



Propane Technology Review

2008

About the Propane Education & Research Council

The Propane Education & Research Council (PERC) promotes the safe, efficient use of propane as a preferred energy source. With the passage of the Propane Education and Research Act (PERA) in 1996 by the U.S. Congress, the propane industry conducted a referendum among propane producers and marketers, who overwhelmingly approved the formation of PERC.

PERC is funded by an assessment or “check-off” on each gallon of odorized propane gas sold. The assessment will collect five-tenths of one cent per gallon in 2008.

Through PERC, the propane industry has undertaken a multidisciplinary effort to improve consumer and employee safety, fund research and development of new and more efficient propane equipment, and expand public awareness of propane and its many uses and advantages.

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Credits

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Welcome

Propane is an energy source that is well positioned to meet the increasing demands of American consumers. As they begin to demand more efficient, clean, and reliable sources of energy, propane stands ready to meet the challenge.

One of the ways our industry can meet those demands is by offering customers efficient propane utilization technology. Already, propane is used by millions of Americans in their homes, on their patios, on their farms, and even in their vehicles, and the propane industry remains committed to fostering further growth through the development and commercialization of new propane technologies.

The development and promotion of new technology is supported by PERC's technology committees, namely the Research and Development Advisory Committee (RDAC), the Engine Fuel Advisory Committee (EFAC), and the Agriculture Advisory Committee (AAC).

What follows on these pages is an overview of the programs, projects, and partnerships that these technology committees have undertaken. These committees owe their success to the contribution of volunteers from all sectors of the propane industry (for a full list of committee members, see back cover).

Already, we have seen PERC-supported technologies enter the marketplace. In the engine fuel market, school districts and fleet managers across the country can now order a propane-powered Blue Bird Vision school bus. A fully warranted propane-powered Roush Ford F-150 pick-up truck is also available. In agriculture, we continue to help promote a fully commercialized poultry house sanitizer manufactured by Flame Engineering. Plans are currently under way to bring a newly redesigned steam weed control device for orchards and vineyards to market, as well.

The engine fuel and agriculture markets are not the only markets where PERC is focused. In the commercial market, PERC has teamed up with Blue Mountain Energy to develop and commercialize a propane-powered 10 RT gas heat pump. This technology has significant potential for the propane industry, as it could open the doorway for development of gas cooling technologies for the residential market.

In 2008 and beyond, PERC will continue to promote emerging technologies and highlight the many benefits of propane. Recently, a one-of-a-kind study was commissioned to analyze propane's greenhouse gas emissions compared to other common fuels such as gasoline, diesel, fuel oil, and ethanol. In nearly every application analyzed, propane had fewer greenhouse gas emissions than those other commonly used fuels.

As this report details, the propane industry remains committed to providing consumers with a clean, efficient, and environmentally friendly alternative energy source.



Roy Willis, President and CEO
Propane Education & Research Council



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PERC's technology efforts created unique partnerships, explored new arenas, and enlisted industry and academic help in meeting the following goals in 2007:

- ✓ **Explore propane's green advantages.** *Propane Reduces Greenhouse Gas Emissions: A Comparative Analysis* compared propane's greenhouse gas emissions to those of other fuels for ten common applications. Propane outperformed conventional fuels in almost every application, confirming propane's value as an environmentally friendly alternative. In other projects, PERC examined methods to produce propane from biomass and identified steps to minimize deposit formation in propane-fueled engines in order to lower emissions.

- ✓ **Explore critical new markets for product commercialization.** PERC's R&D activities are focused on technologies and markets that can increase year-round propane sales and boost off-peak demand. These efforts have brought the propane-fueled Roush Ford F-150 light-duty truck and Blue Bird Vision school bus to market. Other projects explored the use of propane-fueled heat to sanitize dairy beds and control weed populations, helping solidify propane's role as a reliable fuel in agriculture. Residential applications are being examined as researchers work to bring small combined heat and power units to market.

