Geothermal

Mission Supporting Goals and Objectives

Program Mission

The mission of the Geothermal Energy Program is to work in partnership with U.S. industry to establish geothermal energy as an economically competitive contributor to the U.S. energy supply.

Program Goals and Objectives

The Geothermal Energy Program has established the following goals:

- Supply the electrical power or heat energy needs of 7 million homes and businesses in the United States by 2010.
- Reduce the levelized cost of generating geothermal power to 3-5 cents/kWh by 2007.
- Double the number of States with geothermal electric power facilities to eight by 2006.

Strategic Approach

Geothermal facilities use the natural heat in the earth's interior to produce electricity or to satisfy other heat energy needs. Currently, the installed commercial geothermal electric capacity in the United States is about 2,800 megawatts. Other, nonelectric uses of geothermal energy total 800 megawatts. The potential to produce sustainable, environmentally sound geothermal energy is much greater, especially in the western United States.

The Geothermal Energy Program directly supports three of the five goals of the DOE Comprehensive National Energy Strategy (CNES): (1) Geothermal electricity will contribute 6,000 MW to the overall goal for renewables of at least 25,000 MW by 2010, while helping to promote energy production and use in ways that respect health and environmental values. (2) Enhanced Geothermal Systems technology offers an attractive, long-term option for an energy resource that is extremely plentiful with few adverse effects. (3) the Program expects to accelerate the deployment of clean, safe, and efficient geothermal systems around the world. CNES supports the development of renewable technologies, such as geothermal energy, to increase domestic energy production in an environmentally-responsible manner.

The Program's R&D activities closely align with its mission and goals. With improved exploration methods, industry will locate and characterize new geothermal fields more accurately, reducing the high cost and risk of development. Better technology for drilling wells will make it possible to access deeper resources and reduce costs, thereby expanding the economic resource base. Advances in energy conversion will establish air-cooled binary technology as a means of generating competitively-priced electricity from more plentiful lower-temperature resources. Studies of reservoir behavior will improve

The Dixie Valley geothermal power plant in Dixie Valley, Nevada.

the management of geothermal fields, allowing fields to operate for over 100 years as sustainable commodities. These activities all contribute directly to reducing the cost of geothermal development and enabling the installation of more geothermal facilities.

Geothermal electric generation projects are capital-intensive enterprises, with the major expenses being incurred before the plant begins to produce revenue. The high-cost components of a geothermal development project include (1) drilling of exploration, production, and injection wells, and (2) plant equipment and construction. The primary risk in a geothermal project is confirmation of a viable reservoir, which usually requires extensive drilling and well testing. To reduce the risks and costs in geothermal development, the Program's research strategy involves:

- improving technologies for exploration, detection of fractures and permeable zones, well siting, and fluid injection;
- decreasing the cost of drilling and completing geothermal wells; and
- reducing the capital, operation, and maintenance costs of geothermal power plants.

The proposed activity level will maintain geothermal R&D at a level of effort that results in continuous technology advances that will produce substantial cost reductions. A new initiative, GeoPowering the West, will lend strong support toward achieving the Program's goals. The initiative will provide Federal leadership, public awareness and education, technology development, and policy support that will enable broad expansion in the use of geothermal resources throughout the western United States.

An Industry Cost-Shared Field Laboratory: The Dixie Valley Geothermal Field, Nevada

In 1988, Oxbow Power Services, Inc. began producing 65 MW of electricity from the Dixie Valley geothermal reservoir along the Stillwater fault in central Nevada. Dixie Valley is one of the many fault-bounded basins in the Basin and Range region that includes eastern California, all of Nevada, western Utah, and parts of Oregon and Arizona. Large numbers of geothermal prospects are located on the faults that separate basins from adjacent mountain ranges.

In 1995, Oxbow entered into cost-shared research with DOE to evaluate the Dixie Valley geothermal resource. The investigators determined that fractures in the reservoir must be aligned with the Stillwater fault in order to have the high rate of water flow needed for geothermal power production. In addition, DOE investigators examined the path and speed of the water injected into the reservoir from an injection well to a producing well. The injection must be at a great enough distance to allow the water to heat up and close enough to maintain pressure for production.

The Dixie Valley reservoir provided a natural laboratory for testing the flow of water using chemical tracers that are stable at high temperatures, detectable in minute concentrations, and compatible with the environment. This research project confirmed the usefulness of a number of new tracers and innovative analytical techniques for a wide variety of geothermal systems. Oxbow used the tracer information to inject water into wells that now provide better pressure maintenance and longer paths through the reservoir for heating to production temperatures.

The Dixie Valley geothermal resource is an ideal example of a fault-controlled geothermal system common throughout the Basin and Range region. The history of the geothermal system combined with the measurements of tracer flow and steam production provide information necessary to predict energy recovery and resource lifetime. DOE's partnership with industry at Dixie Valley has yielded very important information and technology improvements that will benefit all future users of geothermal energy.

The R&D program is based upon the Department's interaction with industry stakeholders and geothermal experts at universities and the national laboratories to create a balanced portfolio of core research and well-focused technology development thrusts. Cost-shared activities in geoscience, drilling, and energy systems research will leverage the R&D funds and facilitate technology transfer.

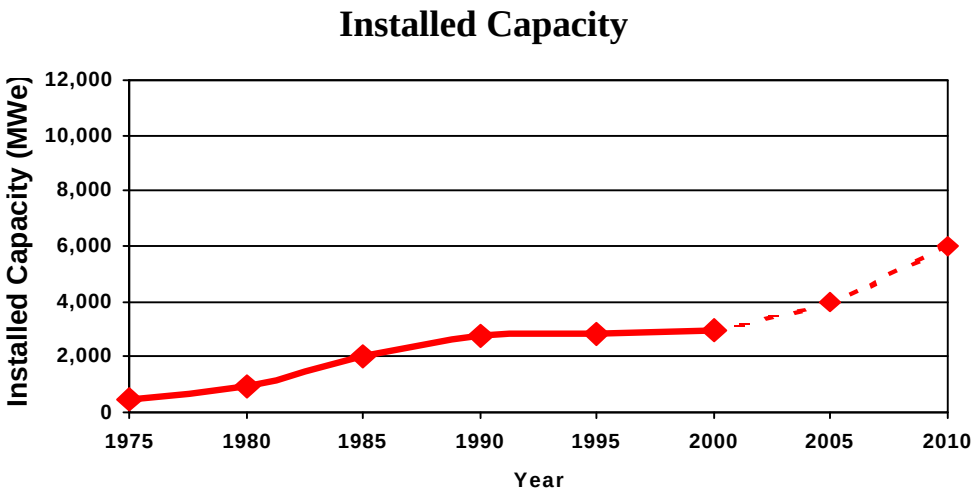
Program Benefits

Metric	FY 2005	FY 2010	FY 2020
Primary Energy Displaced (Quads)	0.02	0.09	0.31
Energy Savings ($ Billions)	0.05	0.24	0.70
Carbon Displaced (MMTCE)	0.45	1.73	5.54

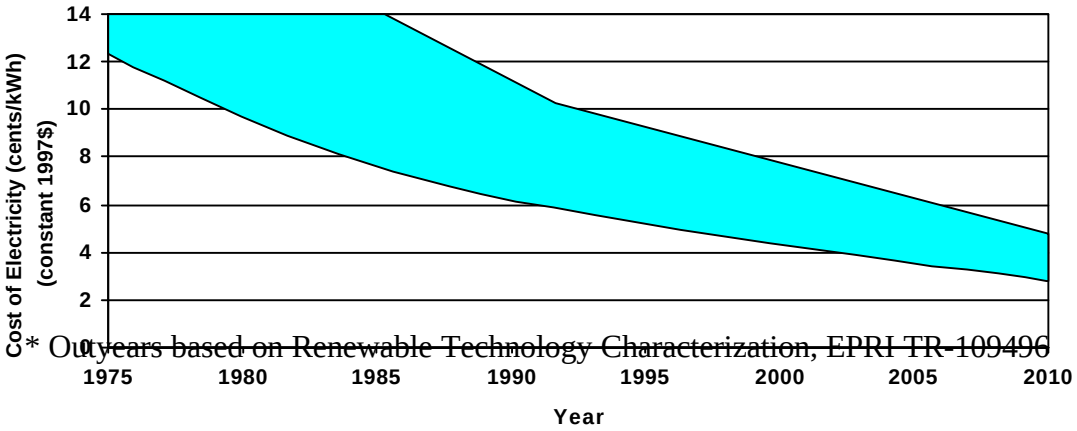
By the year 2010, geothermal energy will supply as much as 6,000 megawatts of electrical generating capacity. This power, in combination with geothermal heat used for non-electric applications, is sufficient to meet the needs of 7 million homes.

Performance Measures

The program performance measures are based on cost reductions to technology, which lead to significant additions to installed capacity in the western United States Installed Capacity (see chart). The research program is designed to improve the cost effectiveness of geothermal systems cost of Electricity (see chart) such that greater use may be made of the nation's extensive geothermal resources.



Reduction in Cost of Electricity*



* Outyears based on Renewable Technology Characterization, EPRI TR-109496

Data on installed capacity in the United States can be obtained from the Geothermal Energy Association and the Geothermal Resources Council. The cost of electricity can be measured by recent geothermal power plant contracts in the United States, and capital costs can be determined from bids on new construction. External factors influencing performance measures include domestic economic growth, interest rates (significant because of high up-front capital costs for power plants), cost of competing power (especially natural gas generation in the United States), and utility restructuring (e.g., Renewable Portfolio Standards and Green Power).

FY 2001 Performance Measures

- # Complete testing and evaluation with industry of methods for producing seismic energy for 3D seismic exploration of fractured geothermal reservoirs.
- # Flash and binary power plant capital costs decline below $1400/kW and $2000/kW respectively, a decrease of about 25% since the late 1980s.
- # Initiate two cost-shared projects under the International Clean Energy Initiative.
- # Domestic geothermal generating capacity exceeds 3,000 MW.

FY 2002 - 2006 Performance Measures

- # Complete field verification of small-scale power generation facilities.
- # Increase the annual direct-use energy growth rate from 4% to 10%.
- # Four additional States have geothermal power generation facilities.
- # Domestic geothermal generating capacity exceeds 4,000 MW.

Significant Accomplishments and Program Shifts

Pre-FY 1999 Accomplishments

- Demonstrated the use of slimhole drilling for geothermal exploration, thereby reducing exploration drilling costs by 30 to 50% relative to standard 1995 technology.
- Developed technologies that achieved up to 10% improvements (relative to 1990 levels) in efficiency of power plants operating with high non-condensible gas concentrations (at The Geysers, CA) and with reduced brine temperatures (at Mammoth, CA).

FY 1999 Accomplishments

- Transferred rolling float meter, which provides better control of the drilling process, to industry for commercialization.
- Completed conceptual design of an innovative air-cooled power cycle with reduced condensing temperatures.
- Completed straddle packer drilling tool resulting in three companies evaluating the tool for commercialization.
- Completed field test of insulated drill pipe with an industrial partner to provide much lower bottomhole fluid temperatures during drilling thereby saving up to $150,000 in a 10,000 foot geothermal well.

FY 2000 Planned Accomplishments

- Develop smart systems that integrate individual geophysical methods and provide a more reliable resource target.
- Field test a new, innovative electromagnetic exploration tool to locate subsurface fractures.
- Complete two designs of advanced air-cooled condensers for geothermal applications.
- Complete field tests of gas monitors that reduce plant operating and maintenance costs by over 5%.
- Complete initial fracturing R&D at Dixie Valley, NV, and begin large-scale fracturing effort to augment the Dixie Valley field.

FY 2001 Planned Accomplishments

- Complete field testing of improved PDC bits designed to double bit life and penetration rates thereby reducing well costs by about 5%.
- Complete development of high-temperature unshielded electronics and batteries for logging tools that will operate at temperatures exceeding 300°C.
- Identify opportunities for new cost-shared geothermal projects in six western states.
- Evaluate advanced flash and binary power plants to verify decline in capital costs.

FY 2002 - 2005 Planned Accomplishments

- Complete the high-speed diagnostics-while-drilling (DWD) system. This will greatly improve drilling operations while providing an additional reduction in well costs of more than 20%.
- Conduct initial testing and evaluation of the Geothermal Advanced Drilling System combining state-of-the-art components (e.g., DWD).
- Complete installation of an Enhanced Geothermal System at a geothermal field with an industrial partner.
- Complete field verification of small-scale, distributed power generation technology.

FY 2001 Program Shifts

- The new GeoPowering the West initiative will create opportunities for the installation of new geothermal facilities in the Western States.

Program Completion

The completion of the Geothermal Energy Program is linked to the overall Program goals. With the attainment of those goals, geothermal energy should be established as a widespread, economically competitive energy option. Program activities would be reduced and refocused exclusively on high-risk advanced research that benefits the nation's long-term energy security.

