Distributed Energy Resources

Program Mission

The mission of the Distributed Energy and Electricity Reliability (DEER) Program is to strengthen America's electric energy infrastructure and provide utilities and consumers with a greater array of energy efficient technology choices for the generation, transmission, distribution, storage, and demand management of electric power and thermal energy.[a] This effort is accomplished through research, development, demonstration, technology transfer, and education and outreach activities in partnership with industries, businesses, utilities, States, other Federal programs and agencies, universities, national laboratories, and other stakeholders.

The program covers a portfolio of technologies, tools, and techniques including advanced industrial turbines, microturbines, reciprocating engines, chillers, desiccants (for humidity control), combined heat and power systems, energy storage devices, load management programs, transmission operations software, and high temperature superconducting cables and transformers. The program addresses the development of utility interconnection and other codes and standards, environmental siting and permitting regulations, and policies that affect the use of these distributed energy and electricity reliability technologies, tools, and techniques.

Distributed energy involves the use of relatively small-scale and modular energy generation devices that can be installed onsite or near the customer's premises. They are options for utilities and industrial, commercial, institutional, and residential consumers to use, along with grid connected services and other energy efficiency and renewable energy devices and equipment, for back-up, peak shaving, baseload, and combined heat and power applications. For example, a chemical plant could retrofit its facilities and install an advanced industrial turbine to make electricity and thermal energy to meet its energy needs and make money by selling excess power to the grid when power system conditions warrant. Or, a new commercial building could include onsite power generation and natural gas-fired chillers and desiccant systems in its architectural designs. They would do this to reduce costs and improve power reliability and quality for sustaining critical operations when grid-connected power is not available or sufficient.

Strategic Context

Accomplishing this mission contributes to several national energy and environmental goals. For example, expanding the use of distributed energy and electricity reliability technologies will upgrade America's aging electricity power infrastructure, relieve congestion on transmission and distribution systems, reduce consumption and increase supplies during periods of peak demand, accelerate the introduction of advanced systems to improve the efficiency of market operations, support the transition from traditional monopoly regulation to more competitive markets, and reduce environmental emissions, including greenhouse gases.

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[a] This Interior section is focused on the distributed energy portion of the program. The Energy and Water section focuses on electricity reliability.

America's power system is in a state of transition. Capital investment is needed to expand electricity supplies and upgrade existing systems. Policy makers are looking for opportunities to expand competition to replace traditional monopoly regulation, where it is appropriate to do so. Digital systems are replacing electro-mechanical devices in electric power networks. High speed telecommunications systems and the Internet are being integrated into power system operations, thus enabling real-time responses to system emergencies and changes in supply-demand conditions. Customers with needs for high levels of reliability and power quality (e.g., high-tech manufacturing plants and information and telecommunication service providers) are installing distributed energy devices and demanding lower cost, lower emission, and more energy efficient equipment, as well as new business practices and regulations to speed installation and facilitate distributed energy operations.

The President's National Energy Policy (NEP) contains more than twenty recommendations pertaining to the development of distributed energy and electricity reliability technologies and programs. For example, microturbines are referred to as a technology that offers a number of "significant advantages" over currently available small-scale power generators. These include having fewer moving parts, compact size and light weight, optimal efficiency, lower emissions and electricity costs, and the ability to use waste fuels. The NEP refers to combined heat and power (CHP) as "...one of a group of clean, highly reliable distributed energy technologies that reduce the amount of electricity lost in transmission while eliminating the need to construct expensive power lines to transmit power from large central power plants". The National Transmission Grid Study, which was released in June 2002, contains 51 recommendations for relieving congestion and boosting the efficiency transmission system operations, including expanded development of advanced, clean distributed energy resources and electricity reliability systems.

In fact, distributed energy and electricity reliability devices provide utilities and consumers with more choices and control over how their energy needs are met, and are thus essential for more openly competitive electricity and natural gas markets to flourish. Distributed energy and electricity reliability devices address critical needs of utilities and consumers by:

- reducing energy losses from transmitting electricity over long distances
- providing utilities with tools for more efficient grid operations
- reducing the need for major capital expenditures for electricity infrastructure (e.g., large scale power plants, transmission facilities, substations, and feeder lines)
- offering industrial, commercial, and ultimately residential users with more opportunities for increasing energy efficiency, managing energy costs, achieving desired levels of reliability and power quality, and reducing environmental emissions, including greenhouse gases.

Several regulatory and institutional barriers currently interfere with the expanded use of these technologies, tools, and techniques. These barriers include the lack of uniform utility interconnection standards, the lack of uniform environmental siting and permitting regulations, the lack of appropriate building, fire, and safety codes, the lack of real-time electricity pricing that reflects the marginal costs of production and delivery, and the lack of comprehensive national policies for achieving competitive utility markets across the country. Needed are policies and procedures in these areas to create a regulatory framework that is more conducive to competition and choice for Federal, regional, State, and local government agencies to follow.

Management Strategy

The program conducts research, development, demonstration, technology transfer, and education and outreach activities in partnership with industry, State agencies, universities, national laboratories, and other stakeholder organizations. It solicits opinions from experts outside of the U.S. Department of Energy to guide decision making about program directions and priorities. To accomplish this the program develops technology roadmaps and holds peer reviews.[a] A key element of the strategy is to build RD&D partnerships with industry and others to make distributed energy and electricity reliability systems more energy efficient, reliable, and affordable to consumers than the energy services they currently receive, and for these systems to have better power quality and lower environmental impacts. The ultimate aim is to improve the energy and environmental performance of distributed technologies, and increase the level of distributed technology integration among on-site energy generation alternatives so that the Nation can achieve a more flexible and smarter energy system. This new energy infrastructure will operate seamlessly alongside the existing system to enable consumers to make wiser energy choices and implement customized solutions, thereby boosting the Nation's economic productivity, energy efficiency, and environmental stewardship.

To address the regulatory and institutional barriers, the program has initiated analysis, education, and outreach activities, in concert with industry groups and government agencies, to support the development of better environmental siting and permitting regulations, more effective building codes and standards, and more open and competitive utility markets and business practices. The aim is to streamline procedures, accelerate distributed energy project development timetables, and lower the costs of regulatory compliance. The program is working with manufacturers and building code officials to ease the process for using distributed technologies in buildings for electricity and combined heat and power applications.