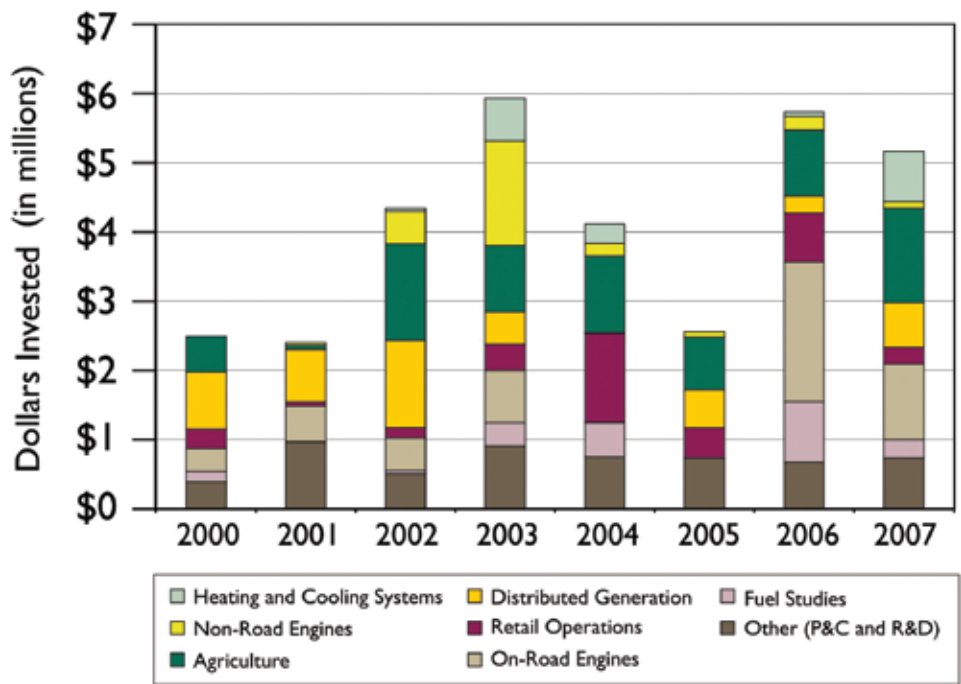
- ✓ **Improve efficiency in distribution and production.** Through performance testing, PERC is working to improve the safety and efficacy of propane technologies. A recent project compared underground steel tank coatings to give marketers a clear idea of each coating's ability to prevent corrosion. Another project has explored the use of composite materials for underground tanks, while still another is developing a portable tool to measure water and methanol levels in propane. These efforts help ensure fuel quality and increase the efficiency of distributing and storing propane, making the fuel a more attractive option for consumers.

- ✓ **Leverage resources through partnerships.** Projects this year are funded and performed by an impressive array of academic, government, industry, and international partners. By increasing the variety of its partnerships, PERC has invited new thinkers and new methodologies into its R&D landscape. Work with the U.S. Department of Agriculture (USDA), the U.S. Department of Energy (DOE), and trade associations has proven especially beneficial in bringing outside perspectives and resources to the development of promising propane technologies.

Financial Summary

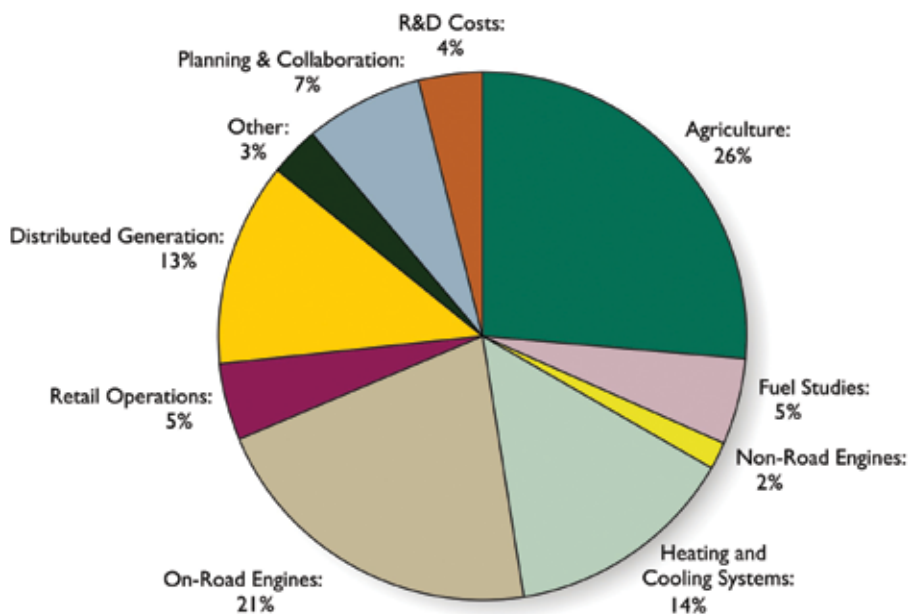
R&D Investments, 2000–2007

PERC's research and development mission invests in technology areas that hold the greatest promise for expanding the propane market. In 2007, considerable resources were devoted to the development and commercialization of technologies in promising markets such as distributed generation, engine fuel, and agriculture. In 2008, PERC plans to support R&D with a budget of just over \$7 million.