Funding Schedule

(dollars in thousands)

	FY 1999	FY 2000	FY 2001	$ Change	% Change
Geothermal Energy R&D					
Geoscience and Supporting Technologies	10,866	12,050	11,000	-1,050	-8.7%
Drilling Research	4,934	5,500	5,500	0	0.0%
Energy Systems Research and Testing	5,930	6,071	10,500	4,429	73.0%
Subtotal, Geothermal Energy R&D	21,730	23,621	27,000	3,379	14.3%
Geothermal Heat Pumps	6,420	0	0	0	0.0%
Total, Geothermal	28,150	23,621	27,000	3,379	14.3%

Detailed Program Justification

(dollars in thousands)

	FY 1999	FY 2000	FY 2001
Geoscience and Supporting Technologies			
# **Core Research** - Core research will be conducted in the areas of materials, geofluids, geochemistry, geophysics, rock properties, and reservoir modeling. The work ensures that the United States continues to lead the world in geothermal science and technology, while expanding the geothermal knowledge base. Core research provides the understanding of complex geothermal processes and facilitates development of suitable technology for exploiting geothermal resources. The requested funding maintains a productive level of effort with researchers at national laboratories and the U.S. geothermal industry.	2,992	3,900	3,000
# **Enhanced Geothermal Systems** - The cost-shared Enhanced Geothermal Systems (EGS) project will apply hydraulic injection and fracture mapping technologies to both new and operating geothermal fields in the United States. The project applies EGS technology (rock fracturing, water injection, and water circulation) to sweep heat from the unproductive areas of existing geothermal fields, or new fields lacking sufficient production capacity. Several cost-shared proposals will be competitively selected in FY 2000 to develop comprehensive EGS engineering designs. In FY 2001, the two or three most promising designs will be selected for further development and field verification. The requested funding level is consistent with budget needs to begin a field verification effort.	1,000	2,250	3,300
# **University Research** - Funding will enable researchers at universities to expand their geothermal knowledge base in the areas of heat flow and temperature gradient research, reservoir dynamics and two-phase flow, the stress and thermal history of fractures, active faulting areas, and the history of plutonic hydrothermal systems. This research complements core research conducted by national laboratories and industry.	2,790	2,750	2,500

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
# **Seismic Exploration** - Building on the design and testing of seismic source instruments to generate seismic energy, researchers in collaboration with industry will complete the development of 3D seismic exploration methods. The technology is used routinely in the oil and gas industry, but the generally poor seismic reflection properties of geothermal fields requires extensive adaptation for geothermal use. If successful, the technology will become the tool of choice for precisely locating geothermal fields. The requested funding level assures a continuity of effort by participating national laboratories and universities.	1,000	850	700
# **Detection and Mapping** - Mapping of geothermal fields and detection of open fractures and permeable zones are critically important to the overall productivity of a geothermal well field. Cost-shared exploration projects with industry are used to find and confirm new geothermal resources in the United States. In FY 2001 researchers will use tracers to determine the flow paths of injected water through a geothermal reservoir, analyze fractures with a borehole televiewer which takes pictures of the fractures in a well, analyze rock cores for correlation with seismic exploration interpretations, detect fractures with seismic shear-wave splitting, develop new software to interpret downhole electromagnetic data, and conduct geologic mapping of existing geothermal fields.	3,084	2,300	1,500
Total, Geoscience and Supporting Technologies	10,866	12,050	11,000
Drilling Research			
# **Innovative Subsystems** - When completed, the Geothermal Advanced Drilling System will provide dramatic improvements in the economics of drilling wells in deep, hard, and fractured hot rock. This system will consist of a number of improved and innovative subsystems. Subsystems currently under development include lost circulation control, hard-rock drill bits, high-temperature well sampling and monitoring instrumentation, and wireless data telemetry. Work on subsystem development is performed with careful attention to integration of			

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
components into a complete advanced drilling system. The funding level permits continuity of development during FY 2001.	3,110	3,000	2,500
# **Near-Term Technology Development** - Incremental improvements to existing technology will continue while development of the Geothermal Advanced Drilling System takes place. These drilling improvements, which involve cost-shared projects with industry, include a valve-changing assembly, downhole motor stator, foam cements, and a percussive mud hammer. Funding for these projects is consistent with equal levels of cost sharing from industrial partners.	1,624	1,200	1,000
# **Diagnostics While Drilling** - The principal subsystem component of the Geothermal Advanced Drilling System is a high-speed data link that can provide drilling data and information about rock characteristics to the surface in real time for better decision-making by drillers. The data link will be the focus of work in FY 2001. With the completion of a reliable data link, other components of the subsystem that rely on the flow of high-quality data, such as bit sensors, can be developed.	200	1,300	2,000
Total, Drilling Research	4,934	5,500	5,500

Energy Systems Research and Testing

# **Advanced Plant Systems** - Development of new technology for generating electricity from geothermal resources will continue. Areas of investigation will include air-cooled condensation of binary working fluids, control of heat exchanger fouling, and instrumentation for process monitoring. The requested funding level is based on anticipated laboratory in-house, consulting, and equipment costs for basic and applied research.	4,000	3,740	3,000

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
# **Small-Scale Field Verification** - Based on preliminary studies completed in FY 2000 and using prior year funds, several prototype systems will be constructed and field tested in FY 2001 to establish the performance characteristics of small-scale geothermal power plants and the economic benefits of improved electric power generation technology in geothermal applications. These projects will involve cost-shared, competitively selected contracts.	150	0	2,000
# **GeoPowering the West** - GeoPowering the West is a major new initiative that will foster awareness of the availability and benefits of geothermal energy throughout the western United States where geothermal resources are most readily accessible. The initiative will begin with education, awareness, and outreach activities aimed at a variety of stakeholders such as businesses, government organizations, Native American groups, and the general public.	0	0	2,000
# **International Clean Energy Initiative** - Exceptional opportunities exist for increased use of geothermal resources in overseas markets. Combined heat and power, hybrid systems, distributed power, and off-grid applications all present means for harnessing more geothermal energy. The Program will assist U.S. industry in identifying potential new markets in developing and transition countries. Program activities will focus on prefeasibility studies, resource assessments, technical assistance, and educational activities. This work supports the International Clean Energy Initiative recommended by the President's Committee of Advisors for Science and Technology. All funds will be competitively awarded. The requested funding level is appropriate for initiating 2-3 cost-shared industry partnerships for projects involving data collection, analysis, and possible field verification activities over a period of 3-5 years	0	0	2,000
# **Industry Support** - This activity will provide support to the U.S. geothermal industry in resolving near-term technical and institutional problems and enhancing technology transfer for both low and high temperature			

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
systems. Geothermal applications in a variety of situations, ranging from small-scale systems to traditional central stations, will be assessed for technical, economic, and institutional feasibility. The requested funding is based on past experience in the level of support needed to conduct activities that help the U.S. geothermal industry compete in domestic energy markets.	1,780	2,331	1,500
Total, Energy Systems Research and Testing	5,930	6,071	10,500
Total, Geothermal Energy R&D	21,730	23,621	27,000
Geothermal Heat Pumps			
# Program completed in FY 2000; no activities are planned.	6,420	0	0
Total, Geothermal	28,150	23,621	27,000

Explanation of Funding Changes from FY 2000 to FY 2001

	FY 2001 vs. FY 2000 ($000)
Geoscience and Supporting Technologies	
# **Core Research** - Decrease results from industry cost-share of field verification projects.	-900
# **Enhanced Geothermal Systems** - Funding increase to begin field verification of competitively selected engineering designs selected in FY 2000	1,050
# **University Research** - Decrease reflects completion of several multi-year projects	-250
# **Seismic Exploration** - Completion of software development phase for new electromagnetic exploration tool	-150
# **Detection and Mapping** - Decrease results from completion of cooperative studies at The Geysers	-800
Total Funding Change, Geoscience and Supporting Technologies	-1,050

	FY 2001 vs. FY 2000 ($000)
Drilling Research	
# **Innovative Subsystems** - Decrease stems from completions in drill bit development and lost circulation control	-500
# **Near-Term Technology Development** - Decrease reflects reduced emphasis on near-term technology	-200
# **Diagnostics While Drilling** - Increase results from greater priority given to high-speed data link	700
Total Funding Change, Drilling Research	0
Energy Systems Research and Testing	
# **Advanced Plant Systems** - Decrease reflects laboratory consolidation with reduced inhouse costs	-740
# **Small-Scale Field Verification** - Increase represents detailed design and construction of several small-scale power plants	2,000
# **GeoPowering the West** - Supports new initiative to increase the use of geothermal energy across 19 western states	2,000
# **International Clean Energy Initiative** - Increase supports competitively-selected, cost-shared projects	2,000
# **Industry Support** - Decrease in funding reflects reduced requests for support in resolving near-term issues	-831
Total Funding Change, Energy Systems Research and Testing	4,429
Total Funding Change, Geothermal	3,379

Hydrogen Research and Development

Mission Supporting Goals and Objectives

Program Mission

The mission of the Hydrogen Research and Development program is to enhance and support the development of cost competitive hydrogen production and storage technologies, and provide for integrated systems. Hydrogen can serve as an energy carrier that can reduce adverse environmental impacts, improve national security, and facilitate the penetration of renewable energy resources into the U.S. energy mix.

Program Goals and Objectives

Over the next five years, hydrogen is expected to make a significant penetration in several niche markets as concerns increase for energy security and global climate change. Reduction of U.S. vulnerability to oil disruptions and greenhouse gases are major emphases of the Hydrogen Program, consistent with the objectives of the DOE Comprehensive National Energy Strategy. Major initiatives in the Program to meet these objectives include: (1) the transitional use of natural gas as the feedstock for the production of hydrogen while renewable resource technology is under development; (2) the introduction of PEM fuel cells for cogeneration systems integrated with natural gas reformers; (3) the development of codes and standards to ensure the safest technologies are produced and ready for market penetration; and (4) the use of domestic resources to produce hydrogen as a future energy carrier.

Development of critical technologies to lower the cost of hydrogen production, storage and utilization is vital for the introduction of hydrogen into the energy infrastructure. The Program facilitates the introduction of these technologies in high priority areas -- such as renewable/hydrogen electric generation systems, refueling stations for hydrogen vehicles, and electricity for Native American villages and other remote locations. These crucial activities reduce dependency on expensive oil products, promote rural electrification, and economic development, and use grid-independent systems, while reducing NOx, SOx, and CO_2 emissions. The goals of the program are compatible with the following goals and objectives outlined in the DOE Comprehensive National Energy Strategy: (1) Goal I, Objective 1 — Significantly increase energy efficiency in the transportation, industrial and buildings sectors by 2010; (2) Goal II, Objective 1— Reduce the vulnerability of the U.S. economy to disruptions in oil supply; (3) Goal III, Objective 1, Strategy 3 —doubling non-hydroelectric renewable generation capacity to a total of at least 25,000 megawatts by the year 2010; and (4) Goal IV, Objective 2—Develop long-term energy technologies that increase energy options.

The Core Research and Development effort will:

- Achieve hydrogen production costs of $12.00 - $15.00 per million Btu for pressurized hydrogen from natural gas and biomass when systems are produced in quantity;

- Develop and validate safe, low-cost, hydrogen storage technology for on-board a vehicle to achieve a 350 mile range; and
- Develop a reversible fuel cell at <$600/kW when systems are produced in quantity.

The Technology Validation effort will:

- Install a wind/reversible fuel cell in a remote Arctic environment;
- Install distributed refueling stations that demonstrate co-production of hydrogen and electricity from natural gas. The hydrogen will be less than $1.20 per gallon equivalent and an electricity production cost less than $0.06 per kWh when systems are produced in quantity;
- Install a distributed network of liquid-fueled PEM fuel cell systems for remote and village power applications; and
- Deploy high-pressure (5,000 psi) hydrogen tanks >10% hydrogen by weight.

Strategic Approach

To achieve its mission, the hydrogen program has four strategies: (1) expand the use of hydrogen in the near-term by working with industry, including hydrogen producers, to improve efficiency, lower the emissions, and lower the cost of technologies that produce hydrogen from natural gas and to introduce renewable-based production options; (2) work with fuel cell manufacturers to develop hydrogen-based electricity storage and generation systems that will enhance the introduction and penetration of distributed, renewable-based utility systems; (3) coordinate with the Department of Defense and DOE's Office of Transportation Technologies to demonstrate safe and cost-effective fueling systems for hydrogen vehicles in urban non-attainment areas and to provide onboard hydrogen storage systems; and (4) work with the National Laboratories to lower the cost of technologies that produce hydrogen directly from sunlight and water.

The FY 2001 request continues to implement the program outlined in the Department's Hydrogen Multiyear Plan and recommended by the Hydrogen Technical Advisory Panel (HTAP) report, including increased collaboration with the Office of Fossil Energy (FE). The Program has already initiated two co-funded projects with FE, one to develop a reactor that separates oxygen from air while reforming natural gas to hydrogen for distributed production systems at refueling centers; and the second to produce hydrogen from low rank coals while simultaneously sequestering the carbon dioxide. The Hydrogen Program is pursuing other technologies, such as producing high-value carbon products in cooperation with FE's Vision 21 plan.

The market conversion to widespread hydrogen is a mid-term option which requires the development and introduction of a number of critical technologies. These include low-cost, high-density storage systems, low-cost PEM fuel cells, and small load-following reformers for distributed production systems. This technology has received a major boost due to three industry-led developments: the Daimler Chrysler, Ford and Ballard joint venture to produce fuel cell vehicles by 2004; the Plug Power joint venture to produce hundreds of natural gas reformer/ PEM fuel cell systems for home cogeneration; and General Public Utilities' joint venture with Ballard to produce 250 kWe PEM fuel cells by 2002. These activities are providing market pull to other manufacturers of hydrogen energy systems. Increased hydrogen

activity will open up markets for renewable technologies, such as wind and photovoltaics, by providing energy storage options.