The program receives appropriations from both the Interior and Related Agencies and the Energy and Water Development subcommittees. Interior activities focus on the development of cleaner and more energy efficient distributed energy generation equipment and integration into end-use applications. Energy and Water development activities focus on developing advanced electricity reliability technologies, including high temperature superconducting systems.

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[a] For example, Distributed Energy Resources - The Power to Choose, Peer Review, November 28-30, 2001

The Program is organized into the following areas of activity:

- Distributed Energy (Interior)
  - Distributed generation technology development
  - End-use systems integration and interface

- Electricity Reliability (Energy and Water)
  - High temperature superconducting R&D
  - Transmission reliability R&D
  - Distribution and interconnection R&D
  - Energy storage R&D
  - Electricity restructuring

In conducting these activities, the program operates a comprehensive set of RD&D partnerships. For example, collaborations include competitively awarded cost-shared projects. Federal partnerships include participation with the Federal Energy Management Program (FEMP) to promote and install distributed energy systems at Federal facilities; the State Energy Program to increase awareness, promote benefits, and remove barriers to distributed energy; and small businesses through the Small Business Innovation Research program.

The DEER program complements the Hydrogen Program by developing technologies that could utilize hydrogen based fuels for onsite power generation and combined heat and power applications. In addition, the program coordinates with the Industrial and Buildings Technologies Programs to identify co-funding opportunities for assessing distributed energy systems in these sectors. The program also partners with the U.S. Environmental Protection Agency on education and outreach efforts to address environmental siting and permitting of combined heat and power (CHP) and other distributed energy devices. Partnerships with State agencies include the California Energy Commission, the New York State Energy Research and Development Agency, and the Texas Natural Resources and Public Utilities Commissions. The program works with national laboratories including Oak Ridge National Laboratory (ORNL), National Renewable Energy Laboratory (NREL), Sandia National Laboratories (SNL), Pacific Northwest National Laboratory (PNNL), and National Energy Technology Laboratory (NETL) to develop an integrated national laboratory support effort that assembles the capabilities of the various labs and makes them available to manufacturers and end-users for testing and evaluation of the performance and integration of the various distributed energy systems.

Program Benefits

Each year, EERE estimates the benefits of program activities to support Government Performance and Results Act (GPRA) reporting. Methods are complex and vary by program. A complete explanation of methodology and assumptions will be posted this spring on line at www.eren.doe.gov/eere/budget.html. An overview of the methods and results for the DEER Program is provided below.

EERE's benefits estimate modeling starts with the Energy Information Administration's (EIA's) National Energy Modeling System (NEMS) and modifies it to create NEMS-GPRA04. The Baseline for the DEER program is essentially the EIA's Annual Energy Outlook (AEO) 2002 reference case, which includes considerable improvement in distributed generation (DG) technologies over time. The NEMS-GPRA04 baseline limits the rate of new technology adoption and the maximum share of DG technologies based on the extent to which future markets are expected to be able to accommodate these technologies. The Program goals for development of distributed electricity technologies (microturbines, reciprocating gas engines, and IC engines at 800 kW and 3,000 kW) are modeled directly in NEMS-GPRA04 by incorporating the improved costs, efficiencies, and other attributes in NEMS-GPRA04 for the program case. NEMS-GPRA04 compares these improved distributed technologies with other expected future sources of electricity (e.g., combined cycle natural gas plants). The portions of the program designed to enhance the ability of electricity markets to absorb and manage DG are modeled by increasing the maximum CHP market share. Because NEMS-GPRA04 cannot model markets for high-temperature superconductivity (HTS) products, the benefits from these products are modeled directly as reductions in transmission and distribution losses for electricity systems, based on estimates by Energetics of kilowatt-hour reductions from HTS generators, transformers, cables, and motors. The portions of the program which reduce market barriers to consumer investment are addressed by adjusting the model's consumer acceptance curves (market adoption rates by payback period) for CHP.

Not all kWh of electricity have equal value to consumers. Market experience suggests that at least a portion of consumers are willing to pay more for electricity that is more reliable, of higher quality, locally controllable, available during emergency, or cleaner. While market information was available to incorporate the impact of "green power" preferences in these benefit estimates, they do not include consumer purchases based on preferences for improved reliability, load management, or power quality advantages of distributed generation. As a result, these benefit estimates are likely based on an underestimate of the demand for these products under baseline market assumptions.

FY 2004 GPRA Benefits Estimates for the Distributed Energy Resources Program (NEMS-GPRA04)			
	2005	2010	2020
Electricity Capacity (GW)	2.3	7.4	25.0
Electricity Generation (BkWh)	16.7	53.8	180.1
Non-Renewable Energy Savings (quads)	0.08	0.19	0.46
Oil Savings (quads)	0.00	0.01	0.02
Carbon Savings (MMT)	1.4	3.4	8.5
Energy Expenditure Savings (B2000$)	0.7	3.1	9.0

Estimates for additions to electricity capacity and generation, energy savings, oil savings, carbon emission reductions, and energy expenditure savings resultant from realization of DEER Program goals are shown in the table above through 2020.[a] By facilitating the development of distributed electricity generation and improving the ability to manage peak demand loads for electricity, the DEER program helps alleviate the growing pressure on our Nation's critical electricity infrastructure, reducing the need for new generating and transmission capacity. The need for new central power construction is reduced by about 27 GW (the 25 GW of distributed power reported above displaces 27 GW of centrally-generated electricity capacity when transmission and other lines loses are factored in) by 2020, or 11 percent of expected needed additional capacity during this period (2005 to 2020). Almost 90 percent are gas turbines or combined cycles, and 10 percent are coal steam plants. Energy savings are measured as the displaced energy from central station plants and thermal building use, net of fuel consumed by the DG technologies.

These estimates reflect EIA reference case assumptions about future energy markets. The development of these technologies will also provide the nation with the opportunity to produce additional clean distributed energy if future electricity markets are more constrained than EIA projections expect (e.g., transmission lines prove more costly or difficult to site than expected), or if additional environmental policies associated with electricity production are implemented.

In addition to the quantified benefits identified above, the DEER program provides significant public energy reliability and security benefits. By improving the local availability and controllability of electricity, the DEER program helps achieve the electricity reliability and quality required demanded by our information economy and provides local sources of electrical power during emergencies.

