$ 2,762,398
Total Direct and Indirect R&D Funding			$ 412,024	$ 822,002	$ 1,128,351	$ 954,279	$ 650,731	$ 832,506	$ 642,266	$ 1,224,952	$ 1,010,883	$ 7,264,299	$ 10,804,498

Formation of the Liquid Fuels Research Center

In 2007, NORA created the Liquid Fuels Research Center to significantly advance liquid fuels as a clean, economic and sustainable solution for the energy future.

Liquid fuels are increasing in their importance to provide combustion solutions for space heating, domestic hot water heating, thermal cooling and even onsite power generation.

Low sulfur diesel will offer the Oilheat industry an opportunity to begin a transition toward economically providing clean heating solutions and provide consumers an easy link between their future car and heating system. It will also enable new technologies and encourage use of heating oil for a variety of uses in the home including cooling and electricity generation.

Biodiesel, produced from oil-producing plants such as oilseed, rape and soy, opens up the option for using diesel fuel derived from a renewable resource. Using gasification processes conducted in a targeted manner, synthetic fuel oil can be made from biomass waste matter; experts refer to this as BTL (biomass-to-liquid) fuels. Natural gas, which today is usually burned off unused in the offshore extraction of crude oil, could be used in the production of GTL (gas-to-liquid) fuels. Solid waste can deliver a form of synthetic crude oil WTL (waste-to-liquid). Finally, the nation's most abundant energy resource – coal – can produce synthetic fuel oil using gasification processes delivering CTL (coal-to-liquid) fuels. These liquid fuel sources can power America for centuries.

Five-Year Research Plan

The world has undergone breathtaking changes over the last twelve months. Many of these changes have not been encouraging. However, the renewed global focus on energy and the environment has created a major opportunity to move forward with significant fuel, combustion and appliances technologies that will revolutionize the liquid fuels industry.

The Nation will require successful development of all sustainable energy sources to achieve its economic, energy and environmental goals. Liquid fuels can be one key element in the future, provided the research already begun is completed. The current liquid fuels research portfolio consists of seven discrete areas of research and development requiring $8.4 million in investment over the next five years. The specific areas of research are:

Research Portfolio

The research portfolio summary funding requirements are listed below:

Projects	Start Date	Completion Date	Funding Requirement (in $1,000)				
			2009	2010	2011	2012	2013
Fuels	2008	2013	_	300	100	100	_
Combustion	2007	2013	152	400	400	400	400
Heat Transfer	2009	2012	175	400	400	400	300
Appliances	2006	2013	175	600	600	600	600
Systems & Controls	2007	2013	175	200	250	250	200
Venting	2008	2011	_	200	200	250	250
Standards	2009	2012	50	200	150	50	50
TOTALS:			777	2,300	2,100	1,750	1,800

Fuels Research and Development

The deployment of established and novel biofuels and biofuel blends provide an exciting opportunity for economical and sustainable energy solutions. For many fuels, this market sector provides a good

opportunity to achieve market introduction and establish long term performance. This also provides certain challenges to be sure appliance efficiencies and emission are maintained. Fuel research will cover key standards development. A second effort will cover advanced liquid fuels storage concepts.

Goal: Support industry efforts to reduce fuel quality related service requirements and enable expansion of use of alternative and bio-based fuels.

Research: Create technical foundation to enable widespread use of B-20 blends and site-specific use of higher blends.

Development: Fuel Quality Center – Will combine on-site measurements and measurements made at contract labs to: 1) track changes in basic fuel quality parameters, 2) address specific fuel quality issues and 3) evaluate impacts of fuels, additive, and equipment changes on fuel quality related issues.

Development: Advanced fuel storage concepts.

Projects	Start Date	Completion Date	Benefit	Funding
Compatibility of elastomers at higher blend levels	2009	2010	Formally establish materials related blend level limits	100k
Fact finding study at higher blend level	2010	2010	Data needed for approvals of higher blend levels	200k
CTL fuel compatibility	2010	2012	Preliminary evaluation of this key alternate option	200k
Screening of other biofuel alternatives	2010	Ongoing	Rapid evaluation of new proposed alternatives such as pyrolysis oils, levulinates as blend components	60k/year
Fuel quality trends	2010	Ongoing	Track changes in fuel quality and address specific issues including additive effects	150k/year
Advanced storage concepts	2011	2013	Cost, integration options, reduced service	200k

Combustion Research and Development

The lowering of sulfur content in liquid fuels (through refining and/or biofuel blending) provides an opportunity to reduce the cost of achieving very high efficiency levels in part through the use of advanced combustion technology to vaporize and premix fuel and air. This will allow liquid fuel combustion to be utilized in conventional natural gas appliances – lowering equipment costs to consumers.

Goal: to develop oil combustion technologies and derived products which provide high efficiency at lower cost than conventional products and enable new application concepts.

Research: Develop vaporization and ultrafine atomization / air mixture schemes to deliver liquid fuels combustion using typical gaseous fuel combustion technologies.

Development: commercialization of products based on the combustion technology developed

Projects	Start Date	Completion Date	Benefit	Funding
Track relevant combustion technologies worldwide	2009	On-going	Efficiency of NORA R&D efforts	40K/year
Low input burner based on fuel partial	2009	2010	Establish technical foundation	200K

vaporization – proof of concept				
Thermal management in vaporizing burner	2010	2011	Reduce electric power needed	200K
Product development based on partial vaporization	2011	2013	Introduction of product(s)	800 K
Field tests/ benefits	2012	2013	Ensure reliability and establish benefits	400K

Advanced and Integrated Appliances

The need to increase energy efficiency requires utilization of new principles like thermal heat pumps and combined heat and power (CHP) systems. A thermally-driven heat pump is being developed and microCHP concepts are being explored. Furthermore, continued strain on the electric grid is increasing interest in low emission, liquid-fueled standby power solutions, as well as, liquid-fueled peak shaving system development.