2007 R&D Investments

In 2007, PERC invested more than \$5.1 million to support new propane technologies.



Distributed generation demonstrations increase public awareness of technology

As an on-site source of energy, propane-powered distributed generation (DG) technology can achieve higher efficiencies than traditional electric grid supply. Combined with its low initial costs, this efficiency potential makes DG ideal for providing power to off-grid applications or to locations where grid-based electricity costs are high.

PERC increased its support of work in this market through the *Propane Distributed Generation Demonstration Program (Docket 12336)*. The project funded a number of product demonstrations to examine the abilities and benefits of propane-powered DG and convey them to industry members, government organizations, and potential consumers. Expanding public awareness of this technology is a crucial step in moving more propane-powered DG systems to market.

Combined heat and power shows commercial and residential promise

Combined heat and power (CHP) systems supply electrical and heating needs through the use of a propane-driven engine, which recovers excess heat for alternate uses. The reuse of this heat adds to DG's efficiency benefits, providing homes and businesses with the opportunity to reduce energy costs. PERC conducted five development and demonstration efforts investigating the use of CHP technology:

- *Climate Energy Propane Warm Air Micro-CHP System (Docket 12199)* is currently comparing the ease of home installation for conventional furnaces and propane-powered Honda engine micro-CHP systems, which are 90 percent energy efficient and reduce CO₂ emissions. These systems are currently used in thousands of small commercial applications in Japan and are relied on for cost-effective, reliable energy. A demonstration system was installed in a Massachusetts home to evaluate the benefits over conventional heating systems.
- *Yanmar CHP Performance Testing & Field Evaluation (Docket 11866)* brought to the U.S. the Yanmar micro-CHP system, which has proven highly successful in Asia. This project rigorously lab-tested the performance of the Yanmar system. The system has since been installed at a demonstration site and will be monitored for a year.
- *Conversion and Demonstration of Ecopower Micro-CHP to U.S. Utility Grid Configuration (Docket 10967)* and *Program Finalization for Electric Power Generator (Docket 10646)* assisted Marathon Engine Systems in designing, developing, and commercializing a line of propane-fueled remote power electric generators and micro-CHP systems. The systems were refined for use with the U.S. electric standard and are now commercially available.
- *Propane-Fueled Combined Heat and Power (CHP) Systems for Residential Applications (Docket 12200)* compared the performance of propane-fueled CHP systems to conventional electric heat pumps and vapor compression air conditioning units that use propane furnaces for heating, in order to better understand competitive advantages.



“Distributed generation technology provides consumers with affordable and efficient energy, opening a promising market for propane.”

—Stuart Weidie,
Chairman,
PERC Research and
Development Advisory
Committee

Hybrid Distributed Generation

Hybrid DG partners renewable energy with propane technology

Renewable energy sources, such as solar and wind, can power DG systems with low operating and maintenance costs and zero emissions, but they often lack reliability and can be costly upfront. The right combination of renewable energy and propane electricity-generating technology produces power efficiently and maximizes the performance of renewable energy, resulting in sustainable power and potentially lower overall cost than other alternatives. PERC explored this innovative technology through the following efforts:

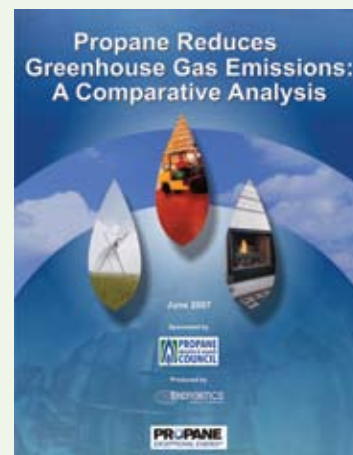
- *LPG Genset with Solar Hybrid Power Station for 2007 WLPGF Display (Docket 12337)* demonstrated a new LPG generator at the 2007 World LP Gas Association Forum hosted in Cape Town, South Africa. The PolarPower Genset system is 95 percent efficient, with a variable speed three-cylinder Daihatsu engine that operates between 3kW and 6kW. Solar energy comes from three BP Solar Array panels capable of producing 185W per panel.
- *Propane/Solar Hybrid Project for Urban/Municipal Applications (Docket 12074)* will evaluate the technical feasibility of and demonstrate providing backup power to key traffic lights throughout the Washington, D.C., region with a backup hybrid propane/solar power system.
- *Investigation of Propane-Genset Hybrid Power Systems for Rural Tribal Communities (Docket 12264)* investigated the technical and economic viability, including installation and maintenance requirements, of propane-genset hybrid solar and wind power systems for remote, tribal communities.