Program Strategic Performance Goals

The Program Strategic Performance Goal represents the Distributed Energy and Electricity Reliability Program in entirety, and thus encompasses efforts under both the Energy and Water Appropriation and the Interior Appropriation:

The DEER Program has the following overall performance goals: 1) by 2008, DEER Program will complete development and testing of a portfolio of distributed generation and thermally activated technologies that show an average 25 percent increase in efficiency (compared to 2000 baseline) with NOx emissions less than 0.15 grams/kWh.; 2) by 2008, demonstrate the feasibility of integrated systems in three new customer classes, which could achieve 70 percent efficiency and customer payback in less than 4 years, assuming commercial-scale production; 3) by 2008, demonstrate the capability to double the power carrying capacity of transmission and distribution wires compared to that available in 2000, and 4) by 2012, develop a portfolio of technologies and software tools that allow real-time monitoring, understanding, and control of the transmission and distribution system by identifying over 90percent of

[a] Benefits reported are annual, not cumulative, for the year given for the entire DEER program (both the Interior and EWD portions). Estimates reflect the benefits associated with program activities from FY 2004 to the benefit year or to program completion (whichever is nearer), and are based on program goals developed in alignment with assumptions in the President's Budget.

incipient system disturbances and cue the operator for action as necessary (reducing response time through automated actions) to mitigate disturbance propagation.

Performance Indicators

The Interior section focuses on distributed energy, and addresses sub-program goals (1) and (2) in the stated performance goal. The respective performance indicators and technology baselines are stated below:

Performance Indicator

Distributed Energy Resources (Technology Development) - By 2008, DEER Program will complete development and testing of a portfolio of distributed generation and thermally activated technologies that show an average 25 percent increase in efficiency (compared to 2000 baseline) with NOx emissions less than 0.15 lbs/MWh with an equivalent reduction in cost compared to 2000 baseline.

Average efficiency of a portfolio of distributed generation and thermally activated technologies. *2000 Technology Baseline*: Microturbine - 25 percent; Reciprocating engine - 36 percent[a]; Dessicant (primary energy COP) - 0.5

Performance Indicator

Distributed Energy Resources (End-Use System Integration) - By 2008, demonstrate the feasibility of integrated systems in 3 new customer classes[b]; these systems will achieve 70 percent efficiency and customer payback in less than 4 years, assuming commercial-scale production.

Demonstration of integrated system. *2000 Technology Baseline*: no commercially-available integrated systems in specified customer classes.

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[a] These are estimates; actual data to be tracked via public source (e.g. Diesel and Gas Turbine Worldwide, 2001)

[b] Note: Integrated systems traditionally have focused on industrial CHP applications; these "new" customer classes target commercial, light industrial, and microgrid systems, which are representative of thousands of applications throughout the United States. After final determination, specific Standard Industrial Classification (SIC) codes will be added to the metrics [e.g. Grocery Stores - 4451; Limited-Service Eating Places - 7222; Hospitals - 622; Hotels (except Casino Hotels) and Motels - 72111; Broadcasting and Telecommunications - 513; Information Services and Data Processing Services - 514]

Annual Performance Results and Targets

FY 2002 Results	FY 2003 Targets	FY 2004 Targets
Demonstrated a microturbine package (highly efficient for reducing peak loads) at a university site. Completed preliminary systems designs for a 40 percent efficient microturbine and a low emission reciprocating engine. Demonstrated an advanced ceramic combustor liner in an industrial gas turbine for over 16,000 hours service. Completed testing and evaluation of a large absorption chiller.	Complete testing of 12 Beta Ambian units of high efficiency natural gas-fired heat pump (60percent better than pulse combustion furnace) and install at field test sites hosted by major U.S. Gas Utilities. Complete 4,000 hour field test of ceramic composite shroud components to demonstrate performance and emission benefits to a gas turbine. Demonstrate 5 percentage point increase in efficiency for an advanced microturbine system.	Complete and demonstrate heating coefficient of performance of 1.4 for commercial introduction of a thermally activated system (approximately 40 percent more efficient than a conventional heating system) Complete final design and initiate field testing of low emission technology with less than 7 ppm NOx. Demonstrate 6 percentage point increase in efficiency for an advanced reciprocating engine. Complete final design and initiate field testing and evaluation of a complete, fully functional integrated CHP system consisting of a turbine, absorption chiller and control system.

The following table represents the installed base of distributed generation in the United States.

Installed Base of Distributed Generation and CHP (GW)[a]

	1998	1999	2000	2001
Distributed Generation Excluding Renewables, Biomass and Off-Site Power	15.2	15.4	15.6	16.2
CHP	56.8	59.0	61.7	67.4

Distributed generation estimates exclude wind, solar, geothermal, and sources that export over 90percent power off-site. Data is for non-emergency generators, non-utility owned, under 50 MW, and over 1 MW. CHP estimates include all fuel sources (except wind and hydro) and prime mover types that self-classify as cogenerator or FERC-qualifying cogenerator.

Significant Program Shifts

The program completed the Advanced Turbine Systems subprogram in fiscal year 1999. This subprogram successfully resulted in the development of a new design for an advanced industrial turbine for distributed energy applications that achieved the goals set forth at the subprogram's inception in 1992 for improved energy efficiency and lower environmental emissions. The developer of that advanced design, Solar Turbines, Inc., is reviewing the potential commercialization of its advanced turbine system, the Mercury 50. This product is cost competitive with other products in its class but uses less fuel and emits less nitrogen oxides. It is capable of meeting air emissions regulations in non-attainment areas.

The program is following a similar RD&D model in pursuing activities in microturbines, reciprocating engines, thermally activated devices, and other areas. Plans call for supporting RD&D partnerships in the development of advanced designs for these products, cost sharing field testing and demonstrations to validate performance up to 8,000 hours of operation. These milestones are expected to be reached for microturbines in 2007 and reciprocating engines in 2010. Until then, efforts will be focused on cost shared RD&D to select promising approaches that lead to the achievement of RD&D goals for energy efficiency, environmental emissions, and cost effectiveness.

The Stationary Fuel Cell Program (formerly Building Fuel Cells) has been transferred to Fuel Cells program.

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[a] Sources: DG: 2000 EIA Form 860B, for 1998-2000 data, and Resource Dynamics Corporation estimates for year 2001, based on Diesel and Gas Turbine Worldwide estimates for 2001 in U. S.

CHP: 2001 EIA Form 860B, for 1998-2000 data, and Resource Dynamics Corporation estimates for year 2001, based on Diesel and Gas Turbine Worldwide estimates for 2001 in U. S. for units under 100 MW, and for units over 100 MW based on EIA capacity additions for 2001 that self-classify themselves as cogenerators.