Program Benefits

Metric	FY 2005	FY 2010	FY 2020
Primary Energy Displaced (Quads)	0.00	0.04	0.31
Energy Savings ($ Billions)	0.00	0.00	0.00
Carbon Displaced (MMTCE)	0.02	1.87	13.45

For hydrogen fuel cell vehicles, the estimated benefits are based on a calculated share of the mandated Zero Emission Vehicles (ZEV) market in California, New York, and Massachusetts as well as additional penetration into niche markets nationwide. In the three ZEV markets, for both 2010 and 2020, the hydrogen fuel cell cars compete against battery-based electric vehicles for the segment of the mandate market that can only be satisfied by "true" ZEV's (not with partial ZEV credits). In the national market, for 2020, hydrogen fuel cell vehicles are assumed to compete for the high valued Sport Utility Vehicle (SUV) market, where they compete against conventional fuels and advanced hybrid diesel technologies.

For residential applications, hydrogen fuel cell estimated benefits are based on the use of this technology as part of a distributed generation approach to power production and cogeneration. The analysis assumes that new housing developments will incorporate one 50 kW hydrogen fuel cell for every 10 houses in the development. Market introduction is in 2005, with steadily increasing market penetration in 2010 and 2020 as the cost of fuel cells decrease. Market penetration is limited by new housing starts for sale by the developer. Only half the potential market is considered for Office of Power Technologies' share.

Performance Measures

FY 2001 Performance Measures

- Produce 20 cubic meters per hour of hydrogen via steam reforming of biomass pyrolysis oil in a Process Development Unit.
- Operate experimental 400 cm^2 photoelectrochemical system for greater than 3000 hours.
- Develop and demonstrate Phase 4 advanced electrolysis system for refueling fuel cell vehicles.

FY 2002 - 2007 Performance Measures

- Validate advanced hydrogen reformers (2) that can reduce the cost of hydrogen production by 25 to 35% over conventional methods.
- Design a process development unit for a photoelectrical production process.
- Develop a compressed hydrogen storage tank with 7.5% by weight hydrogen.

Construct a pilot plant for fabrication of carbon nanostructures for 4 percent hydrogen by weight storage.

Develop and validate a $600/kW Proton Exchange Membrane reversible fuel cell when produced in quantity.

Develop and validate a $300/kW electrolyser when produced in quantity.

Significant Accomplishments and Program Shifts

FY 1999 Accomplishments

Initiated a resource assessment for the Montana Trade Port Authority for the construction of a solid waste hydrogen fuel cell manufacturing facility.

Issued a solicitation for the construction of a refueling station to be built in Nevada to service Las Vegas.

Operated a cryogenic gas tank for vehicle storage to support a 400 mile range configuration for 100 refilling cycles.

Completed scale-up of Sorbent Enhanced Reformer concept and performed economic analysis of the system for central generation of hydrogen.

Demonstrated a photochromic method for rapidly identifying algae that will produce hydrogen from water, without being inhibited by by-product hydrogen.

A fuel cell power system that uses diesel oil to produce hydrogen for a residential fuel cell was operated at the University of Alaska.

FY 2000 Planned Accomplishments

Demonstrate a new metal hydride complex (alanates) has been developed with a hydrogen capacity in excess of 5% by weight and energy storage efficiency greater than 74% in a system.

Successfully operate a reversible fuel cell with 60% round-trip efficiency in an Arctic environment.

Operate a quick-fill refueling station to be built in Nevada to service Las Vegas shuttle buses, and Nevada Test Site and Nellis Air Force Base vehicles.

Demonstrate a 3-fold increase in hydrogen production at 15 atmospheres using photosynthetic bacteria for the water gas shift reaction.

Demonstrate over 90% absorption of carbon dioxide in a dual bed sorbent enhanced reformer reactor used for hydrogen production.

Fabricate a lightweight tank to validate a new class of 4.5% hydrogen by weight magnesium-based metal hydrides at a dehydriding temperature of 150^{o} C.

FY 2001 Planned Accomplishments

- Field test a scaled-up, 50,000 standard cubic feet/day higher performance reformer to quantify emissions and efficiency.
- Scale-up one prototype PEM fuel cell concept and quantify the efficiency at different electrical loads.
- Successfully deploy and operate small liquid fueled reformer/PEM fuel cells in an arctic environment.
- Successfully operate a pilot plant for a biological water gas shift catalyst using reformed biomass for one year.

FY 2002 - 2005 Planned Accomplishments

- Successfully operate for three months the carbon dioxide free production of hydrogen using a plasmatron (electrical torch) at a scale of 30kWe.
- Demonstrate a 1kWe solid oxide fuel cell with integrated natural gas reformer for one year.
- Operate a single-stage 150 square meter photobiological reactor to produce hydrogen from water using oxygen tolerant mutants.
- Install advanced reformers for refueling stations for fleets of vehicles that demonstrate the ability to provide hydrogen at $1.00/gallon equivalent and electric power at $0.05/kWh for mass-produced systems.
- Demonstrate 8% efficiency for hydrogen production and greater than 3,000 hours operation in an outdoor photoelectrochemical system using amorphous silicon.

Program Completion

The program will be completed in FY 2030 after the following strategic objectives have been achieved:

- FY 2002 - Non-energy (capital and operating) cost of electricity from hydrogen-based storage systems will be lowered to $0.05/kWh. The cost of hydrogen delivered to a vehicle at pressure will be reduced to $12.00-$15.00/MMBtu when systems are produced in quantity.
- FY 2008 - Hydrogen use increases from 0.3Quad/yr (as a chemical feedstock to produce reformulated gasoline), to 0.4Quad/yr (as a transportation fuel and chemical feedstock).
- FY 2010 - Deployment of new hydrogen production technologies to convert natural gas for fuel cell applications will reduce emissions by: 13,700 tons per year NOx, 96,800 tons per year CO, and 5.4 million tons per year CO_2. Hydrogen-based systems will begin to displace fossil fuels in utility, building, and vehicle applications leading to 0.1Quad/yr .
- FY 2020 - Cost of renewable hydrogen produced at atmospheric pressure from sunlight and water not using electrolysis will be reduced to $9.00 - $15.00/MMBtu. Market penetration of new hydrogen technologies will reduce emissions by: 51,900 tons per year oxides of nitrogen, 390,500 tons per year carbon monoxide, and will displace 45.6 million tons of carbon dioxide.
- FY 2030 - Renewable energy based hydrogen production will contribute the equivalent of 1 Quad/yr in the primary energy market.

Funding Schedule

(dollars in thousands)

	FY 1999	FY 2000	FY 2001	$ Change	% Change
Core Research and Development	8,951	13,353	13,020	-333	-2.5%
Technology Validation	10,856	8,754	7,500	-1,254	-14.3%
Analysis and Outreach	2,169	2,480	2,480	0	0.0%
Total, Hydrogen Research and Development	21,976	24,587	23,000	-1,587	-6.5%

Detailed Program Justification

(dollars in thousands)

	FY 1999	FY 2000	FY 2001
Core Research and Development			
# **Thermal Processes -** Support will be provided for the operation of two process development units to demonstrate production of hydrogen, one using biomass and one using natural gas. Performance characteristics will be determined. Research will be supported for fabrication and operation of a 30kW integrated plasma reformer, development of a liquid fueled reformer, and completion of subsystem testing and evaluation of ion transport membrane reactor technology in a collaboration with the Office of Fossil Energy. The funding level was derived through past experience and evaluation by experts in a peer review of on-going efforts. This is linked to the goals and objectives outlined in the R&D Technology roadmap.	4,559	5,880	5,280
# **Photolytic Processes** - The goal of this program element is to achieve $10-15/million Btu hydrogen production costs from water. Research will be supported to genetically engineer marine algae to split sea water to hydrogen and oxygen, for fabrication of a modular photo electrochemical production cell, lifetime testing of high efficiency coated cells, developing higher efficient multijunction amorphous silicon semi-conductors, and the operation and design of a process development unit to biochemically react waste carbon monoxide to produce hydrogen at near 100% efficiency using an engineered strain of microbes.			

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
The Hydrogen Program in conjunction with the National Science Foundation, conducted a Peer Review of the renewable-based production technologies. This information provided the most important tool to determine if the funding levels requested were appropriate. Through analysis, the experts determined the funding level was appropriate to meet the goals outlined in the R&D Technology roadmap.	1,700	2,630	2,630
# **Storage** - Build a light-weight storage module that will hold 2 kilograms of hydrogen using an advanced metal hydride (alanate). Complete the evaluation of regenerating lithium hydroxide for a chemical hydride system. Scale up the capability for the continuous production of carbon based hydrogen storage materials, including nanotubes. Demonstrate this system at benchscale to store 4% by weight of hydrogen gas to total tank system weight.			
The funding level was determined through project reviews with program participants to provide on-board hydrogen storage systems for vehicles and for distributed generated systems to support the collaboration with the Office of Transportation Technologies.	1,692	3,090	3,090
# **Utilization** - Develop end-use technologies, sensors, and other processes that can effectively use the system advantages of converting chemical energy to electrical energy. The program co-funds and co-manages projects in collaboration with the DOE Office of Transportation Technologies' and the Office of Building Technologies' (OBT) Fuel Cell Programs. The following technologies are included: PEM fuel cell and reversible fuel cell technologies, internal combustion engines, hydrogen detectors and measurement sensors. Support will be provided for field testing of hydrogen leak detectors for one			

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
technology demonstration and several renewable hydrogen program prototype designs; for development of a 50kW scalable modular PEM fuel cell readily adaptable to inexpensive mass production; and for fabrication of several prototype designs for an air breathing PEM fuel cell for integration into a small stationary power system. Funding will support a collaboration with NASA to develop a comprehensive database on hydrogen combustion, efficiency and emissions for use in advanced power systems. The increased funding level is based on extensive experience with the development of PEM fuel cells and sensors to produce several research prototypes for environmental testing to meet key programmatic milestones.	1,000	1,753	2,020
Total Core Research and Development.	8,951	13,353	13,020
Technology Validation			
# **Renewable Energy Systems** - Install and validate two solar/electrolysis and one wind/reversible hydrogen generation and storage fuel cell systems and confirmation of the economic viability of these systems for remote and on-grid utility applications.	2,387	1,565	2,765
# **Remote Power** - Install and validate a distributed network of liquid fuel cell (PEM) systems for use in a remote village in an arctic environment. An overall efficiency of 80% including electricity generation and heating, and improved reliability due to networking multiple units will be demonstrated..	2,823	2,389	1,170
# **Hydrogen Infrastructure** - Validate technologies for hydrogen infrastructure for fueling of hydrogen vehicles. Complete safety tests on high pressure hydrogen storage tanks and cryogas tanks. Install these tanks on vehicle test beds for operational testing. The activity will include work initiated in FY 1999 for a natural gas based refueling station to be located in Nevada to service a fleet of vehicles with advanced hydride and cryo-pressure tanks installed. Demonstrate an advance electrolysis system for hydrogen production	2,675	4,800	3,565

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
# Fabricate high-pressure hydrogen storage tanks for vehicles. Completed the construction of one joint-venture renewable hydrogen venture.	2,971	0	0
The level of funding requested for technology validation activities was determined by analysis of individual component technologies to provide a hydrogen fueling station, on-board hydrogen storage for vehicle validation projects, three PEM fuel cell systems for distributed remote power projects, and a 100kW reversible fuel cell system for an arctic environment. In fiscal years 1999 and 2000, Congress appropriated funds for projects in Montana and Nevada. The increase for the renewable energy systems in FY 2001 was to provide the planned funding which was impacted due to the earmarks in FY 2000. All industry projects are cost shared on a 50/50 basis.			
Total, Technology Validation.	10,856	8,754	7,500

Analysis and Outreach

# Conduct economic analyses and technical assessments for technologies being developed and demonstrated, in addition support will be provided for similar studies on hydrogen systems involving technologies from production to end use, to provide insight into the applications most likely to be commercially viable and identify areas of further needs in R&D and technology validation including distributed electric generation and hydrogen production systems. Continue development of educational materials including an interactive CD ROM for middle and high school students, a curriculum and the environmental impact of fuels, and the production of an educational film on hydrogen use in energy applications. Develop comprehensive database on the operation of the Nevada and Alaskan validation projects to finalize the acceptance and initiate the implementation of codes and standards for the use of hydrogen in public buildings by local and State permitting officials.			
The funding level is appropriate as determined by the Secretary's Hydrogen Technical Advisory Panel and by the Program's Peer Review Team.	2,169	2,480	2,480

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
Total, Hydrogen Research and Development	21,976	24,587	23,000

Explanation of Funding Changes from FY 2000 to FY 2001

	FY 2001 vs. FY 2000 ($000)
Core Research and Development	
# **Thermal Processes** - Reduce funding for Phase III R&D of advanced natural gas reformers.	-600
# **Utilization** - Increase funding to produce several different sensor prototypes for environmental testing	267
Total Funding Change, Core Research and Development.	-333
Technology Validation	
# **Renewable Energy Systems -** Increase funding for Phase III awards and fully fund the wind/reversible hydrogen system.	1,200
# **Remote Power** - Decrease funding for stand-alone power generation systems using proton exchange membrane fuel cells to produce electricity and generate hydrogen to focus on higher program priorities associated with production and storage research and development activities.	-1,219
# **Hydrogen Infrastructure** - Less funding is required for the hydrogen fueling station and decreased funding for the completion of test beds for operational testing.	-1,235
Total Funding Change, Technology Validation	-1,254
Total Funding Change, Hydrogen Research and Development.	-1,587

Hydropower

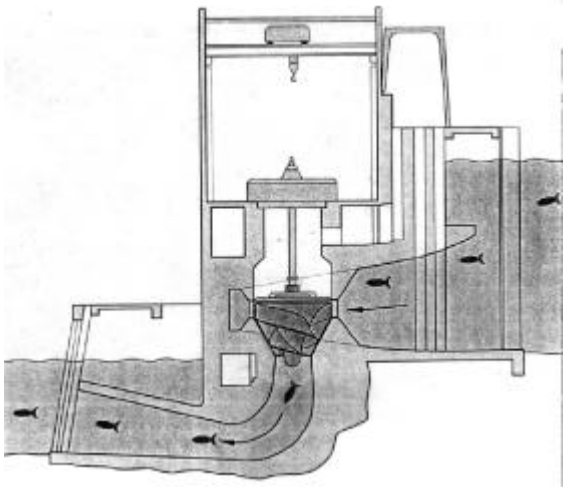
Mission Supporting Goals & Objectives

Program Mission

The mission of the U.S. Department of Energy's Hydropower Program is to improve the technical, societal, and environmental benefits of hydropower resources by conducting collaborative research and development with industry and other Federal agencies.