Goal: Market introduction of new, liquid fuel-fired appliances which can lead to efficiency levels far higher than with condensing boilers and furnaces and/or increased reliability of heating service.

Research: Combustion technologies compatible with target appliances that can meet input, heat flux, efficiency, and emission goals.

Development: Product prototype development and testing, field trials, certification approvals, and market introduction.

Projects	Start Date	Completion Date	Benefit	Funding
Heat pump proof of concept	2008	2010	Establish basic feasibility	175K
Heat pump product commercialization	2009	2011	Market introduction of extreme efficiency heating system	500k
Liquid fuel-fired backup generator commercialization	2009	2010	Market introduction of clean diesel-fired home generator	500k
microCHP proof of concept HCCI	2009	2011	Demonstrate very low emission engine alternative for liquid fuels	300k
microCHP reciprocating engine commercialization	2011	2013	Market introduction of high efficiency micoCHP system	500K
alternate liquid fuel-fired microCHP systems	2010	2013	Establish other liquid fuel options (reciprocating, steam, Stirling)	600k

Heat Transfer Research and Development

Advanced liquid fuels combustion needs to be integrated with natural gas appliances. Further, advanced heat exchanger designs need to be developed for high efficiency lower cost condensing appliances – such as using polymer composites.

Goal: Low cost, high efficiency heat exchangers (boiler and furnaces) with liquid fuel combustion.

Projects	Start Date	Completion Date	Benefit	Funding
Ultralow sulfur heating oil to enable use of low cost, gas-designed heat exchangers	2009	2011	Establish benefits, corrosion rates, and issues	200K

Feasibility of low cost, polymer composites for condensing sections	2010	2012	Low cost option for high efficiency	200K
Product development based on gas-designed heat exchangers	2011	2013	Introduction of product(s)	600K
Product development based on polymer composites	2011	2013	Introduction of product(s)	600K

Systems and Controls

Energy efficiency requires integrated system approaches. Applying advanced controls to residential housing hydronic heating and cooling systems may be the most cost effective approach to reducing oil use in the near term. However, best practices need to be determined to assure successful results. Solar thermal and other hybrid systems may emerge as economically viable solutions that require assessment.

Goal: Provide solid technical basis to quantify the benefits of advanced controls and systems that can lead to strong reductions in fuel consumption in new and existing oil-fired homes.

Research: In lab and field studies, establish the energy savings potential of a rapidly expanding field of controls options. Develop new concepts for low cost, hydronic distribution compatible with advanced liquid fuel-fired appliances including condensing, microCHP, and heat pumps.

Development: Establish actual energy savings potential of integrated solar systems.

Projects	Start Date	Completion Date	Benefit	Funding
Evaluation of hydronic control options	2010	2012	Quantify energy savings benefits of a wide range of control options	200k
Low temperature hydronic distribution options	2010	2013	New options for low cost condensing boiler and hydronic cooling	400k
Solar-liquid fuel integrated systems	2008	2013	Demonstrate / evaluate concepts for highly integrated solar systems	400k

Advanced Venting Systems and Technology

High efficiency combustion requires venting systems that need to withstand high or fluctuating temperatures are acid resistant and maintain draft. Advanced metals and plastics and new design concepts need to be employed to assure cost effective solutions to fully use advanced appliances being developed and deployed.

Goal: Market introduction of low cost venting options for high efficiency liquid fuel-fired equipment. Focus on high efficiency, non-condensing regime.

Research: Materials options and compatibility. Impacts of configurations on transient combustion performance.

Development: Commercialization of new venting systems.

Projects	Start Date	Completion Date	Benefit	Funding
Dilution venting	2009	2011	Low cost plastic venting option with no startup backpressure	300k
Mid range metal options for ULS heating oil	2010	2012	Establish materials suitability with next generation of fuel	200k

Venting guidelines for high efficiency equipment	2011	2013	Support vent models and codes	400k

Field Evaluation and Protocol Development

Large energy gains can be made by proper upgrading of residential and small commercial heating systems. However, the gains that can be made by retrofitting a burner, adding or changing controls, orinstalling a new appliance are not easy to accurately calculate. This research will evaluate field measures of performance, establish a protocol to quantify upgrade energy savings and maintain an upgrade database for reference.

Collectively, this body of research and development will provide the over 8,700 liquid fuel dealers and suppliers with a viable future, the nation with a sustainable clean energy supply and continued green jobs for about 50,000 Americans.

Goal: Protocol and database for energy savings associated with upgrades.

Research: Develop standard protocol for energy savings field studies to be conducted by manufacturers and service organizations. Note: the idea here is to develop a NORA standard that companies can use to estimate the actual energy savings achieved when an old system is replaced with a new, advanced system. It will also apply to controls and other retrofits to existing systems. This procedure will include data collection requirements, preconversion fuel use and weather data, and analysis. This will also include evaluation of tools such as the new EU "Heating System Check" and the ability to use such tools to better estimate annual performance of existing systems and energy savings potential of upgrades.

Development: NORA will maintain a public database of results, without manufacturer names. Companies will be able to advertise that their energy savings meet the NORA standard and we will be better able to demonstrate the point about energy savings with upgrades, or advanced systems.

Projects	Start Date	Completion Date	Benefit	Funding
Evaluate field measures of performance	2010	2011	Establish practical measurement techniques to quantify performance of existing systems	150k
Establish protocol to quantify upgrade energy savings	2008	2010	Standard method industry can use to report actual energy savings	150k
Maintain upgrade database	2011	ongoing	High quality data on actual achieved energy savings	50k/year