Funding Profile[a]

(dollars in thousands)

	FY 2002 Comparable Appropriation	FY 2003 Amended Request	FY 2004 Request	$ Change	% Change
Distributed Energy Resources					
Total, Distributed Energy Resources	55,137	54,784	51,784	-3,000	-5.5%

Public Law Authorizations:

P.L. 94-163, Energy Policy and Conservation Act (1975)
P.L. 94-385, Energy Conservation and Production Act (1976)

[a] SBIR/STTR funding in the amount of $ 1,259,000was transferred to the Science appropriation in FY 2002. Estimates for SBIR/STTR budgeted in FY 2003 and FY 2004 are $ 1,250,940 and $ 1,182,437 respectively.

Funding by Site[a]

	(dollars in thousands)				
	FY 2002	FY 2003	FY 2004	$ Change	% Change
Albuquerque Operations Office					
Argonne National Lab (East)	410	775	775	0	0.0%
Golden Field Office	110	100	17,039	+16,939	+16,939.0%
National Renewable Energy Lab	2,300	1,814	1,814	0	0.0%
Total, Albuquerque Operations Office	2,820	2,689	19,628	+16,939	+629.9%
Chicago Operations Office					
Brookhaven National Lab	525	450	0	-450	-100.0%
Chicago Operations Office	23,130	20,689	1,200	-19,489	-94.2%
Total, Chicago Operations Office	23,655	21,139	1,200	-19,939	-94.3%
National Energy Technology Laboratory	3,000	1,600	1,600	0	0.0%
Oakland Operations Office					
Lawrence Berkeley National Lab	624	200	200	0	0.0%
Total, Oakland Operations Office	624	200	200	0	0.0%
Oak Ridge Operations Office					
Oak Ridge National Laboratory	23,178	25,574	25,574	0	0.0%
Office of Scientific & Technical Information	27	45	45	0	0.0%
Total, Oak Ridge Operations Office	23,205	25,619	25,619	0	0.0%
Richland Operations Office					
Pacific Northwest National Lab	523	1,200	1,200	0	0.0%
Total, Richland Operations Office	523	1,200	1,200	0	0.0%
Washington Headquarters	1,310	2,337	2,337	0	0.0%
Total, Distributed Energy and Electricity Resources	55,137	54,784	51,784	-3,000	-5.5%

[a] "On December 20, 2002, the National Nuclear Security Administration (NNSA) disestablished the Albuquerque, Oakland, and Nevada Operations Offices, renamed existing area offices as site offices, established a new Nevada Site Office, and established a single NNSA Service Center to be located in Albuquerque. Other aspects of the NNSA organizational changes will be phased in and consolidation of the Service Center in Albuquerque will be completed by September 30, 2004. For budget display purposes, DOE is displaying non-NNSA budgets by site in the traditional pre-NNSA organizational format."

Site Description

Argonne National Laboratory

Argonne National Laboratory (ANL) performs research and development including non-destructive evaluation (NDE) of advanced ceramics, high temperature recuperators and coatings and laser ignition research for reciprocating engines. The NDE laboratory at ANL is renown for the techniques they have developed for the DEER technologies.

Golden Field Office

Golden Field Office (GO) administers and manages cost-shared cooperative agreements with industry participants for the industrial gas turbine, microturbine, reciprocating engine and communication and controls activities.

National Renewable Energy Laboratory

National Renewable Energy Laboratory (NREL) conducts research and development of novel material and processing techniques for advanced dessicant systems for humidity control and mitigation of Indoor Air Quality (IAQ). NREL also performs analysis addressing regulatory and institutional barriers to distributed energy resources

Brookhaven National Laboratory

Brookhaven National Laboratory (BNL) performs research and development of novel concepts in oil heat combustion and fuel flexibility technologies. This work has lead to proof-of-concept systems and to the acceleration of commercialization and integration of advanced technologies necessary to bring oil heating equipment to their practical potential. These technologies contribute to the combined heat and power initiative.

Chicago Operations Office

Chicago Operations Office (CO) administers and manages cost–shared cooperative agreements with industry participants for the industrial gas turbine, microturbine, reciprocating engine and communication and controls activities. The R&D managed by the Chicago Operations Office is crucial to the success of the DEER program.

National Energy Technology Laboratory (NETL)

National Energy Technology Laboratory (NETL) manages the university program that supports the advanced reciprocating engine program and performs in house R&D for that program.

Lawrence Berkeley National Laboratory

Lawrence Berkeley National Laboratory (LBNL) will perform analysis tasks to quantify benefits of distributed generation technologies to the customer, the system and the nation.

Oak Ridge National Laboratory (ORNL)

Oak Ridge National Laboratory (ORNL) is the primary lab for DEER technology development and end-use systems integration. ORNL conducts research and development in advanced materials and sensors for industrial gas turbines and microturbines, advanced reciprocating engines, thermally activated technologies, and combined heat and power (CHP). To conduct this research, ORNL leverages state-of-the-art, unique resources such as the High Temperature Materials Laboratory (HTML) User Center, the Building Technology User Center, and the CHP Integration User Center.

Office of Scientific and Technology Information

The Office of Scientific and Technology Information (OSTI) performs standard distribution of information for the Energy Efficiency programs. This distribution consists of publishing and maintaining on-line full text electronic current awareness publications and the production of CD-ROM disks containing program reports and documents.

Pacific Northwest National Laboratory

Pacific Northwest National Laboratory (PNNL) performs research, development, demonstration and deployment of advanced communication and control solutions to enable interoperable and integrated operation of large numbers of distributed energy resources from varying suppliers to achieve optimization in power quality, power reliability and economic performance.