Program Goals and Objectives

Working with industry and other Federal agencies, the Hydropower Program's research and development activities will provide a biological and engineering basis for a new generation of hydropower turbines. Successful development will reduce turbine-induced fish mortality to 2% or less, compared to current levels ranging up to 30% or greater. This program addresses the goal stated in the Comprehensive National Energy Strategy (CNES) "to promote energy production and use in ways that respect health and environmental values - improving our health and local, regional and global environmental quality." To meet this goal, one of the strategies proposed in the CNES is to "maintain the viability of existing hydropower sources". Specifically, CNES states that "the development of advanced hydropower turbines to repower existing dams has the potential to avoid some of the environmental challenges posed by conventional hydropower plants and extend the life of existing hydropower plants to help preserve their contribution to U.S. energy production."



Advanced turbine design for proof-of-concept testing.

Strategic Approach

Hydropower currently generates about 10% of the nation's electricity. However, existing generation is in jeopardy, due to a combination of real and perceived environmental problems, regulatory complexity and pressures, and changes in energy economics. Current hydropower technology, while essentially emission-free, can have undesirable environmental effects such as fish injury and mortality from passage through turbines.

In FY 2001 the program will continue the proof-of-concept testing of an innovative design selected through a competitive bidding process. Biological performance will be determined and test results provided to industry. Experiments to establish biological performance criteria will continue, providing biologists and engineers with quantitative data on fish behavior and response in the turbine environment.

Support for cost-shared testing of competitively selected environmentally-friendly turbines will continue, and testing of larger turbines will be initiated in order to determine biological performance.

The DOE program is intended to develop hydropower technology with improved environmental performance, together with an increased understanding of biological effects. Much of the research presently carried out by Federal hydropower operators, as well as utilities, is site-specific, addresses specific environmental and equipment problems, and has limited general applicability. Moreover, with deregulation, utilities are beginning to reduce their research activities, and utility organizations which sponsor R&D are losing membership. They cannot maintain these activities at previous levels. Research funded by the few US manufacturers is aimed at minor improvements to the product line, is usually proprietary, and for that reason again lacks general applicability.

Program Benefits

Turbine technology available by 2010 to reduce fish mortality to 2% or less at existing projects, helping to maintain current avoided carbon emissions of 75,000,000 tons, developed capacity of 76,700 MW, and energy production of 325,265 million kWh.

Performance Measures

FY 2000 Performance Measures

- Continue proof-of-concept testing of advanced turbine conceptual design.

FY 2001-2010 Performance Measures

- Continue proof-of-concept testing of advanced turbine conceptual design in FY 2001.
- Proof-of-concept testing of advanced turbine conceptual design completed in FY 2002.
- Biological performance predictions verified and test results provided to industry**,** successfully demonstrating the capability of reducing turbine-induced fish mortality to 2% or less by 2010.

Significant Accomplishments and Program Shifts

Pre-FY 1999 Accomplishments

- Completed conceptual designs for advanced turbines.

FY 1999 Accomplishments

- Begin proof-of-concept testing of advanced turbine conceptual design to verify predicted biological performance.
- Begin design of instrumentation for real-time visualization and accurate simulation of fish passing through turbines.

FY 2000 Accomplishments

Complete laboratory biological studies of the effects of shear and pressure stresses on turbine-passed fish.

Issue RFP to provide cost-shared support for testing small environmentally-friendly turbines.

FY 2001 Planned Accomplishments

Issue RFP to provide cost-shared support for testing large environmentally-friendly turbines.

Complete laboratory biological studies of the effects of turbulence on turbine-passed fish.

FY 2002-2004 Planned Accomplishments

Complete proof-of-concept testing of conceptual turbine design.

Complete testing of fish passage visualization/simulation instrumentation.

Program Completion

Program completion is envisioned for the 2010 time frame assuming levels of funding sufficient to achieve the successful demonstration of biological performance of advanced hydropower technology.

Funding Schedule

(dollars in thousands)

	FY 1999	FY 2000	FY 2001	$ Change	% Change
Advanced Turbine Research and Development	3,210	4,921	5,000	79	1.6%
Total, Hydropower	3,210	4,921	5,000	79	1.6%

Detailed Program Justification

(dollars in thousands)

	FY 1999	FY 2000	FY 2001
Advanced Turbine Research & Development			
# Complete the pilot-scale laboratory proof-of-concept testing of the conceptual design to verify biological criteria and predicted biological performance using live fish.	722	2,600	0
# Biological experiments and instrumentation development to establish biologically-based performance criteria required for advanced turbine development.	2,488	1,900	1,500

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
# Support cost-shared testing and support of competitively selected environmentally-friendly turbine designs developed by industry for small free flowing or run-of-river sites in order to determine biological performance.	0	421	500
# Initiate cost-shared testing and support of competitively selected environmentally-friendly large turbine designs developed by industry for larger run-of-river or projects with impoundments in order to determine biological performance. .	0	0	3,000
Total, Hydropower	3,210	4,921	5,000

Explanation of Funding Changes from FY 2000 to FY 2001

	FY 2001 vs. FY 2000 ($000)
Advanced Turbine Research and Development	
# Decrease due to completion of proof-of-concept testing begun in FY 1999. Prior year funding is considered adequate and no additional funding is required in FY 2001.	-2,600
# The decrease will allow for continuation of biological experiments and continued development of turbine passage visualization/simulation instrumentation.	-400
# Increase due to continuation of cost-shared testing of small environmentally-friendly turbines	79
# Increase due to initiation of large turbine testing for larger run-of-river or projects with impoundments to determine biological performance.	3,000
Total Funding Change, Hydropower	79

Renewable Indian Energy Resources Program

Mission Supporting Goals and Objectives

The FY 1998 and FY 1999 Energy and Water Development Appropriations Report language for solar and Renewable Energy designated funding for supporting the construction of hydropower and related projects under the Renewable Indian Energy Resources. This program is being reconstructed in FY 2001 to more appropriately meet the needs of the Native American community.

Program Mission

Tribal Energy Program - The mission of the Tribal Energy Program will be to enable American Indian Tribal Governments and their entities to gain expertise in energy planning capabilities — particularly for remote settings — and in developing conventional and renewable energy resources. Included in developing energy resources would be a subprogram to increase the expertise of tribal members in energy system design and implementation. This activity promotes the Department of Energy's (DOE) commitment toward a new approach to working with Indian tribes, improving communication with the tribes, and improving the economic circumstances of tribal members. In addition, it reflects the Department's commitment to a government-to-government relationship underscored in the DOE American Indian Policy. Inadequate recognition and the insufficient energy services on Indian reservations are well documented even though many reservations have an abundance of fossil and renewable energy resources. Due to an unfortunate legacy of American history and longstanding depressed socioeconomic conditions, tribes have not had ready access to energy development, energy efficiency, and renewable energy assistance.

Program Goals and Objectives

The Tribal Energy Program goal will be to provide Tribal Governments the same supportive framework that is as effective as the programs that are now in place for states. It will serve as a focal point for a wide range of activities that promote a cleaner environment, provide economic development enhancement opportunities, and efficient utilization of Tribal energy resources consistent with cultural, tribal and environmental concerns. Working toward the objective that each tribe will have sufficient and reliable energy services necessary for their social and economic well being.

Strategic Approach

The Tribal Energy Program will be a centralized office coordinating energy-related activities for the tribes through a comprehensive program that will direct, coordinate and implement tribal energy efficiency policy direction for field operations and ensure that all operations are conducted in an effective and efficient manner. The program will also provide for the personnel and contractual services for all Federal management and administrative personnel to carry out the Tribal Energy Program mission.

Technical Assistance contributes to, but is different from capacity building. It ensures that installations are technically, economically, and environmentally sound, and it provides information and expertises that may not be available at the tribal level, such as, system or resource data. Potential installations and sites and their associated energy needs must be analyzed and the appropriate technology selected, systems specifications must be prepared, bids must be analyzed, installations must be done properly, acceptance testing must be performed, and systems must be properly maintained. Economic and financial analyses are also necessary, as is environmental impact review.

Implementation of Pilot Systems will be done to institutionalize a vertically integrated approach to energy within the tribes. As mentioned previously, hands-on experience is a necessary ingredient in capacity building. Pilot systems also serve to publicize, promote, and establish the credibility of energy technologies applied within a tribal framework.

Program Benefits

The Tribal Energy Program is supportive of the specific program mission and goals to strengthen and improve our government-to-government relationship with Tribal governments. And will ensure the broadest possible participation with other energy technology programs. The Tribal Energy Program will target Indian households that do not have power. For example, we know that approximately one-fifth of the residents on the Navajo reservation do not have power, and this recurs on a similar basis on many other Indian reservations across the country. Additionally, 34% of Indian reservation households rely on wood as heating fuel and suffer disproportionately from poorly insulated buildings. The obstacles are surmountable and the Tribal Energy Program offers good opportunities to help address them.

Performance Measures

- Replication of tribally installed energy systems is the ultimate measure of success. As successful pilot systems are implemented and internal capacity to implement tribal energy installations is established, tribal institutions will begin to implement programs on their own to manage their tribal energy needs.
- Monitoring the result of the program is necessary to evaluate its effectiveness, to learn from it, and to apply the lessons to future work.
- Cost sharing and leveraging of program resources to enhance the programs impact. Funds of 20 percent will match the Tribal Energy Program contributions of the pilot project.

Significant Accomplishments and Program Shifts

- This Tribal Energy Program is a reconstruction of the Renewable Indian Energy Resource Program authorized under Title XXVI of the Energy Policy Act of 1992, entitled “Indian Energy Resources”. Indian tribes were funded in FY 1994 and FY 1995 to assess the technical and economic feasibility of renewable energy on Indian lands. In FY 1996 through FY 2000, all of the congressional appropriated funds for this program were earmarked for Alaska. Thus, no general solicitation was

undertaken. The Tribal Energy Program will be implemented through program activities and competitive solicitations.

Funding Schedule

(dollars in thousands)

	FY 1999	FY 2000	FY 2001	$ Change	% Change
Renewable Indian Energy Resources	4,779	3,864	0	-3,864	-100.0%
Tribal Energy Program	0	0	5,000	5,000	>999%
Total, Renewable Indian Energy Resources Program	4,779	3,864	5,000	1,136	29.4%

Detailed Program Justification

(dollars in thousands)

	FY 1999	FY 2000	FY 2001
Renewable Indian Energy Resources Program			
# Eyak Native Corporation Power Creek Hydroelectric Project: Incremental funding was awarded on this 6-mw project, located near Cordova, AK; start-up estimated for September 2000.	1,243	1,642	0
# Old Harbor Hydroelectric Project: A grant was awarded for project construction of this 335-kW project on Kodiak Island, AK. Completion is estimated for December 2000.	383	290	0
# Upper Lynn Canal Regional Intertie: A grant was awarded for project construction of this 35-Kilovolt submarine cable.	123	0	0
# Scammon Bay Hydroelectric Feasibility Studies: A grant was awarded to conduct feasibility studies for hydropower development.	15	0	0
# Construction of Pyramid Creek Hydroelectric Project (600 kW, located on Unalaska Island, AK. Completion estimated for September 2001.	1,000	0	0
# Construction of Sitka Diesel Backup System. Completion estimated by September 2000.	1,000	966	0
# Competitively award Native American solicitation for off-grid and grid compatible projects on Native lands.	1,000	0	0
# Nome diesel upgrade.	0	966	0

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
# DOE monitoring and technical assistance.	15	0	0
Total, Renewable Indian Energy Resources.	4,779	3,864	0