Propane's green advantages investigated

With a growing global push to use cleaner, more efficient energy that emits fewer greenhouse gas emissions, PERC focused on the investigation of propane's potential environmental benefits through the following studies:

- *Propane Reduces Greenhouse Gas Emissions: A Comparative Analysis (Docket 12294)* compared the greenhouse gas emissions (GHG) per Btu of propane to those of natural gas, ethanol, gasoline, and other fuels in several common applications. The results show that propane outperforms conventional fuels in almost every application analyzed. In the area of residential water and space heating, propane performed as well as natural gas and better than other fuels, while for distributed power generation, propane outperformed diesel. Light-duty trucks also proved to be particularly promising—the study found that the new propane-powered Roush Ford F-150 produces less GHG emissions than similar gasoline or ethanol (E85) models.
- *Investigation into Bio-Propane (Docket 12335)* performed a detailed review and subsequent testing of various methods to produce propane from renewable sources. The final report will provide information on the production, economic viability, and competitive advantages of each method.



Agricultural Technologies— Growing the Market for Propane

PERC's vision is that by 2010 the agricultural industry will recognize propane as a preferred energy source offering exceptional value through product benefits such as cost-effectiveness, efficiency and productivity, reliability, portability, and environmental friendliness.



Propane flame sanitization efforts expanded

The successful commercialization of propane flame sanitization technology in poultry houses as an effective means of reducing harmful pathogen populations sparked a number of initiatives to increase the value and usage of this technology. A tilling apparatus was added to the Red Dragon Poultry House Sanitizer in an effort to incorporate heat deeper into the litter in *Poultry House Sanitation with Prototype Tiller (Docket 12344)*. *Poultry House Sanitation to Reduce Pathogen Transport to Groundwater (Docket 12026)* tested

the efficacy of various levels of flame treatment on microbiology and flock performance to develop better protocol for the heat sanitization of poultry buildings.

Propane flame sanitization also made the shift to dairy farms. *Dairy Bed Sterilization Through Propane Flame (Docket 12292)* tested the ability of propane-fueled concentrated heat to reduce mastitis-causing pathogens in sand dairy bedding, further increasing the technology's utility.

Cotton defoliator undergoes additional testing

Previous testing has proven that propane-fueled cotton defoliation offers a number of benefits at an equivalent cost to chemical treatments. It kills pests immediately and requires only 24 to 48 hours until crops may be harvested, it is environmentally friendly, and it is effective in all weather conditions. *Harvest Preparation Demonstrations and*

Tests Using Prototype Thermal Defoliator (Docket 11729) expanded on this research to specifically test the effects of propane-fueled cotton defoliation on cotton physiology, yield, and fiber value. The logistics of this project were supplemented by *Cotton Defoliation Testing Logistical Support (Docket 12025)*.

“Propane-fueled heat, flame, and steam are applications becoming a staple on the farm for controlling weeds, pests, and parasites.”

—Robert Jacobs,
Chairman,
PERC Agriculture
Advisory Committee

Thermal weed and pest control market continues to develop

Brought to the U.S. from Australia in 2005, the innovative Batchen Stinger thermal weed control machine was the focus of several projects attempting to enhance its capabilities and efficiency. *Batchen Stinger Steam Weeder – Design Study (Docket 12297)* collected and evaluated data on the current Batchen Stinger model, making recommendations to increase durability, fuel capacity, and size. *Batchen Stinger Steam Weeder – Engineering Design and Preparation of Detailed Drawings (Docket 12420)* is designing a new model based on these recommendations that is capable of performing weed control on both sides of the machine, carrying twice as large a reserve of water and propane, and allowing for easily adjustable canopy design to increase customer ease of use.

Developing a Propane-Fueled Means to Control Soil Nematodes – Phase 1 (Docket 12203) performed the initial studies into the technical and economic feasibility and subsequent design of

a propane-fueled system capable of controlling nematode populations, offering an alternative to chemical treatments. Promising results led to *Develop and Test a Propane-Fueled Means to Control Soil Nematodes: Phase 2 (Docket 12423)*, which will build a prototype steam-heating system and field test it in rural locations. This project will then develop an aggressive commercialization plan for the system, targeting the U.S. agriculture market.

Thermal (Pest) Remediation in Grain and Other Ag Structures (Docket 11958) evaluated the compatibility of existing grain dryer systems with heat treating for insect control. The project also developed and tested a mobile heat treatment unit for insect control in bins, silos, and other storage facilities before they are loaded with grain. Heat treatment applications present a promising market for propane, as they possess many environmental, ease-of-use, and economic advantages over conventional chemical means.