Funding Schedule

	(dollars in thousands)				
	FY 2002	FY 2003	FY 2004	$ Change	% Change
Distributed Generation Technology Development					
Industrial Gas Turbines	4,500	4,500	3,000	-1,500	-33.3%
Microturbines	11,000	7,000	7,000	0	0.0%
Reciprocating Engines	11,000	10,000	9,000	-1,000	-10.0%
Technology Based - Advanced Materials and Sensors	6,997	8,256	8,256	0	0.0%
Fuel Flexibility	500	500	0	-500	-100.0%
Thermally-Activated Technologies	4,660	4,660	4,660	0	0.0%
Subtotal, Distributed Generation Technology Development	38,657	34,916	31,916	-3,000	-8.6%
End-Use Systems Integration and Interface					
Distributed Energy Systems Applications Integration	4,950	7,338	7,338	0	0.0%
Cooling, Heating and Power (CHP) Integration	11,000	12,000	12,000	0	0.0%
Subtotal, End-Use Systems Integration and Interface	15,950	19,338	19,338	0	0.0%
Technical/Program Management Support	530	530	530	0	0.0%
Subtotal, Technical/Program Management Support	530	530	530	0	0.0%
Total, Distributed Energy Resources	55,137	54,784	51,784	-3,000	-5.5%

Detailed Program Justification

	(dollars in thousands)		
	FY 2002	FY 2003	FY 2004
Distributed Generation Technology Development	**38,657**	**34,916**	**31,916**
▪ **Industrial Gas Turbines . . . . . .**	**4,500**	**4,500**	**3,000**

Industrial gas turbines are used in many industrial and commercial applications ranging from 1MW to 20MW. A key effort in the Industrial Gas Turbine Program has been to enhance the performance of gas turbines for applications up to 20MW. The focus of this effort is on advanced materials research, such as composite ceramics and thermal barrier coatings, which will continue to improve performance. Efficiency gains can be achieved with materials like ceramics, which allow a significant increase in engine operating temperature. The increased operating temperature also lowers its greenhouse gas and NOx emissions. In addition, low emissions technology research and development will improve the combustion system by greatly reducing the NOx and CO produced without negatively impacting turbine performance. These technologies use techniques to control the conditions for combustion so that NOx is not formed in the first place. Recent breakthroughs will allow these important technologies to move forward.

FY 2002: Continued durable cost effective low emissions technology research and development to field test emission levels of less than 7 ppm NOx for advanced gas turbines. Demonstrated technical feasibility of achieving low emissions under rig conditions. Continued R&D that demonstrates innovative high temperature materials such as coatings and ceramics in gas turbines to achieve endurance levels of greater than 8,000 hours. Initiated field testing of advanced thermal barrier coating and ceramic shrouds in gas turbine engines.

FY 2003: Field and rig test cost effective low emissions technologies with the goal of less than 7 ppm NOx for advanced gas turbines. Continue research and development on promising low emissions technologies and will develop perspective new technologies including fuel flexibility. Investigate long-term durability of developed low emission technologies. Continue R&D to demonstrate innovative high temperature materials such as coatings and ceramics in gas turbines to improve endurance levels and push beyond 8,000 hours. Continue testing of advanced ceramic components and add additional components to advanced turbine field tests. Based on field test results, will modify material systems to improve durability and life. Investigate additional components and materials to improve efficiency and emissions in gas turbine engines.

FY 2004: Continue field and rig test of cost effective low emissions technologies with the goal of less than 7 ppm NOx for advanced gas turbines. Will continue research and development on promising and new low emissions technologies with more stringent goal of less than 5 ppm NOx, including efforts to lower the manufacturing costs and increase the durability of gas turbines and other distributed generation technologies. New system attributes could include fuel flexibility and dual fuel capabilities. Research integration of low emissions technologies into

(dollars in thousands)

FY 2002	FY 2003	FY 2004

new and existing distributed generation technologies. Develop methods to measure, verify very low emissions levels and model the impact. Continue R&D and testing to demonstrate innovative high temperature materials such as prime reliant coatings and ceramics in gas turbines to improve endurance levels and push beyond 8,000 hours. Modify material systems to improve durability and life and decrease manufacturing costs. Investigate additional components and materials to improve efficiency and emissions. Research technology attributes compared to competing technologies to assess and quantify expected benefits and market acceptance.

▪ **Microturbines . . . . . .**	**11,000**	**7,000**	**7,000**

Microturbines are a new type of combustion turbine for use in distributed energy generation applications. About the size of a refrigerator, microturbines produce 25 to 500 kW of energy and can be located on sites with limited space for power production. Waste heat recovery can be used in combined cooling, heating, and power (CHP) systems to achieve energy efficiency levels greater than 80 percent. Microturbines offer many advantages over other technologies for small-scale power generation, including the ability to provide reliable backup power, provide power for remote locations, and peak shave. Other advantages include less maintenance and longer lifetimes because of a small number of moving parts, compact size, lighter weight, greater efficiency, lower emissions, and quicker starting. Microturbines also offer opportunities to use waste fuels such as landfill gas. The Microturbine subprogram will lead a national effort to design, develop, test, and demonstrate a new generation of microturbines for DER applications that are cleaner, more affordable, reliable, and efficient than products that are currently available.

FY 2002: Continued efforts on second generation of advanced microturbines to achieve electrical efficiencies of at least 40 percent, single digit emissions, fuel flexibility, and 10 percent reduction in costs. Fabricated and began testing of key critical components and subsystems such as recuperators, turbine, combustor, gas compressor, and control package to improve efficiency, reliability, and durability.

FY 2003: Continue efforts on second generation of advanced microturbines to achieve electrical efficiencies of at least 40 percent, single digit emissions, fuel flexibility, and 10 percent reduction in costs. Continue fabrication and testing of key critical components and subsystems such as recuperators, turbine, combustor, and power electronics to improve efficiency, reliability, and durability. Initiate subsystem integration tasks.

FY 2004: Begin to verify design and subsystems necessary to meet the advanced microturbine goals of at least 40 percent electrical, single digit emissions, fuel flexibility, and 10 percent reduction in costs. Research technology readiness and advancements with respect to current state of the art and end use applications. Continue design, fabrication and rig testing of subsystems such as recuperators, turbine, combustor, turbine hot section, generator, and power electronics to improve efficiency, reliability, and durability. Continue efforts to integrate subsystems into microturbine engine and initiate rig testing of modified engine packages.

	(dollars in thousands)		
	FY 2002	FY 2003	FY 2004
▪ **Reciprocating Engines**	**11,000**	**10,000**	**9,000**

Gas-fired reciprocating engines offer many advantages over other technologies for small-scale power generation. With their wide power range and operating flexibility, reciprocating engines can be used for many purposes—local power grid and substation support, peak-shaving, remote power, combined cooling, heating, and power (CHP) applications, high-density electric loads, standby power, and mechanical drive used for compressors and pumps—in industrial, commercial, institutional, and residential applications. The Advanced Reciprocating Engine Program will lead a national effort to design, develop, test, and demonstrate a new generation of gas-fired reciprocating engines for DER applications that are cleaner, more affordable, reliable, and efficient than products that are commercially available today.