Tribal Energy Program

# The program will facilitate partnerships with other Federal agencies, states and the private sector to ensure the broadest possible participation exploring leveraging strategies. This will integrate the various issues associated with energy, technology, environment, and economic development into a coherent set of activities.	0	0	750
# Develop and maintain Tribal Energy Information. Establish a database that will tabulate energy-related characteristics of the tribes, such as, energy resources, utility systems operations and costs and tribal energy issues, that will provide the basis for addressing energy solutions that can be shared and replicated with other tribes	0	0	250
# Perform energy audits for community buildings, such as, schools, tribal government facilities, and residential homes for conventional utility, energy efficiency, and renewable opportunities.	0	0	500
# Assist in the development of Tribal Integrated Resource Plans so that tribal investments in energy services will contribute to sufficient and reliable energy services necessary for their social and economic well being.	0	0	500
# Assess and promote electrification to remote tribal members and communities because of extensive and well-documented lack of utility infrastructure throughout tribal lands that have never had the benefit of rural electrification.	0	0	500
# Increase technology transfer through cost shared pilot projects for economic development opportunities for tribal members. Projects installed early within the program as part of formal training to build the capabilities of the tribal participants will generate enthusiasm for the Tribal Energy Program, and establish the credibility and benefits of the technology solutions in a tribal economic framework.	0	0	2,000

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
# Encourage implementation of energy conservation programs in Indian housing, schools, and Federal and tribal government buildings. Because these programs will not only improve the conditions of those buildings where they are implemented, but also have permanent impacts on the cost of operation	0	0	250
# Encourage fuel switching or resource conversion for efficiency and environmental reasons — the improper combustion of coal can contribute to respiratory health problems both locally and regionally.	0	0	250
Total, Tribal Energy Program.	0	0	5,000
Total, Renewable Indian Energy Resources Program.	4,779	3,864	5,000

Explanation of Funding Changes from FY 2000 to FY 2001

	FY 2001 vs. FY 2000 ($000)
Renewable Indian Resources Program	
# The decrease in funds is due to projects beings funded through the Solar Program Support Competitive Solicitation	-3,864
# **Tribal Energy Program** - A new program is being initiated to perform activities benefitting the Native American community to include plan development, pilot projects, and infrastructure development.	5,000
Total Funding Change, Renewable Indian Energy Resources Program	1,136

Electric Energy Systems and Storage

Mission Supporting Goals and Objective

Program Mission

Transmission Reliability - The Transmission Reliability line item consist of two programs: Power Systems Reliability and Distributed Power. The mission of the Power Systems Reliability Program is to develop technologies and policy options that will maintain and improve the reliability of the nation's electricity delivery system during the transition to competitive power markets. The mission of the Distributed Power Program is to address the technical, institutional and regulatory barriers to realizing the full potential benefits and value of distributed power.

High Temperature Superconducting R&D - The mission of the High Temperature Superconductivity R&D program is to perform research and develop superconducting power systems which will significantly improve the efficiency of electric generation, delivery and end-use and which will also provide higher capacity electric transmission and distribution systems.

Energy Storage Systems - Energy Storage Systems - The mission of the Energy Storage program is to perform research that develops advanced energy storage systems, which will (1) enhance the reliability and power quality of electricity delivered to consumers through transmission and distribution systems; (2) increase the use of distributed power systems; and (3) increase system value for certain types of renewable energy system by making them more dispatchable.

Program Goals and Objectives

Transmission Reliability - The goal of the Power System Reliability Program is to ensure an efficient, reliable power delivery system in the U.S. during the electricity industry transition to competitive markets, through development of advanced technologies that allow lowest-cost, efficient power delivery systems, and integration of distributed resources.

The objectives of the program are to ensure the reliability and security of the Nation's electric power system in the context of market economics, increase utilization of renewable energy sources, enable customer choice in power quality and self-generation options, provide the capability for information flow needed for the efficient operation of competitive markets, enable significant reduction of air emissions, and enable distributed utility options that integrate natural gas and electric power delivery benefits.

The program will ensure that research and development for reliable systems and competitive markets is maintained until new market and/or regulatory structures are developed that provide the incentives for the private sector to assume this work. To ensure that competitive markets are driving technology choices, any hardware development would be at least 50% cost-shared by the private sector, and Federal support for field validations would be limited to test and evaluation activities. The Program also provides a Federal electric power system technical capability to support government policy decision-making during this transition.

The goal of the Distributed Power Program is to achieve the market share of 30-40% of new capacity for distributed power by 2020 through the integration of distributed resources (generation, storage and targeted load management) into the power system, the development of new interconnection hardware and software and operational concepts, and the stimulation of new regulatory and institutional approaches that remove existing market barriers. With growing consumer demand for electricity, the increased use of distributed power can relieve stress on the Nation's transmission systems by generating power near its point of use by consumers. Facilitating the distributed power self-generation option will support competition by providing an alternative to bulk power markets which may be dominated by large generation companies.

High Temperature Superconducting R&D - This program is accomplishing two major technological goals: solving the difficult problem of manufacturing electrical wires from the family of brittle ceramic superconducting materials, while in parallel, creating designs of super efficient electrical systems such as motors, transmission cables, generators, transformers and current limiters that use these wires. The electrical wire goal is to produce a resistance-free alternative to conventional wires that also carries 100 times the amount of electricity. The systems goal is to design environmentally benign pre-commercial electrical equipment prototypes that have only half the energy losses and are half the size of conventional alternative of the same power rating.

Superconductivity will bring a more fundamental change to electric power technology than has occurred since electricity use became widespread over a century ago. The potential is for an energy revolution as profound as the impact fiber optics has had on communication. The fiber optic "information superhighway" was constructed by replacing copper wires with a higher capacity alternative. Superconductivity provides an "energy superhighway" that greatly improves efficiency and capacity. The economic (several billion dollars per year market by 2020) and energy impacts (offset potential of 40 medium size conventional generation plants in the U.S. alone) are predicted to be huge.

An environmental goal is to avoid the serious environmental problems associated with leakage and combustion of dielectric oil now needed for conventional transmission and distribution equipment such as transformers and cables. Superconducting versions are oil-free, using benign liquid nitrogen cooling. Another environmental goal is to provide a cost-competitive underground solution to conventional overhead electrical transmission and distribution lines that are intrusive and require large (100 - 150 foot) rights-of-way cleared of trees. Superconducting cables are underground and require only a single lane service road.

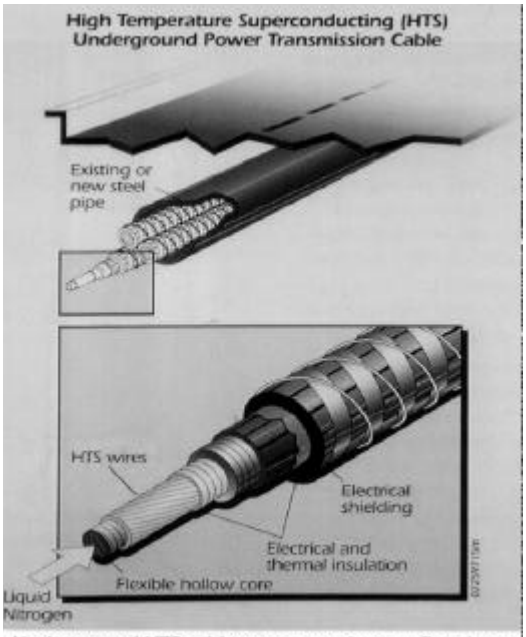
The High Temperature Superconducting R&D (HTS) program fits within Goal I of the Comprehensive National Energy Strategy by increasing the efficiency and economic performance of the national energy system while helping to protect the environment and enhance national security.

Introduction of HTS technology will affect the environment in two important ways. First, efficiency improvements will reduce the amount of electricity that would otherwise be needed and the associated pollution. Second, high capacity underground superconducting cables would become an attractive alternative to overhead transmission lines. This would reduce the visual effects of large transmission towers and power cables. It would also reduce the amount of land required by conventional overhead lines (only approximately 10% the area would be needed).

"**Power Line Makes Use of a Miracle of Physics**

After 87 years of alternating exuberance and disappointments, and a decade after a famous conclave of physicists at which the key to success seemed to be within reach, the world's first superconducting power line is about to become a reality."

NY Times - November 3, 1998 describing the DOE project to provide electricity to downtown Detroit using a superconducting cable.



Underground HTS cables can carry three to five times more current than conventional copper cables.

Energy Storage Systems - The Energy Storage Systems (ESS) program is working to achieve energy storage technologies with a cost of $700 per/kW and an energy density of 5 kWh per square foot by the year 2003.

The Energy Storage Systems program will develop integrated, cost-effective energy storage systems for the three thrust areas of reliability (including power quality), productivity, and renewables. These systems will offer multiple benefits to electricity providers and consumers over a wide array of applications, ranging from small scale remote installations to major industrial facilities. Among these benefits are reduced cost to the U.S. economy of power quality and reliability problems; enhanced utility and customer choices in responding to electric industry restructuring; and increased economic value of renewables and distributed resources.

Energy storage systems will improve the reliability and security of the Nation's electricity transmission and distribution system, helping to meet the objectives of ensuring energy system reliability, flexibility, and emergency response capability as outlined in the Comprehensive National Energy Strategy. Transmission and distribution system productivity and efficiency will be enhanced by storage systems that correct the brief power outages and distortions estimated to cost U.S. industry over $150 billion a year.

The Storage Program will focus on systems offering multiple benefits to utilities and consumers, including avoidance of peak demand charges, deferral of costly utility equipment upgrades, and reduced equipment failures from outages. The Program will also develop integrated distributed systems which will contribute in making some types of renewable energy generation more dispatchable.

Strategic Approach

The Secretary has established an Energy Grid Reliability Initiative. The electricity component of this initiative consists of Transmission Reliability (Power Systems Reliability program and the Distributed Power program) and the Energy Storage program. The transition to competitive, restructured electric markets coupled with growing consumer demand for electricity, and constraints in the Nation's transmission and distribution systems requires the development of an integrated set of advanced power delivery technologies to enable the reliable delivery of electric services for the consumer. Overcoming regulatory, technical, and institutional barriers to distributed power will provide more efficient use of the power delivery system by producing energy closer to its point of use. The development of lower cost, high performance power electronic controllers will enable advanced energy storage systems that provide improved power quality; fully integrate and reliably operate the power delivery system with the full spectrum of central and distributed power technologies; and enable real time control of the existing transmission and distribution system infrastructure to provide additional operational capacity, security, and reliability. The development of high temperature superconducting power equipment is addressed to significantly reduce losses in the generation, delivery and end-use of electricity and to relieve power delivery system constraints, particularly in urban areas, with very high capacity transmission and distribution cables. The Secretary's Power Outage Prevention Initiative is a related, near term effort that studies significant electric power outages and recommends appropriate federal actions to avoid the recurrence of similar system disturbances in the future.

Transmission Reliability - Transmission Reliability will be implemented through a National laboratory/electric industry/university partnership to conduct research on the reliability of the Nation's electricity infrastructure. This strategic partnering approach will ensure that research and development (R&D) is defined and initiated that meets electric industry needs, and can transition smoothly for further development or deployment by the industry. The Program will collaborate with industrial and academic partners to develop technologies that promote competitive markets, ensure system reliability (adequacy and security), increase network capacity for large scale, long distance power transfers, and promote integration of distributed resources, including microturbines, fuel cells, renewable energy generation and storage. The Program will also examine how market stimuli, and Federal and State regulation combined with the development and application of advanced technologies can be structured to assure incentives for private funding for reliability R&D, and additions of new technologies during and after the transition to competition. The near-term analytical and assessment activities in Power Systems Reliability program will provide important information and technology developments that support the Secretary's Power Outage Prevention Initiative in formulating recommended federal actions to avoid the recurrence of similar power outages and system disturbances in the future.

The Power System Reliability Program focuses on applying advanced computing, sensing, power electronics, communications, and control technologies to provide real time system control for reliable, efficient operation of the Nation's electric power system under both normal and emergency operating conditions. These fundamental technologies will be developed into advanced systems applications under the Power Systems Reliability and Distributed Power activities. Power Systems Reliability will pursue three activities - real time system control, integration of distributed technologies, and reliability and markets. Real time system control will develop control and information systems to monitor and control the power system in real time. Integration of distributed technologies will develop technologies and control strategies to facilitate large-scale adoption of distributed resources to enhance overall operation

of the electric system. The reliability and markets activity will support interdisciplinary research to develop options that balance market economic mechanisms with utility operating practices. The Power System Reliability Program will be reassessed each year to determine the level of federal involvement depending on the nature and implementation needs of new regulations, and the impact of market forces.

The Distributed Power Program supports the development of technologies and the removal of barriers to enable the integration of distributed generation (e.g., photovoltaics, wind, fuel cells, microturbines), storage and direct load control into the electric system. Since many of these distributed generation units will use natural gas, related issues concerning integration with the natural gas system will be addressed. To accomplish this the Distributed Power Program, through a collaboration of the national laboratories and the Program's industry partners, pursues activities in three areas: 1) Strategic Research which includes the development of new operational concepts for optimal integration and utilization of distributed generation and storage and controllable load; and research on advanced hardware and software for interfacing distributed resources with a power system. 2) System Integration which addresses safety, reliability, power quality, interconnection and environmental issues related to the integration of distributed generation and storage into a power system; and the exploration of issues related to distributed power impact on integration of the natural gas and electric delivery systems. 3) Mitigation of Regulatory and Institutional Issues by working with industry and state and local government organizations to eliminate unnecessary barriers to distributed power created by current policies, regulations, and business practices.

The National Renewable Energy Laboratory is leading the effort to integrate distributed generation and storage with the power system and the development by industry, through the Institute of Electrical and Electronics Engineers, of a national interconnection standard. The Nevada Test Site has the potential to become a key facility in validating the integration of distributed generation and storage with the power system and in the collection of operational test data which are essential for understanding the interactions of distributed resources with power systems. These data will also support the development and verification of models and simulation tools to analyze safety, power quality, reliability and operational issues.