A viable propane-powered steam system to control soil nematodes could increase off-peak propane sales by 10 million gallons per year in warmer climates alone.

Agricultural equipment utilizes propane-powered engines

Economic Analysis and Demonstration of Propane Irrigation Engines (Docket 12049) tested the capabilities of three of the most common and economical propane engine platforms used throughout the upper Midwest in the vast majority of irrigation systems.

The project collected data both in a laboratory setting at the Nebraska Tractor Testing Laboratory and in a field setting at several highly visible, highly accessible irrigation wells to determine efficiency and value of the products.



Engine Fuel Programs— Driving Propane in New Directions

PERC's vision in engine fuel is to expand propane's leading alternative fuel position and sales volume by retaining, optimizing, and penetrating existing and new market segments.



Propane-powered vehicles enter promising alternative fuel market

Alternative-fuel vehicles continue to capture an increasing share of the automotive market, and the propane industry is actively participating. *Development and Commercialization of OEM Propane School Bus in 2006 (Docket 11943)* developed, tested, and marketed a propane version of the Blue Bird Vision school bus. The propane-fueled bus is an important component of the Blue Bird alternative fuels strategy, and has been developed with both the air brake and hydraulic brake option to maximize consumer appeal.

Light-duty trucks constitute a significant portion of U.S. vehicle fleets, offering a large market to the fuels that power them. *Development of Propane Light Duty Vehicle (Docket 11942)* built and commercialized the propane-powered Roush Ford F-150. In a PERC-sponsored greenhouse gas study, this propane-powered model was found to produce less GHG emissions than similar gasoline or even ethanol models.

Compared to gasoline, propane cuts emissions of toxins and carcinogens such as benzene and toluene by up to 96 percent.



Market research targets fleet manager expectations to determine opportunities for propane

To evaluate the challenges and expectations of fleet managers, *Fleet Manager Market Research (Docket 12465)* conducted an analysis that surveyed fleet managers and documented fleet customer locations and size. The study developed a questionnaire based

on focus group responses, which it distributed to a random sample of fleet managers across the U.S. The data collected will help to determine how propane can best meet and exceed fleet managers' needs as an alternative fuel.

Development of low-emission propane engines demonstrates commitment to improving performance while meeting stringent regulations

Propane engines run clean without sacrificing performance. On average, propane mower engines deliver approximately 20 percent savings on fuel costs over gasoline while reducing hydrocarbon emissions by nearly 70 percent. PERC's engine fuel programs are dedicated to delivering these results to the industry and consumers through the development of innovative engine technologies.

PERC Partners with Mississippi State University on Diesel Emissions Reduction Program – Performance Evaluation of Propane Injection for Diesel Engines (Docket 12195) evaluated technology that allows for the injection of propane into a diesel engine without engine modification. The project conducted limited baseline tests on commercially available products to acquire engine performance and emissions reduction data. Researchers used this data to set clear guidelines for using propane in diesel engines that optimize engine performance and minimize emissions.

GM 6.0L LPG Engine Emissions Certification and Durability Development (Docket 12413) aims to design, test, and commercialize a dedicated liquid propane injection (LPI) system for an engine designed for light- to medium-duty GM trucks and vans. The system will be certified and calibrated to meet stringent emissions requirements, opening markets for additional propane-fueled vehicles.

Development and Commercialization of an EPA-Certified (Blue Sky) Zero Turn Radius Mower (Docket 12466) is developing and commercializing a line of low-emission, closed-loop commercial mowing products fueled by propane. Emission levels will achieve EPA Blue Sky standards, which require engines to run about 40 percent cleaner than those that meet mandatory standards. Plans are to market and sell 1,000 mower units in the first year of commercialization, with an increase to 5,000 units by the third year.

“Propane-powered vehicles offer the best combination of durability, performance, and driving range of commercially available alternative fuels.”