FY 2002: Continued to support the development of the advanced reciprocating engines systems (ARES) program to develop a 50 percent efficient reciprocating engine with single digit emissions and 10 percent reduction in costs. Engine manufacturers begin development and testing of specific engine components and subcomponents. Pre-competitive R&D continued with National Laboratories. Continued partnership with National Energy Technology Laboratory on reciprocating engine University research program.

FY 2003: Continue to support the development of the advanced reciprocating engines systems (ARES) program to develop a 50 percent efficient reciprocating engine with single digit emissions and 10 percent reduction in costs. Engine manufacturers will continue development and testing of specific engine components and subcomponents. Pre-competitive R&D will also continue with National Laboratories. Continue partnership with National Energy Technology Laboratory on reciprocating engine University research program.

FY 2004: Continue to support the development of internal combustion reciprocating engines in the ARES program. With industry cost shared programs, develop engines with potential efficiencies of 50 percent, single digit emissions, and 10 percent reduction in cost. Engine manufacturers will continue design and analysis of advanced material for critical components. Begin fabrication and laboratory testing of critical components based on initial design and analysis. Continue search for advanced process techniques for incorporation in to new build gas engines. Continue development of critical components i.e., turbo-chargers, catalyst, advanced spark plugs, combustion techniques and emission controls for improved life, reliability and reduced cost. Continue University R&D program with industry partners and National Laboratories. Research engine technology opportunities and advances in state-of-the-art to evaluate the benefit of engine performance enhancements and impacts on market acceptance.

▪ **Technology Based - Advanced Materials and Sensors**	**6,997**	**8,256**	**8,256**

Advanced materials, such as ceramics and thermal barrier coatings, are some of the key enabling technologies for stationary industrial gas turbines and microturbines to improve the efficiency

and to meet strict emission standards by operating at higher temperatures. Engineered ceramics, such as ceramic matrix composites offer all of the advantages of ceramics—resistance to heat, corrosion, erosion, and chemical activity—while adding strength and thermal shock resistance that conventional ceramics do not demonstrate. Advanced microturbines will require improved high-temperature performance and reliability from their recuperators in order to achieve higher efficiency. Researchers are working with microturbine manufacturers and materials suppliers to develop metallic alloys with more oxidation/corrosion resistance and tensile/creep strength at higher temperatures must be developed.

FY 2002: Completed development, testing, and integrating of advanced materials with superior high temperature strength and fatigue, corrosion, and wear resistance for combustor liners and other applications in distributed generation systems. Developed and tested Continuous Fiber Ceramic Composites (CFCC) for applications such as combustor liners and shrouds in gas turbine applications. CFCC components completed field testing under commercial operating conditions for at least 4,000 hours.

Developed and tested advanced ceramics, coatings and high temperature metals for the next-generation microturbines. New materials for hot section components such as rotors and combustor liner and recuperators are under development. Material properties and durability in microturbine environments, including temperature, pressure and water vapor are determined. Testing of next generation candidate recuperator materials is initiated. SBIR/STTR funding in the amount of $1,259,000 was transferred from this subprogram to the Science Appropriation.

FY 2003: The technology base will continue to develop and test enabling technologies such as materials, information technologies, sensors and power electronics for distributed generation systems. Continue development and testing of advanced materials with superior high temperature strength and fatigue, corrosion, and wear resistance for hot section components and other applications in distributed generation systems.

Develop and test advanced ceramics, coatings and high temperature metals for the next-generation microturbines. New materials for hot section components such as rotors and combustor liner and recuperators will be developed. Material properties and durability in microturbine environments, including temperature, pressure and water vapor will be determined by laboratory experiments and high and medium velocity rigs. Next generation candidate recuperator materials will be evaluated in real microturbine environments.

FY 2004: The technology base will continue to develop and test enabling technologies such as materials, information technologies, sensors and power electronics for a wide variety of distributed generation systems. Will evaluate technology advancements to assess the cross-cutting impacts and benefits of the developments on distributed generation systems and end-use applications.

(dollars in thousands)

FY 2002	FY 2003	FY 2004

Will continue development and testing of advanced materials with superior high temperature strength and fatigue, corrosion, and wear resistance for hot section components and other applications in distributed generation systems. Will continue to develop, fabricate and test advanced ceramics, coatings and high temperature metals for the next-generation turbines. New materials for hot section components such as rotors and combustor liner and recuperators will be developed. Material properties and durability in microturbine environments, including temperature, pressure and water vapor will be assessed determined by laboratory experiments and rigs. Methods to improve material environmental resistance and fabrication technologies to produce cost effective high quality engine parts will be developed.

▪ **Fuel Flexibility . . . . . .**	**500**	**500**	**0**

The Fuel Flexibility Program develops ultra-low emissions combustion technologies that can be used in distributed generation and cooling, heating, and power (CHP) applications. The program develops technologies specifically for oil combustion in CHP chiller hybrid systems, where high preheated air is useful. R&D efforts focus on the dynamics of low NO_x flames, oil-fired cooling application development, NO_x reduction in conventional appliances, and improved burner performance and the viability of low-sulfur fuel and biofuels for cleaner feedstock.

FY 2002: Continued to improve the quality of oil combustion systems and fuel flexibility for distributed energy resource applications, including combined heat and power.

FY 2003: Continue to improve the quality of oil combustion systems and fuel flexibility for distributed energy resource applications, including combined heat and power. Test of an advanced oil combustion system in a modified microturbine.

FY 2004: No activity.

▪ **Thermally-Activated Technologies . . . . . .**	**4,660**	**4,660**	**4,660**

Thermally-Activated Technologies (TAT) use the viable heat energy from gas-fired systems and rejected/waste heat from industrial processes or electricity generation. TAT provide important keys for achieving the overall efficiency benefits of distributed energy technologies by converting natural gas, exhaust, or rejected heat into useful energy services like heating, cooling, humidity control, thermal storage, or bottoming cycles. TAT are the essential building blocks for CHP integrated systems, which are widely recognized as the next wave of energy-efficient power generation devices that will transform central power station electric power generation into discrete, economical, reliable, and secure distributed power generation. The program facilitates research, development, testing, and integration of advanced heating, cooling, dehumidification, and refrigeration equipment.