High Temperature Superconducting R&D - To accomplish its mission, the High Temperature Superconducting (HTS) program has mobilized the resources of U.S. industry, national laboratories and universities in a high-risk, parallel development approach: research on the underlying technology, superconducting wires, is being done at the same time applications systems are being designed.

This approach will effectively reduce the time to introduction of full-scale systems by a decade or more. A strategic alignment is followed in the program structure, with two industry-led initiative elements and a government lead research element.

The very successful Superconductivity Partnership Initiative (SPI) element supports aggressive industry-lead projects to design advanced electrical applications. SPI projects include generators, transformers, motors, transmission cables, current controllers, flywheel energy systems and magnetic separation systems. A unique SPI feature is that each project involves vertically integrated teams (typically including an electric utility, a system manufacturer and a superconducting wire supplier as well as one or more national laboratories). This vertical integration has proven a powerful way to include customer focus and leverage resources.

The industry-led Second Generation Wire Initiative is exploiting breakthroughs at Los Alamos and Oak Ridge National laboratories that promise unprecedented current-carrying capacity in high-temperature superconducting wires. These breakthroughs, which made headlines worldwide, will allow long wire lengths to behave as a single crystal, thus eliminating internal barriers to current flow that may limit the use of wires now being manufactured. Several industry teams are now working with the national laboratories to scale up the new discoveries.

The Strategic Research program element provides the underlying knowledge base needed for the success of the above industry-led projects. The Second Generation Wire Initiative evolved from five years of strategic research that achieved world record performance breakthroughs in short wire samples. Strategic Research will continue on wire processing as well as exploratory research on innovative systems. In addition, research and analysis will be conducted on issues associated with integration of superconducting systems into an increasingly competitive and restructured industry framework. A key issue is the development of cryogenic systems that are robust, efficient and low cost.

Energy Storage Systems - The ESS program works with a diverse group of partners to develop effective storage systems, explore advanced components and devices, and support research on appropriate electronic controls. The Program cooperates extensively with electricity users and providers, equipment manufacturers, system integrators, academic and research organizations. This cooperation helps identify emerging trends, and supports development of energy storage systems that will play a vital role in a restructured electricity marketplace. Collaboration with industry partners also allows the ESS Program to leverage resources through substantial cost-shared agreements.

Program thrusts will be to evaluate power quality on a regional transmission grid, design storage-based power quality systems to enhance reliability of the power grid, advance the technology of advanced battery systems, develop factory-integrated PV/storage systems, and investigate power electronics critical for integration of storage into the grid.

Program Benefits

Transmission Reliability

Metric	FY 2005	FY 2010	FY 2020
Primary Energy Displaced (Quads)	0.06	0.16	0.34
Energy Cost Savings ($ Billions)	0.30	0.65	1.43
Carbon Displaced (MMTCE)	1.07	2.78	5.50

Using real time control and information systems along with fast, power electronic switching, power systems will quickly evolve that require less conventional power transmission equipment and less reserve generation capacity, while maintaining overall reliability. These systems will allow energy savings and air emissions reductions from less run-time of standby fossil-fired generation, capital savings through greater utilization of existing system facilities, and system benefits through the integration of distributed resources.

The Distributed Power Program will expand markets for distributed power from the present annual market of 10% of new capacity to a market share of 30-40% of new capacity by 2020 by supporting the accelerated development of a national interconnection standard, by stimulating the creation of new and

advanced interface hardware and software to enable automated control of distributed generation and storage, and by removing barriers to the emergence of new markets for distributed power including customer to customer power sales and transfers. The resulting increased reliability of electricity supply will add $1.4 billion to the economy annually which would otherwise be lost because of power outages.

High Temperature Superconducting R&D

Metric	FY 2005	FY 2010	FY 2020
Primary Energy Displaced (Quads)	0.01	0.09	0.34
Energy Cost Savings ($ Billions)	0.01	0.21	0.78
Carbon Displaced (MMTCE)	0.10	1.58	6.20
Direct Electricity Displaced (Billion kWh)	0.00	8.50	35.0
Direct Coal Displaced (Million Short Tons)	0.00	22.68	95.4

Other major benefits are expected in electricity grid capacity and reliability as superconducting technologies are introduced. These benefits may be necessary to meet expected new patterns (and large increases) of electricity flow from producers to consumers as markets are deregulated.

Conservative estimates of gradual technology penetration show that within 20 years over 3 million households could be supplied by the gains in efficiency due to superconductivity. Efficiency gains possible with an all HTS system represent the electrical needs of 23 million households.

Energy Storage Systems

FY 2001 Program Metrics

Metric	FY 2005	FY 2010	FY 2020
Primary Energy Displaced (Quads)	0.00	0.00	0.00
Non-Energy Cost Savings ($ Billions)	0.00	1.80	3.82
Energy Cost Savings ($ Billions)	0.87	0.00	0.01
Carbon Displaced (MMTCE)	0.01	0.02	0.07

Federal involvement through the ESS Program is critical to the long-range development of conventional and emerging storage technologies. These storage technologies are key to increasing the value of DOE's renewable energy programs for both grid-connected and remotely-sited systems. Energy storage systems integrated with distributed resources in electric supply systems, provide customers with more flexible and cost effective energy options.

Carbon Reduction results from enhanced integration of renewable energy resources into the electricity market, and peak load reduction. Improved productivity and electric power reliability resulting from improved power quality account for the Non-Energy Cost Savings. These productivity gains also translate into carbon savings.

Performance Measures

FY 2001 Performance Measures

Transmission Reliability

Power Systems Reliability

Complete prototype of real time reactive power data monitoring and analysis system.

Complete simulation tools that recognize impending system disturbances.

Complete prototype data monitoring and analysis system to facilitate ancillary services markets.

Distributed Power

Complete draft of the national interconnection standard for distributed power for balloting process.

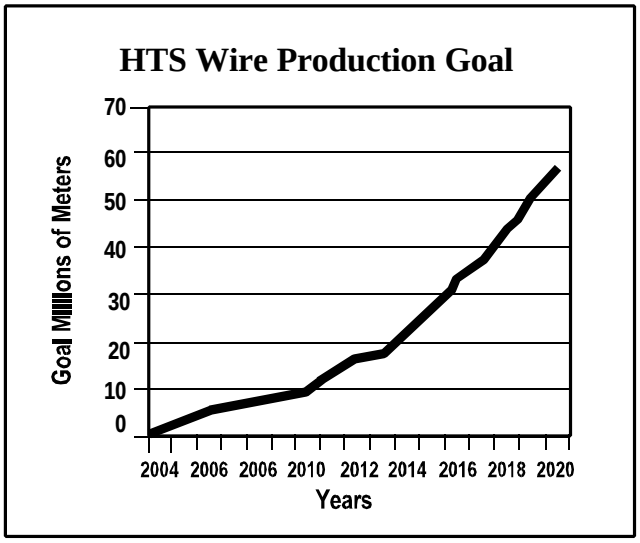
High Temperature Superconducting R&D

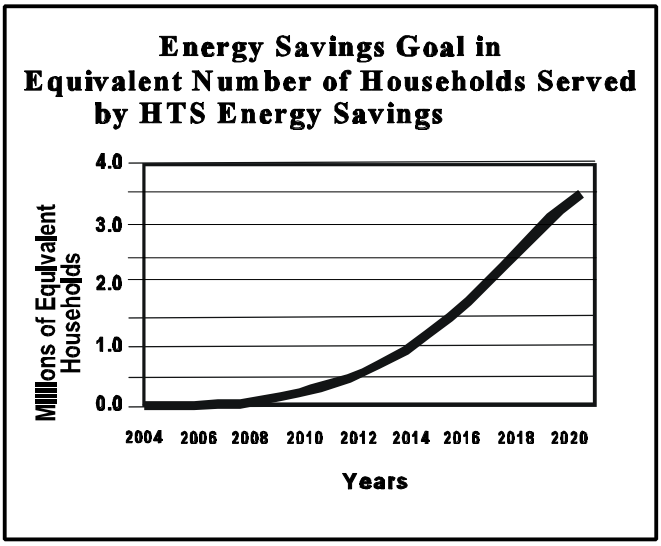
Develop an alternative to conventional wires that has 100 times the capacity and eliminates energy losses due to electrical resistance losses by 2004.

Develop first-of-a-kind devices that are typically half the size and eliminate half the efficiency losses when compared with conventional alternatives of the same power rating. By 2002 complete initial designs of motors, transformers, power cables, fault current limiters, magnetic separation systems and flywheel electricity systems.

Continuously improve research and development quality and reputation for excellence as measured by annual independent peer review and by award recognition by outside organizations not associated with the program.

The program's wire production goal and energy savings goal from 2004 through 2020 are illustrated in the graphs below.





- Develop the second generation wire in continuous, long lengths which carry 1500 amperes per square millimeter in current density.
- Operate the 5000 horsepower motor at rated power and satisfy requirements for future commercialization.
- Test the superconducting power transformer which must carry its rated capacity of 10,000 kW with no energy losses due to electrical resistance and cryogenic refrigeration penalties within a reasonable range set forth for this research project.
- Complete the design, fabrication installation and testing of the underground high temperature superconducting cable at the Detroit Edison substation.

Energy Storage Systems

- Complete proof of concept testing at second utility/consumer site for mobile power quality 2MW/15 second system.
- Finish one year of field testing of 400 kWh Advanced Battery Energy Storage System at utility site.

FY 2002 - 2007 Performance Measures

Transmission Reliability

Power System Reliability

- Recommend policy options on market incentives that promote reliable electric systems.
- Develop computer software system that will detect signatures of impending disturbances and initiate mitigating actions.
- Test intelligent distributed control system to provide control and information for distributed power management.

Distributed Power

- Complete national interconnection standard for distributed power.
- Establish certification process for distributed generation and storage.
- Conduct distributed power integration test and verification project at Nevada Test Site.
- Complete development and testing of prototype universal interface device for distributed power.

High Temperature Superconducting R&D

- Groundbreaking electrical power systems are developed which use second generation wire.
- The first-of-a-kind systems installed during this period show significant improvements over conventional systems in terms of efficiency, capacity and reliability.

Energy Storage Systems

- Complete development of an approximately 100 kW integrated, distributed renewable/hybrid energy system, including storage.
- Complete development of an approximately 5 MW transmission power quality energy storage system.
- Complete development and testing of a 400 kWh Advanced Battery Energy Storage System at a utility site.
- Initiate development of a full scale advanced energy storage technology integrated with a complete system for distributed energy system applications.

Significant Accomplishments and Program Shifts

Pre-FY 1999 Accomplishments

Transmission Reliability

Power System Reliability

- No program established.

Distributed Power

- No program established.

High Temperature Superconducting R&D

- Program participants have set most of the world's technological milestones in the last several years, including those for motors (200 horsepower motor tested), cables (50 meter, 3,000 ampere cable), and transformers (1 MVA unit tested). Six R&D 100 awards were won, as well as the DOE award for Solid State Physics and the Lockheed Martin Corporation's NOVA award for teamwork and the 1998 Small Business Innovative Research (SBIR) "Technology of the Year" Award.

Energy Storage Systems

- In FY 1997, a 1.4 MWh energy storage system was installed on the Annette Island Reserve in southeast Alaska, home to the 1,700-member Metlakatla Indian tribe. The system, built with technical assistance from the ESS Program and charged by hydropower, eliminates continual use of a 3.3 MW diesel engine. In the first eight months of operation, fuel use was reduced by 180,000 gallons, resulting in a cost savings of over $39,000 a month.
- A 3.5 MWh battery energy storage system was installed at a lead battery recycling plant in Vernon, CA. The system supports critical plant loads during power disturbances and outages to prevent violations of lead emissions standards. The system has provided peak shaving and uninterrupted power since 1996.
- The first commercial PQ 2000 energy storage system was installed at an industry site in Homerville, GA. The 1 MW, 10-second, factory-assembled system corrected over 90% of the plant's power quality disruptions during the first six months of operation. In 1997, DOE, AC Battery and other industry partners, received the prestigious R&D 100 award for the PQ 2000 energy storage system.

A Mobile PQ2000 2 MW/15 second power quality system was designed, built, and field tested at sites on the Virginia Power grid.

Climate Challenge

Establishment of Climate Challenge program in which over 70 percent of the electric utility industry participants, with 124 individual agreements totaling 48 million metric tons of carbon equivalent of pledged greenhouse gas reductions. Climate Challenge is now the world's largest voluntary greenhouse gas reduction program.

Serving as a catalyst for electric power industry involvement in many of the voluntary climate programs such as EPA's Green Lights, Energy Star Transformer, Landfill Methane, and SF6, and DOE's Motor Challenge, Rebuild America, and partnerships with the Federal Energy Management Program.

FY 1999 Accomplishments

Transmission Reliability

Power System Reliability

Completed workshop and six draft studies to identify and define needs for reliability research in a restructured U.S. electricity industry.

Distributed Power

Held a workshop with stakeholders to identify priority technical, regulatory and institutional issues for distributed power.

Worked with industry to initiate fast-track development through the Institute of Electrical and Electronics Engineers of a national interconnection standard for distributed power

High Temperature Superconducting R&D

A 15 kV "fault current limiter was successfully tested by a major electric utility. This type of device offers important new protection against lightening strikes and other accidents that would otherwise damage equipment and cause electrical outages.