—Tucker Perkins,
Chairman,
PERC Engine
Fuel Advisory Committee



Photos courtesy of EnviroGard and Dixie Chopper

Commercially viable propane heating, cooling, and dehumidifying units explored

To ensure basic comfort and maintain indoor air quality, homes and businesses rely on heating and cooling systems. As energy prices rise, the cost of this comfort does as well, motivating consumers to seek more efficient alternatives, such as propane-fueled technologies. Recognizing this potential, PERC commissioned the following projects:

- *Study of Propane-Fired Gas Cooling Technologies (Docket 11957)* examined the current state of gas cooling technologies. The resulting report outlines the technical challenges to improving system efficiency and reducing cost, and suggests a potential course for future development and demonstration.
- *10 RT Gas Engine Driven Heat-Pump Product Development Project – Phase 1 (Docket 12314)* is building and testing a 10-ton rooftop unit that will allow propane to penetrate this market and pave the way for other propane-fueled engine-driven heat pump, power, and CHP products for residential and commercial applications. Commercial rooftop units already exist in many applications, offering propane ample opportunity to enter this viable market.
- *Residential Propane Desiccant Dehumidifier (Docket 11552)* tested propane-fueled desiccant dehumidification systems capable of substantially reducing humidity and improving air quality. The project also considered realistic cost concerns for entry into the retrofit and new home markets.



Photo courtesy of Yazaki

Cost-effective materials make commercial underground composite tank feasible

Study of Alternative Tank Materials (Docket 11728) compiled information on material compatibility and corrosion in search of cost-effective alternatives to steel tanks. The results of this study led to the implementation of *Alternative Materials for Underground Propane Storage Tank (Docket 12096)*, which will prepare a detailed design of a potentially competitive 500-gallon underground composite propane tank.

Equipment Comparison Testing Program

PERC's equipment comparison testing program evaluates the performances of a range of available propane equipment. By comparing different models of the same type of equipment, this program can provide accurate, third-party performance testing data to propane marketers and customers.

Future topics of study include remote monitoring systems, regulators, and pressure relief valves.

As part of this program, *Testing and Evaluation of Underground Propane Tank Coatings (Docket 12469)* is evaluating the ability of various coatings to protect steel underground storage tanks. The study is determining each coating's effectiveness in preventing corrosion and other forms of damage from weather effects, chemical exposure, and thermal cycling.

Research and Funding Partnerships

PERC continues to form and strengthen partnerships throughout the propane industry and with government and research institutions to increase technical knowledge, leverage funding, and maximize investments.

Continued partnership with USDA makes advances in agriculture

PERC and the U.S. Department of Agriculture (USDA) continue to co-fund projects that produce commercially viable equipment with the potential to address agricultural problems, expand markets, and increase propane sales. In the past year, the partnership entered the second phase of a project to develop a propane-fueled prototype that uses superheated aerated steam and applies it directly to the soil to effectively control soil nematode populations. This method will be useful for both conventional and organic farmers as an effective and environmentally friendly alternative to methyl bromide, an ozone-depleting chemical traditionally used to control the parasite.

Additionally, the partnership funded testing of a thermal cotton defoliator, which kills pests and requires only 24 to 48 hours before the crops are ready to harvest. Future grants will continue to support breakthroughs in agricultural technologies and fund increased research on alternatives to chemical treatments.

Engine fuel partnerships enhance propane's presence in industry and alternative fuel programs

Continuing partnerships with several industry associations and government organizations have increased the effectiveness of PERC's engine fuel marketing program activities, which focus on improving the market potential for forklifts, commercial fleet applications, off-road applications, and after-market conversions for on-road vehicles.

Partnering with the Industrial Truck Association (ITA), whose members include North American truck and tractor manufacturers, has enabled PERC to reinforce its commitment to propane-fueled forklifts, identify and solve imperative manufacturing and marketing issues with company executives, and bolster its continued marketing efforts for this important segment of the propane industry. In working with the Materials Handling and Equipment Distributors Association (MHEDA), PERC directly communicates with equipment distributors to ensure propane remains an active presence in their work, and to encourage collaboration on education and training materials for propane-fueled equipment.

PERC also continues to leverage funding for product demonstrations and critical research projects by participating in the U.S. Department of Energy's (DOE) Clean Cities program, which promotes the use of alternative fuels and engines in the transportation sector. Many collaborative projects have resulted, including the installation of new propane refueling stations, the addition of propane-fueled vehicles to public and private vehicle fleets, and the development of a commercially available propane-powered mower.