(dollars in thousands)

FY 2002	FY 2003	FY 2004

FY 2002: Fabricated several engineering prototype residential GAX (Generator/Absorber Heat Exchange) heat pumps for multiple unit field test. Continued laboratory testing of solid/vapor "high cool" complex compound 3-ton heat pump. Completed laboratory testing of prototype ammonia/water heat pump for light commercial application, and began fabrication of a field test unit. Continued test and evaluation of an Absorption Chiller at the Clark Country Office Building in Las Vegas, NV. Initiated concept design of an air-cooled absorption chiller for commercial application. Continued working with the gas industry and Georgia Tech Research Institute to commercialize desiccant technology for improved ventilation and indoor air quality. Continued R&D on advanced novel desiccant material for improved performance in humidity control, regeneration time and energy, and reduced cost. Completed fabrication and began testing and evaluation of an engineering model on Advanced Liquid Desiccant systems.

FY 2003: Begin field testing several GAX residential heat pumps. Complete laboratory testing of solid/vapor "high cool" complex compound 3-ton heat pump. Finalize design and begin fabrication of an engineering prototype unit. Begin field test of a prototype ammonia/water heat pump for light commercial application.

Continue design and begin fabrication of critical components for an air-cooled absorption chiller for commercial application. Continue working with the gas industry and Georgia Tech Research Institute to commercialize desiccant technology for improved ventilation and indoor air quality. Continue R&D on advanced novel desiccant material for improved performance in humidity control, cost, regeneration time and energy, and reduced cost. Continue testing and evaluation of an engineering model on Advanced Liquid Desiccant systems.

FY 2004: Efforts focus on developing gas-fired technologies and waste-heat utilization technologies in support of CHP package systems. Complete field testing of several 3-ton residential ammonia/water GAX absorption heat pumps. Complete laboratory testing of "Hi-cool" 3-ton residential heat pumps. Fabricate an 8-ton ammonia/water engineering prototype heat pump for light commercial applications and testing. Field test and evaluate advanced desiccant systems for improved humidity control and indoor air quality in buildings. Reduce cost and improve performance of advanced desiccant materials. Complete the development of a regenerator for separating water and liquid desiccants. Incorporate that design into LiCl liquid desiccant unit and laboratory test. Test feasibility of technology to remove anthrax spores, bio-aerosols, and other contaminants in indoor air. Continue development of sensors to assess efficacy of equipment for decontaminating indoor air. Explore integration of multiple heat sources to regenerate desiccants and develop hybrid systems for improved heat utilization. Complete a roadmap for thermal-based technologies to explore new concepts for thermal management such as thermo-electric technologies and heat/mass transfer that promise low-cost conversion of heat directly to electricity and evaluate potential impacts on markets and applications.

	(dollars in thousands)		
	FY 2002	FY 2003	FY 2004
End-Use Systems Integration and Interface	**15,950**	**19,338**	**19,338**
▪ **Distributed Energy Systems Applications Integration . . . .**	**4,950**	**7,338**	**7,338**

This activity facilitates acceptance of distributed energy resources (DER) in end-use sectors by forming partnerships with industry consortiums in the commercial building, merchant stores, light industrial, supermarkets, restaurants, hospitality, healthcare and high-tech industries. In high-tech industries such as telecommunications, commercial data processing and internet services, the use of electronic data and signal processing have become a cornerstone in the US economy. This industry represents a high potential for DER due to the ultra-high reliability and power quality requirements and related large cooling loads. Projects include development of decision and design tools and integration of DER technologies at customer sites to meet power and thermal needs and quantify value (such as energy and emissions benefits, installation and retrofit costs and high efficiency, reliability, etc.). Results from assessments are disseminated as information and education materials among the industries, utilities and States.

As these activities are proliferated, advanced communications and controls (C&C) technologies are needed to enable integration and interoperability functions of a broad range of distributed energy resources. These technologies offer a digitally controlled, "smart" electricity network with broadband communication capabilities. Through improvements in communication, information management, and controls, distributed energy technologies can be aggregated to operate in grid-connected or stand-alone modes

FY 2002: Continued supporting R&D solicited for direct support to utility/industrial teams and State partners in addressing power generation/cogeneration reliability issues, and mechanical drive applications. Performed comprehensive assessment of existing and new distributed generation installations at industrial and commercial sites to determine reliability/availability and benefits. These assessments included advanced hybrid technologies and options. Results from assessments were disseminated as information and education materials among potential consumers. Initiated projects to encourage widespread adoption and implementation of distributed energy resources, including combined cooling, heating and power in the data processing and telecommunications industries. These industries have special ultra-high reliability and power quality needs for which only distributed energy resources can supply. The program initiated partnerships with industry consortiums (grocery chains, fast food restaurants, retail stores) to identify promising application for distributed energy technologies.

As the penetration of distributed generation technologies increase throughout the electric system, communication and control functional requirements need to be developed to ensure that the distributed generation technologies can contribute to the grid adequacy and security by providing sufficient generation resources and can communicate in a coordinated manner. Advanced communications and controls need to be cost effective and reliable with "plug and play" capability, including flexibility to handle different types of distributed generation technologies

(dollars in thousands)

FY 2002	FY 2003	FY 2004

with seamless integration. The program initiated activities with industry on development of communications architecture and functional requirements.

FY 2003: Continue partnerships with industry consortiums (commercial buildings, merchant stores, light industrial) to identify promising applications for distributed energy technologies and systems, and will initiate validation projects to quantify the potential energy and emissions benefits. Beginning field testing of technologies (including combined heat and power systems) to validate anticipated benefits to data processing and telecommunications industries that have special ultra-high reliability and power quality needs that can only be met by implementing distributed energy resources. Continuing support of R&D to utility/industrial teams and State partners in addressing power generation/cogeneration reliability issues, and mechanical drive applications.

Supporting solicitations to address development of open, scalable communication and control systems required to aggregate and control the operation of large numbers of DER systems from different vendors while integrating with utility control and protection systems.