Two new awards were made for industrial teams to scale up "second generation" superconducting wires following a free and open competition. Progress continues to be made in improving the performance in short sample lengths (10 cm or less) and five private companies have licensed technology invented at Oak Ridge and Los Alamos for this new processing approach that promises to meet program wire performance and cost objectives.

Laboratory tests were successfully completed for a 30 meter, 3 phase superconducting cable system able to supply power to a manufacturing facility. A small town (population 15,000) could have their electrical needs met with this size cable.

Energy Storage Systems

- Completed final design and applications specifications for 400 kWh Advanced Battery Energy Storage System to be tested at Detroit Edison site in FY 2000.
- Successfully moved Mobile PQ2000 2 MW/15 second power quality system over 800 miles from a utility site to a customer application.
- Completed comprehensive assessment of advanced energy storage technologies (flywheels and SMES) and developed research recommendations.

Climate Challenge

- Compile and report utility industry accomplishments with voluntary action.
- Support and participate in on-going negotiations with the electric power industry to design a voluntary emission reduction program for the post-2000 period.

FY 2000 Planned Accomplishments

Transmission Reliability

Power System Reliability

- Complete models to simulate ancillary services market designs.
- Complete testing of real time system that collects and processes data to perform reactive power analysis on the Western grid.
- Complete the six white paper reports on reliability research requirements.

Distributed Power

- Document interconnection barriers to distributed power.
- Initiate 5-10 cost-shared distributed power system integration R&D projects under a competitive solicitation (with funds appropriated under Solar Program Support for distributed power system integration R&D).
- Conduct two regional workshops for state public utility commissioners on regulatory impacts on distributed power.

High Temperature Superconducting R&D

- Installation and testing were successfully completed of a 3 phase, 20 MVA, superconducting cable that supplies electrical service to two factories of the Southwire Co. in the state of Georgia.
- Initial installation completed of a groundbreaking superconducting cable in downtown Detroit to support the revitalization of the older urban area in a non-intrusive, environmentally friendly way. The cable doubles the power, yet weighs only 250 pounds compared to the 18,000 pounds of copper in the cable it replaces. The equivalent of 30,000 households will be served. Such high capacity cables may be the key to relieving bottlenecks on transmission systems, and enhancing service in constrained urban “load pockets” such as in Detroit.

- A first-of-its kind 1000 horsepower motor will be tested. Large motors (above 500 horsepower) consume approximately 25% of all electricity generated, so the efficiency increase possible with superconducting motors is important.
- Technology of "second generation" HTS wires will have advanced to 100 meter lengths being manufactured that are capable of carrying 100 amperes through a millimeter wire cross-section (over 100 times the capacity of conventional wires).

Energy Storage Systems

- Begin testing phase of an approximately 100 kW advanced battery installed in a Renewable Generation and Storage System at a community facility.
- Initiate Transmission Power Quality Study to measure the level of power quality on a large transmission system in cooperation with relevant DOE programs, EPRI and several utility partners.

FY 2001 Planned Accomplishments

Transmission Reliability

Power System Reliability

- Complete system design and simulation for autonomous distributed control of regional power systems.
- Complete system that monitors and processes data for real time analysis of reactive power on a multi-regional system.
- Complete prototype tools to assist in facilitating ancillary services markets.
- Demonstrate capability of the use of post disturbance outage data to detect future impending disturbances.

Distributed Power

- Initiate development of advanced technology for interface devices for distributed power.
- Develop strategy to mitigate regulatory and institutional barriers to distributed power.

High Temperature Superconducting R&D

- Testing completed of Detroit cable project.
- "Second generation" HTS wire becomes available in continuous lengths for the first time. This wire offers unprecedented performance and low manufacturing cost and has been a program priority since its feasibility was discovered at Los Alamos in 1995.
- Testing of a 5000 horsepower motor is completed to successfully complete this project which is based on first generation superconducting wire.
- Testing of a novel 10 MVA superconducting transformer based on first generation wire is successfully completed.

Energy Storage Systems

- # Begin integration of distributed storage system with hybrid sources for 100kW remote small village or commercial application.
- # Design 5MW prototype power quality energy storage system for substation applications.
- # Design improved control systems for advanced energy storage components and improved battery management in conventional storage systems.
- # Develop performance and economic models for storage systems in grid-connected and stand-alone applications that will estimate performance, predict sizing and economic feasibility.

FY 2002 - 2005 Planned Accomplishments

Transmission Reliability

Power System Reliability

- # Publish policy options for market redesigns, rule changes, and revised operating procedures that increase electric reliability.
- # Demonstrate software that detects impending disturbances based on precursor signatures, and recommends mitigating actions.
- # Initiate large scale simulator tests of real time system control aimed at reducing air emissions and increasing system reliability.
- # Complete laboratory development of techniques for production of high purity silicon carbide or diamond-based material for lower cost, higher performance advanced power electronic switches.
- # Begin tests of advanced high efficiency, high voltage power electronic converters for power transmission applications.

Distributed Power

- # Initiate development of a family of universal interface devices for distributed power for various levels of service.
- # Execute strategy to mitigate regulatory and institutional barriers to distributed power.
- # Complete draft of revised national interconnection standard for distributed power.

High Temperature Superconducting R&D

- # The full utilization of superconductivity in electrical generation, delivery and use will be exploited by developing generators, transformers, transmission cables, and storage devices based on high performance, low cost superconducting wires.
- # The projects resulting from the FY 2001 competition will be successfully completed.

Energy Storage Systems

- # Investigate multimegawatt storage technologies with utility industry partner for energy management application.

- # Initiate multimegawatt storage development project for power quality application using advanced energy storage technologies.
- # Complete the ABESS project; industry will begin commercialization.
- # Assist industry in identifying economic applications of energy storage using performance and economic models for grid connected storage systems.

Program Completion

Transmission Reliability

The Power System Reliability Program is projected to be a five to ten year program to ensure that research and development for reliable systems and competitive markets is maintained until new market and/or regulatory structures are developed that provide the incentives for the private sector to assume this work and to assure successful large-scale integration of distributed resources. The program will be reassessed each year to determine the level for Federal involvement depending on the nature and implementation needs of new regulations, and the impact of market forces under both Federal and State regulations.

The Distributed Power Program is planned as a five to ten year program. Near-term barriers which are at the present time impeding the market penetration of emerging distributed power technologies, such as microturbines, fuel cells, photovoltaics and wind, will be addressed during FY 2005-2007. By FY 2007 it is expected that a revised interconnection standard will be in place and that activities to remove regulatory barriers that distributed power projects now face will have been completed. The "plug-and-play" interface technologies needed to realize the longer-term goal of large penetrations of distributed power into an automated and adaptive power system will be demonstrated and ready for commercialization in FY 2010 - 2015. These hardware and software interface technologies will allow homeowners and businesses to control not only their on-site generation and storage, but also their major appliances and other electrical loads from remote locations, and to sell not only power from their on-site generation and storage, but also provide capacity and voltage support or other operational services to the grid.

High Temperature Superconducting R&D

Basic research activities will be completed during FY 2004 - FY 2006 resulting in practical wires from U.S. manufacturers that can achieve 1,000 amperes per square millimeter of cross-sectional area while operating at liquid nitrogen temperatures in a field of 3 Tesla. "Practical wires" imply flexibility, ruggedness, and affordability when produced in sufficient quantity. The federal role will be completed by 2010 with a full range of applications having undergone sufficient field validation that commercialization activities could begin.

Energy Storage Systems

Development and performance evaluations of current moderate-sized systems that meet the cost and energy density goals for the program will be completed during FY 2004 - FY 2006. In the FY 2005 to FY2010 time frame, large utility scale power management systems will be investigated for performance improvements and economic tradeoffs, using advanced technologies.

Funding Schedule

(dollars in thousands)

	FY 1999	FY 2000	FY 2001	$ Change	% Change
Transmission Reliability	4,251	2,955	11,000	8,045	272.3%
High Temperature Superconducting R&D	32,100	31,408	32,000	592	1.9%
Energy Storage Systems	4,445	3,429	5,000	1,571	45.8%
Climate Challenge	100	0	0	0	0.0%
Total, Electric Energy Systems and Storage	40,896	37,792	48,000	10,208	27.0%

Detailed Program Justification

(dollars in thousands)

FY 1999	FY 2000	FY 2001

Transmission Reliability

**Power System Reliability** - Develop real-time measurement and control systems to collect and apply power system data in real time to ensure and enhance electric power system security and reliability, reduce air emissions, and enable efficient markets. Investigate incremental modifications to grid system models to take advantage of real time data. Evaluate data requirements and develop models for ancillary services markets.

Support additional analysis of distributed resources capability to sell services into the competitive market, and initiates development of power electronic energy conversion equipment. Funding level supports additional National Laboratory, and university and industry participation to develop advanced system models and real time dynamic control systems; areas identified as gaps in the Department's Energy R&D Portfolio Analysis.

Assess DOE role and activities for developing advanced converter designs and switching materials in coordination with EPRI and industry partnerships. These technologies allow the grid to be operated in real time to enable competitive markets, and maximize use of existing rights of way.

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
The funding level is considered appropriate based on program formulation after electric industry views on six scoping papers were solicited at a workshop with broad industry representation, and through discussions with EPRI at the yearly DOE/EPRI Sustainable Electric Partnership Executive Conference. The increase funds analyses of mechanisms and options to assure grid reliability through market incentives under competition.	3,019	2,455	8,000
# **Distributed Power** - Continues multi-year cooperative efforts with industry initiated in FY 2000 under a competitive solicitation to address system integration R&D including: evaluation of innovative concepts for distributed power applications; development of advanced technologies for interconnection and control of distributed generation and storage and controllable load; modeling, case studies, engineering analyses and test and evaluation to address safety, reliability, power quality, interconnection and environmental issues; development and validation of a national interconnection standard; development of interconnection hardware and software; and examination of certification methodologies. Preliminary activities for a distributed power demonstration at the Nevada Test Site were funded in FY 2000 with the $500,000 provided for that purpose and an evaluation of the use of the Nevada Test Site for operational testing in collect data, to support of the development and validation of interconnection standard, will be completed in FY 2001. The Distributed Power Program was formulated after electric industry views on the content and priorities of the program were solicited at workshops with broad industry representation. The increased level of funding is appropriate to support testing necessary to complete the national uniform interconnection standard and the continuation of system integration R&D activities funded in FY 2000 under Solar Program Support ($3,000,000) and the continuation of activities to address technical, regulatory and institutional barriers funded in FY 2000 under Electric Energy Systems and Storage ($500,000).	1,232	500	3,000
Total, Transmission Reliability.	4,251	2,955	11,000

(dollars in thousands)

	FY 1999	FY 2000	FY 2001
High Temperature Superconducting R&D			
# **Superconductivity Partnership Initiative** - Activities will support six major projects to develop first-of-a-kind electrical systems that can provide quantum improvements to the efficiency and capacity of the national grid. These include transmission cables, transformers, large motors, flywheel energy systems and magnetic separation systems that meet performance goals. The programs's past experience has demonstrated that this extremely ambitious schedule is possible within the funding requested because of careful planning and leveraging of resources. Leveraging includes the 50% cost share that the program has been able to attract, even though the projects are very high risk. Additional leveraging occurs because the project teams are typically a vertically integrated consortium of companies containing a future product use (an electric power company), a manufacturer, and a superconducting component supplier	14,100	14,000	14,000
# **Second Generation Wire Initiative** - This effort is crucial to producing superconducting wire that meets the program's performance goals. High-performance, low-cost wire is the key to the success of the Superconductivity Partnership Initiative projects. Four industrial consortia will be working with the national laboratories to scale up discoveries that are the basis for this initiative. Wire performance goals of length, current density and cost will be met. The performance goals are very ambitious but past success indicates that the prospects are good for meeting them at the requested funding level. Private sector participants' 50% cost-sharing leverages program funds.	8,000	8,000	8,000
# **Strategic Research** - This program component has been the incubator for discoveries and innovations now being pursued in the two above initiatives. The entire High Temperature Superconducting program depends on continued results from in-house national laboratory research and joint research being carried out with private companies under 50% cost-shared agreements. This activity provides fundamental knowledge needed in the above two initiatives. Work will begin on advanced cryogenic systems in FY 2001. Important research			

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
leveraging is obtained through complementary work funded by the DOE Office of Basic Energy Science, program funded work at several universities and leveraged research at the National Institute of Science and Technology (two NIST dollars for every program dollar).	10,000	9,408	10,000
Total, High Temperature Superconducting R&D.	32,100	31,408	32,000

Energy Storage Systems

**Storage Systems Integration** - Distributed energy storage systems integrated with renewable generation sources will be developed with substantial industry cost-sharing for stand-alone small village or commercial applications of about 100kW. Several prototypes will be designed, and plans for development and installation in field tests to characterize performance and reliability will be completed. Continued analysis of data gathered from existing systems will identify integration success and challenges.

A 5MW prototype power quality energy storage system for substation applications will be designed and fabrication initiated. The requirements for such a system will be identified in a cooperative project measuring the level of power quality on a transmission network.