2007 Partners

In 2007, PERC teamed up with 28 entities to pursue R&D:

ADEPT Group, Inc.
AFRED/Texas Railroad Commission
Autumn Wind Associates
Battelle Memorial Institute
Blue Bird
Blue Mountain Energy
California State University, Fresno
CleanFuel USA
Climate Energy
Consulting Solutions
Diedrichs and Associates
Eastern Shore Resource Conservation and Development Council
Emmitte Associates
Energetics Incorporated
Ferrellgas
Gas Technology Institute
Husqvarna Group
Iowa State University
Mississippi State University
New West Technologies
National Propane Gas Association
Oregon State University
Osborn & Barr
Polar Power
Roush Industries, Inc.
Southwest Research Institute
TEMP-AIR
TUG Technologies Corporation
University of Nebraska
University of Tennessee
U.S. Department of Agriculture
U.S. Department of Energy
WelchGas

Looking Ahead: Commercializing Our Successes



The commercial success of projects such as the Red Dragon poultry house sanitizer and the propane-fueled Blue Bird Vision school bus has proven PERC's ability to help innovative propane technologies penetrate the market. Moving forward, the Council plans to ramp up its commercialization efforts. Led by the newly established Market Development Task Force (see below), PERC will focus its resources on commercially viable R&D technologies, with the goal of turning them into marketable equipment and aiding industry partners in quickly bringing them to market. Allocating strategic resources specifically to the commercialization of propane technologies will open doors for propane to excel in new areas and will assist the expansion of propane products in established markets.

Agricultural Technologies

- Redesign steam weed control machine
- Analyze test data for irrigation engines
- Increase outreach to organic industry with improved heat flame and steam applications

Fuel Studies

- Promote new solutions for engine fuel deposits
- Advertise propane as a low-carbon fuel that produces fewer emissions than competing fuels

Residential and Commercial

- Promote newly developed distributed generation products and tout renewable hybrid products
- Continue development of gas cooling technologies
- Promote commercialized desiccant dehumidification systems

Engine Fuel

- Increase market of small lawn and garden equipment
- Increase outreach efforts for propane-fueled medium-duty truck

“By focusing on the commercialization of new technologies, PERC can most effectively target its resources to increase propane usage in the most promising market segments.”

—David Lugar,

*Chairman,
PERC Market
Development
Task Force*

Market Development Task Force

The Market Development Task Force is a group of industry volunteers drawn from the Council and the advisory committees whose main goal is to optimize the use of PERC programs and resources to grow the propane industry. To aid the commercial success of new technologies, the task force will work to create a formal commercialization plan for PERC. This plan will guide the task force in analyzing PERC's current efforts in each technology segment so that action plans are created to effectively allocate PERC's resources and maximize its impact on increasing propane usage.