FY 2004: Will continue partnerships with industry consortiums (commercial building, merchant stores, light industrial, supermarkets, restaurants, hospitality, healthcare industries) to identify promising applications for distributed energy technologies to meet power and specialized thermal needs. Will initiate validation projects to: 1) quantify the energy and emissions benefits and installation and retrofit costs, and other benefits; 2) research potential integration issues and recommend improvements; 3) correlate data to analytical models and tools for end use customers. Will continue design of integrated distributed energy systems (including combined heat and power systems) and begin field testing of technologies to validate anticipated benefits to data processing and telecommunications industries that have special ultra-high reliability and power quality needs that can only be met by implementing distributed energy resources. Will continue development of methodology and analysis tools that will allow end-users to compare the true value of DER technologies with other traditional alternatives for high quality, reliability, and availability of power. Results from assessments will be disseminated as information and education materials among potential consumers. Will continue support of R&D to utility/industrial teams and State partners in addressing power generation/cogeneration reliability issues, and mechanical drive applications.

Will facilitate the establishment of a standardized system architecture with scalability and flexibility to integrate and optimize multi-participant DER systems to meet the dynamic nature of demand-side management.

▪ **Cooling, Heating and Power (CHP) Integration . . . . . .**	**11,000**	**12,000**	**12,000**

Cooling, Heating and Power reduces energy costs and emissions by using energy resources more efficiently. In conventional conversion of fuel to electricity, over two-thirds of the energy input

is discarded as heat to the environment and not used for productive purposes. CHP makes greater use of fuel inputs by utilizing the discarded heat with system efficiencies from 60 to 80 percent. The Industry CHP Program goal, which DOE is supporting, is to double the capacity of CHP in the United States to 92 GW by 2010 and develop and test CHP Packages for use integrated in overall building system design. Using the viable heat energy rejected from the making of electricity, high efficiencies can be achieved and package technologies can be integrated and optimized for end-use application. By using the viable rejected heat energy from the making of electricity, these packaged systems will achieve efficiencies of 75 percent or higher. The National CHP Roadmap will be used to guide the program's activities in the areas of raising awareness, eliminating barriers and developing technologies and markets. Research and development is focused on the integration of prime movers such as turbines, microturbines, and reciprocating engines with thermally activated technologies (chillers, dehumidification, etc) for plug and play integrated CHP systems. This work includes the development of necessary controls for seamless integration into buildings systems.

FY 2002: Supported the joint DOE-Industry goal of doubling the amount of CHP capacity in the U.S. by 2010. Conducted CHP technology assessments and provide the technical tools and expertise necessary for documenting how the successes of CHP systems can benefit the industrial, building, and district energy sectors. Results increase awareness and confidence in CHP technologies and demonstrated their benefits.

Packaged combined heat and power systems moved to Cooling, Heating and Power Integration. Awarded six contracts on packaged combined heat and power systems.

FY 2003: Support the industry goal of doubling the amount of CHP capacity in the U.S. by 2010. Continue to raise CHP awareness and assist in eliminating the barriers to CHP installations. Continue CHP technology assessments and provide the technical tools and expertise necessary for documenting how the successes of CHP systems can benefit the industrial, building, and district energy sectors. Building on successful assessment results, implement the most promising projects. These projects will increase awareness of and confidence in CHP technologies including their benefits in efficiency and emissions.

Continue contract support with industry funding (award) to design, and develop new integrated plug and play packages which combine power generation technologies such a gas turbines, microturbines and reciprocating engines with thermally activated technologies such as chillers and desiccant systems along with the necessary control technologies. Testing of prototype packages will begin under laboratory conditions before proceeding to commercial field test sites.

FY 2004: Will support the joint DOE-Industry goal of doubling the amount of CHP capacity in the U.S. by 2010. Activities will support the CHP Technology Roadmap, including raising CHP awareness, eliminating barriers, and developing technologies and markets. Activities will include projects that examine the benefits of CHP, develop analysis tools, develop case studies

(dollars in thousands)

FY 2002	FY 2003	FY 2004

and lessons learned that can benefit future CHP installations, collect relevant data on small CHP installations, and analyze emissions data and emissions credits for CHP and propose guidance for future standards. These projects will increase awareness of and confidence in CHP technologies including their benefits in efficiency and emissions.

Continue industry cost-shared design and development of Integrated Energy Systems in seven contract awards. Begin fabrication and testing of critical components, interface needs, controls heat exchangers and distribution systems. Investigate alternate applications and methods of heat recovery from reciprocating engines cooling-jacket water and flue gas. Systems will use advanced absorption chillers and desiccants in a variety of building applications for system efficiencies approaching 80 percent.

Technical/ Program Management Support	**530**	**530**	**530**

The addition of distributed energy resources as a power choice is a complex issue. This task forms the technical foundation that assists and guides the DER research activities to ensure relevance to the market. Markets, technology advances, and regulations are dynamic, and this task continually monitors available information and adjusts the program direction as necessary to be responsive.

FY 2002: Efforts included activities which are an integral part of the distributed generation technology development program. Representative activities included preparation of program, strategic plans, and operating plans, R&D feasibility studies and trade-off analysis, evaluation of the impact of new legislation on R&D programs, analysis of energy issues pertinent to the R&D program, identification of performance measures and methodologies (including GPRA), data collection to assess program and project performance, efficiency and impacts; and development of performance agreements with management.

FY 2003: Includes activities which are integral part of the distributed generation technology development program. Representative activities include preparation of program, strategic plans, and operating plans, R&D feasibility studies and trade-off analysis, evaluation of the impact of new legislation on R&D programs, analysis of energy issues pertinent to the R&D program, identification of performance measures and methodologies (including GPRA), data collection to assess program and project performance, efficiency and impacts, and development of performance agreements with management.

FY 2004: Includes activities which are integral part of the distributed generation technology development and end-use systems integration. Activities will include preparation of program strategic plans, multi-year plans, technology roadmaps, and operating plans, peer reviews and technical workshop/conferences specific to Distributed Energy Resources Technology Development and End-Use Systems Integration, technical data collection and methodology to support DER performance goals, DER technology assessments and market status.

	(dollars in thousands)		
	FY 2002	FY 2003	FY 2004
Total, Distributed Energy Resources	**55,137**	**54,784**	**51,784**

Explanation of Funding Changes

	FY 2004 vs. FY 2003 ($000)
Technology Development	
▪ Decrease support for Industrial Gas Turbines to encourage increased cost share for demonstration activities.	-1,500
▪ Decrease support for Reciprocating Engines to shift to higher cost share activities	-1,000
▪ Terminate support for Fuel Flexibility. Work is being transitioned to industry. .	-500
Total, Technology Development	-3,000
Total Funding Change, Distributed Energy Resources	**-3,000**