Recent Grants

11941 PERC Hybrid Distributed Generation Study \$5,000	12117 SwRI Sensors for LPG Contaminants Phase I: Gas Detection Tube Proof of Concept \$65,938	12295 Ferrelgas Mobile Propane Powered Surveillance Unit \$26,745	12380 PERC Propane Industry Component/System Testing Program Management \$100,000
11942 Roush Industries, Inc Development of Propane Light Duty Vehicle (Response to PERC's RFP) \$1,059,410	12148 NPGA/Battelle Evaluating Possible Extension of Propane Cargo Tank Inspection Interval — Phase 2 \$536,200	12296 Nebraska PERC Economic Analysis and Demonstration of Propane Irrigation Engines Phase 2 \$51,885	12408 AFRED Reducing LP-Gas Fleet Emissions, Fuel Waste, and Operating Costs and Enhancing Employee Health and Safety through Use of the Maximus™ Overfill Detection Instrument (ODI) \$38,220
11943 Blue Bird Development and Commercialization of OEM Propane School Bus in 2006 \$859,494	12170 PERC 2007 Research and Development Oversight and Advisory Committee Support Docket \$207,400	12297 Diedrichs and Associates Batchen Stinger Steam Weeder – Design Study \$75,000	12409 University of Tennessee Emission, Economic, and Performance Analysis Propane-Fueled Mower \$91,006
11956 PERC Distributed Generation Project Development and Implementation 2006 \$217,760	12186 Energetics Provide Technical Communications Services to PERC's R&D Advisory Committee \$120,000	12314 PERC 10 RT Gas Engine Driven Heat-Pump Development Project \$724,826	12410 Oregon State University Research and Design of a Propane Machine for Reducing the Weed Seedbank \$28,600
11957 PERC Study of Propane-Fired Gas Cooling Technologies \$60,260	12194 TUG Technologies Corporation Tug Technologies Ground Service Equipment Ford 4.2L Engine Development Program \$200,000	12315 PERC Propane Tankless Water Heater to Increase Energy Efficiency on a Dairy Operation \$31,850	12412 California State University, Fresno Investigation of the Effects of Thermal Pest Control Technology on Common Insect and Fungal Diseases and Yield/Quality Parameters in California \$143,000
11958 Temp Air Thermal (Pest) Remediation in Grain and Other Ag Structures \$183,000	12195 Mississippi State University Performance Evaluation of Propane Injection for Diesel Engines (mobile applications) \$115,000	12331 AFRED Introducing 90% Efficient Micro-Trigeneration Technologies to Texas Dairy Farming \$77,900	12413 CleanFuel USA GM 6.0L LPG Engine Emissions Certification & Durability Development \$1,071,975
11992 PERC/Battelle Recommended Proper Use of Methanol in Controlling Water Freezing in LP Gas \$109,000	12199 Climate Energy Climate Energy Propane Warm Air Micro-CHP System \$25,000	12335 PERC Investigation into Bio-Propane \$19,000	12420 Diedrichs and Associates Batchen Stinger Steam Weeder– Detailed Design-Phase 2 \$178,565
12025 PERC Cotton Defoliation Testing Logistical Support \$12,000	12200 Mississippi State University Propane-Fueled Combined Heat and Power (CHP) Systems for Residential Applications: Phase I and II \$70,000	12336 PERC Propane Distributed Generation Demonstration Program \$350,000	12423 Gas Technology Institute Develop and Test a Propane-Fueled Means to Control Soil Nematodes-Phase 2 \$434,503
12026 PERC Poultry House Sanitation to Reduce Pathogen Transport to Groundwater \$35,850	12201 Iowa State University Feasibility Study of Propane Utilization by Transportation Agencies in Road Construction and Maintenance Applications \$15,000	12337 PERC LPG Genset with Solar Hybrid Power Station for 2007 WLPFG Display \$55,000	12425 PERC 2008 to 2012 Strategic Plan Development \$18,000
12027 Emmitte Associates Anaerobic Digestion Using Propane as a Fuel Supplement \$44,989	12202 University of Nebraska Determining Biologically Effective Propane Dose for Weed-Crop Flaming \$101,409	12339 Autumn Wind Associates Propane Cogeneration at a California Vineyard and Winery \$70,500	12454 PERC 2008 Research and Development Oversight and Advisory Committee Support \$208,000
12028 Adept Group LP Gas Portable Incinerator Study \$15,900	12203 Gas Technology Institute Develop and Test a Propane-Fueled Means to Control Soil Nematodes Phase I \$342,000	12340 Emmitte Associates Propane Cogeneration at a Pennsylvania Hydroponic Greenhouse \$36,400	12455 Energetics Provide Technical Communications Services to PERC's R&D Advisory Committee \$120,000
12046 New West Technologies Mid-Atlantic Propane Assisted Biodigester Project \$70,000	12221 Temp Air Fundamental Research on the Efficacy of Heat on Bed Bugs and Heat Transfer in Mattresses \$52,500	12341 PERC Propane Pick-Up Truck Demonstration and Promotion in the Agriculture Market \$100,000	12465 PERC Fleet Manager Market Research \$53,600
12049 Nebraska PERC Economic Analysis and Demonstration of Propane Irrigation Engines \$54,514	12224 New West Technologies Investigation of Propane-Genset Hybrid Power Systems for Rural Tribal Communities \$54,601	12342 Eastern Shore Resource Conservation and Development Council Redesigning Propane Burners which Remove String and Plants from Tomato Stakes \$17,550	12466 Husqvarna Development and Commercialization of an EPA-Certified (Blue Sky) Zero Turn Radius Mower \$90,000
12069 PERC Underground Composite Propane Tank Mockup \$5,000	12275 PERC Distributed Generation Project Development and Implementation 2007 \$260,210	12343 University of Nebraska Design and Optimization of Propane Fueled Weed-Crop Flamer \$70,000	12469 PERC Testing and Evaluation of Underground Propane Tank Coatings \$174,610
12070 New West Technologies Investigation of Propane Heaters for Northern Climate School Bus Applications \$45,000	12292 PERC Dairy Bed Sterilization Through Propane Flame \$47,763	12344 WelchGas Poultry House Sanitation with Prototype Tiller \$5,200	12470 PERC / Battelle Design a Portable Handheld Water Detector for Propane \$213,500
12074 PERC Propane/Solar Hybrid Project for Urban/Municipal Applications \$65,000	12294 PERC Study of Propane's Climate-Change Advantages \$35,000	12345 Osborn & Barr Propane Tractor Study \$11,000	
12096 Battelle Alternative Materials for Underground Propane Storage Tank - Phase 2 \$192,000		12346 ADEPT Group LP Gas Incinerator Follow-on Work \$14,100	
12100 PERC Propane Industry Component/System Testing Program Project Management \$100,000		12359 AFRED 2011 Compliant Propane Commercial Mower, Phase I \$5,000	
12116 SwRI Study of LPG Deposit Formation Mechanisms and Mitigation Methods \$701,500			

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