Initiate one year of field testing of the 400 kWh Advanced Battery Energy Storage System (ABESS) at a site on the Detroit Edison grid. The system will provide benefits to the grid and local consumers which include improved power quality, higher reliability of electric service, and peak shaving which delays costly upgrades of utility distribution equipment. The field test will provide critical storage system performance and life data that are necessary for technology improvement and future widespread implementation of storage technologies. 2,170 1,640 2,500

**Components R&D** - Advanced energy storage and power electronics components will be researched to improve performance and reduce costs for power quality, renewable, and restructured utility applications. From a list including flywheels, superconducting magnetic energy storage, and

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
supercapacitors, the most promising technology will be selected and appropriate power electronics, high speed switches, and circuit architectures will be developed. In battery systems, efforts will continue to improve the system control elements improving system performance, lifetime and reducing life cycle costs. All work will be leveraged with on-going work in academia, private industry and at several independent research organizations such as the California Energy Commission and the National Rural Electric Cooperative Association.	1,384	1,000	1,600
# **Research and Analysis** - Performance and economic models of storage systems in grid-connected and stand-alone networks will be developed. Such models will estimate the performance of storage systems to better predict sizing, load satisfaction, and economic feasibility. Storage technologies to be modeled include batteries, flywheels and SMES. Working with a consortium of utilities, the power quality of the transmission grid will be evaluated quantitatively in the Southeastern region of the U.S. The resultant systematic data will provide essential input for increasing system reliability through energy storage and control systems. Simulations of distributed storage systems will be applied to grid reliability and power flow models on a national scale. Such models presently do not address energy storage and are applied strictly on a local scale. Advanced storage and power electronics technologies will be incorporated in the models to better predict the benefits offered by next generation devices. This research will be leveraged with models already under development by academia, the Department of Defense, and several international research organizations.	891	789	900
Total, Energy Storage Systems.	4,445	3,429	5,000

Climate Challenge

# No funding was appropriated in FY 2000 and there is no request for FY 2001 funding.			

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
The FY 1999 funding provided support for negotiations with the electric power industry to design a voluntary emission reduction program for the post 2000 period.	100	0	0
Total, Electric Energy Systems and Storage.	40,896	37,792	48,000

Explanation of Funding Changes from FY 2000 to FY 2001

	FY 2001 vs. FY 2000 ($000)
Transmission Reliability Program	
# **Power System Reliability** - Increase supports additional development of advanced models and control algorithms, and planning for evaluation of these models and controls; additional analysis of market structure impacts on electric system reliability; and integration of distributed resources into the electric system and into market structures. These are critical reliability R&D gaps identified, but unfunded, by the electricity industry.	5,545
# **Distributed Power** - Increase is comprised of an increase of $2,957,000 due to the consolidation of this activity to Electric Energy Systems and Storage from Solar Program Support, offset by a decrease of $457,000 in the total Distributed Power Program, due to shift in emphasis of program priorities with the Power Systems Reliability Program and the Energy Storage Systems Program.	2,500
Total Funding Change, Transmission Reliability Program	8,045
High Temperature Superconducting R&D	
# **Strategic Research** - The increase will allow initiation of research on advanced cryogenic systems, which are the critical support systems for HTS power equipment.	592
Energy Storage Systems	
# **Storage Systems and Integration:** Perform measurements and full statistical evaluation of power quality on a regional transmission grid. This study, essential for understanding grid reliability, will be carried out together with the Electric Power Research Institute (EPRI) and a consortium of utilities.	860

	FY 2001 vs. FY 2000 ($000)
# **Components R&D:** Explore development of advanced storage technologies such as flywheels and lithium ion batteries.	600
# **Research and Analysis:** Conduct extended economic analysis of benefits for distributed storage systems in a restructured utility environment.	111
Total Funding Change, Energy Storage Systems Program.	1,571
Total Funding Change, Electric Energy Systems and Storage.	10,208

Federal Buildings/Remote Power Initiative

Mission Supporting Goals and Objectives

Program Mission

The Federal Buildings/Remote Power Initiative identifies and documents the economic benefit of using renewable energy technologies in applications that are currently cost-effective in the marketplace.

Program Goals and Objectives

Over the course of the Initiative, the program will demonstrate that renewable energy technologies are economical, reliable, and easy to operate.

Strategic Approach

The Federal building portion of the initiative provides financial cost-sharing assistance to Federal agencies that are seeking to incorporate renewable energy technologies into their power supply porfolio, such as wind development in San Clemente Island, California, solar domestic hot water collectors in Pearl Harbor, Hawaii; and geothermal gradient technologies at the Naval support facility in Diego Garcia. The Remote power portion of the initiative works to deploy renewable technologies–including solar, wind, fuel cell, and biomass power–in remote areas of the United States, and to develop and demonstrate their reliability, economics, and environmental benefits when compared to diesel generators.

Program Benefits

The Federal Buildings/Remote Power Initiative is supportive of the specific program mission, goals and objectives, and benefits of the participating technologies. In FY 2001, those specific sections are indicated in the individual requests of those participating programs including, PV, Wind, Biomass and in the Competitive Solicitation section of the Solar Program Support request. In addition, the funds for projects at Federal Facilities allow Federal agencies to try technologies they may not be familiar with and gain successful experience.

Significant Accomplishments and Program Shifts

Pre-FY 1999 Accomplishments

- More than 70 applications, including requests for PV, solar heating, solar hot water and water pumping projects were submitted under the Federal Buildings Initiative. Awards were made to 26 proposals resulting in 277 renewable systems, including PV, solar heating, solar hot water and water pumping projects being installed at nine Federal Facilities.
- Pursuant to a competitive Remote Power solicitation, 23 projects in 20 States and Territories, including PV, fuel cell, wood fired cogeneration, wind, solar water heating and diesel hybrid systems, were funded resulting in a 5 to 1 leveraging of Federal funds.

FY 1999 Accomplishments

- Issued 91 proposals to Federal agencies, 26 projects were awarded.
- Issued eight cooperative agreements to Native American tribes selected from a competitive solicitation.

FY 2001 Proposed Accomplishments

- Activities will be conducted within the individual requests of those participating programs including, PV, Wind, Biomass and the Solar Program Support Competitive Solicitation.

Funding Schedule

(dollars in thousands)

	FY 1999	FY 2000	FY 2001	$ Change	% Change
Federal Buildings/Remote Power Initiative	4,000	0	0	0	0.0%
Total, Federal Buildings/Remote Power Initiative	4,000	0	0	0	0.0%

Detailed Program Justification

(dollars in thousands)

	FY 1999	FY 2000	FY 2001
Federal Buildings/Remote Power Initiative			
# Activities will be conducted within the individual requests of those participating programs including, PV, Wind, Biomass and the Solar Program Support Competitive Solicitation.. . . .	4,000	0	0
Total, Federal Buildings/Remote Power Initiative.	4,000	0	0

Explanation of Funding Changes from FY 2000 to FY 2001

	FY 2001 vs. FY 2000 ($000)
Federal Buildings/Remote Power Initiative	
# No change from FY 2000 to FY 2001.	0
Total Funding Change, Federal Buildings/Remote Power Initiative.	0

Solar and Renewable Resources Technologies Program Direction

Mission Supporting Goals and Objectives

Program Direction provides the Federal staffing resources and associated funding to support the management and oversight of the Solar and Renewable Energy Programs. This activity includes all funding for support service contractors, equipment, travel, crosscutting activities, and Assistant Secretary initiatives. This permits the continuation of a diverse array of Solar and Renewable projects to be integrated into a national portfolio of world renown research. Program Direction encompasses two principal activities: (1) Headquarters executive and program management; and (2) program operations at the Golden Field Office and the Idaho Operations Office.

Secretary Richardson announced in November 1998 that based on a review of the Department's staffing, the reductions had far exceeded the final FY 2000 Strategic Alignment Initiative (SAI) goals, and in fact the aggressive downsizing was now having a negative impact on technical and professional positions. As a part of the Workforce 21 initiative, the Office of Energy Efficiency and Renewable Energy completed a comprehensive workforce analysis for FY 1999 and 2000, including and in-depth review of requirements for each of the component EE organizations. A total of 51% of the 155 positions that EE lost to downsizing since 1995 were technical and professional personnel, this has impaired EE's ability to deliver on its mission requirements. Further, the downsizing eliminated many lower and mid-level technical and professional employees and this was now straining EE's ability to develop successors to our retiring employees. Moreover, by January 2000, 53 more technical and professional staff were eligible for retirement, and by FY 2003 as many as 131 technical and professional employees will be eligible for retirement.

The FY 2001 Congressional Request provides for continued implementation of Workforce 21 increases to off-set the adverse impacts of the downsizing. Additionally, EE has adopted smarter, more effective business and management practices, and as revealed in the workforce analysis these efforts have greatly reduced the need for most but not all of the staff lost due to downsizing. The additional Workforce 21 hiring in FY 2000 is consistent with EE's Workforce 21 strategy, which is to concentrate the majority of the critical hires to the technical and professional category, leaving the clerical/administrative and manager/supervisor staffing levels virtually the same.

Performance Measures

- # Responsiveness to national energy policy goals and objectives.
- # Continued improvement in the utilization of Federal staffing, travel, and support service contractor funding.
- # Continued reductions in fiscal year-end uncosted obligations.
- # Continued increase in competitive contract awards.
- # Cost sharing and leveraging of program resources to enhance the program's impact.
- # Improvement in environment, safety, and health compliance.

- # Ensuring that all Federal employee costs, travel, support service contracts, ASEE initiatives, and crosscutting activities are supported from within Program Direction.
- # Committed to creating and maintaining an environment that is free from discrimination.

Funding Schedule

(dollars in thousands, whole FTEs)

	FY 1999	FY 2000	FY 2001	$ Change	% Change
Golden					
Salaries and Benefits	1,308	1,550	2,089	539	34.8%
Travel	118	120	125	5	4.2%
Support Services	289	295	370	75	25.4%
Other Related Expenses	190	190	195	5	2.6%
Total, Golden	1,905	2,155	2,779	624	29.0%
Full Time Equivalents	16	22	22	0	0%
Idaho					
Salaries and Benefits	86	95	100	5	5.3%
Travel	0	0	0	0	0.0%
Support Services	0	0	0	0	0.0%
Other Related Expenses	0	0	0	0	0.0%
Total, Idaho	86	95	100	5	5.3%
Full Time Equivalents	1	1	1	0	0%
Headquarters					
Salaries and Benefits	8,909	10,280	10,900	620	6.0%
Travel	313	360	380	20	5.6%
Support Services	5,197	3,140	2,225	-915	-29.1%
Other Related Expenses	1,690	1,690	1,775	85	5%
Total, Headquarters	16,109	15,470	15,280	-190	-1.2%
Full Time Equivalents	90	98	98	0	0.0%
Total Solar and Renewable Resources Technologies					
Salaries and Benefits	10,303	11,925	13,089	1,164	9.8%
Travel	431	480	505	25	5.2%
Support Services	5,486	3,435	2,595	-840	-24.5%
Other Related Expenses	1,880	1,880	1,970	90	4.8%
Total, Program Direction	18,100	17,720	18,159	439	2.5%
Total Full Time Equivalents	107	121	121	0	0.0%

Detailed Program Justification

(dollars in thousands)

FY 1999	FY 2000	FY 2001

Salaries and Benefits

(dollars in thousands)

FY 1999	FY 2000	FY 2001

Staff funded in this decision unit provide the executive management, program oversight, analysis, and information required for the effective implementation of the Solar and Renewable Resources Technologies Programs. The staff are also responsible for the development of policies, strategic plans and related guidance to program offices; the evaluation of program performance; the formulation, defense and execution of the Solar and Renewable budgets; and communications with the public and stakeholders regarding policies, budgets, program performance and related issues. Additionally, Solar Program Direction supports staff at the Golden Field Office and the Idaho Operations Office.

Based on the completion of a comprehensive Workforce 21 analysis, additional critical professional/technical FTEs are being hired to ensure that EE's ability to deliver on its mission requirements is not impaired. EE is committed to reduce the costs for all administrative activities and achieve savings through a more streamlined and efficient management of federal staffing levels in this account. The requested FTEs are consistent with EE's continued implementation of the Department's Workforce 21 strategy, which is to concentrate the majority of the critical hires to the technical and professional category, leaving the clerical/administrative and manager/supervisor staffing levels virtually the same.

The Department of Energy has conducted detailed workforce analyses that have identified current and projected staffing disciplines. During 1999, DOE conducted a systematic analysis of critical staffing needs within the context of current and projected R&D program missions. The Department will develop a comprehensive plan that will focus on building and sustaining a talented and diverse workforce of R&D Technical Managers. The plan will include innovative recruitment strategies, retention incentives, comprehensive training and development programs for new and current employees, and succession planning. The FY 2001 program direction request for Solar and Renewable Energy includes

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
$30,000 to support the Scientific Retention and Recruitment Initiative. This will enable the recruitment of experienced scientists and related support staff (full-time equivalents) in areas of emerging interest to the Department's science mission. Funds will also be used to motivate and retain highly skilled, top-performing technical managers with, for example, retention allowances and performance awards. Additionally, training in areas crucial for effective job performance will be a key element of the initiative.	10,303	11,925	13,089
Travel			
# A nominal increase in travel reflects projected escalation of travel costs and per diem. Travel has been substantially reduced from previous years through the use of teleconferencing facilities for the conduct of oversight activities of some field organizations and further reductions would preclude EE's ability to achieve its mission requirements.	431	480	505
Support Services			
# Includes all funding for support service contractors, equipment, crosscutting activities, and Assistant Secretary initiatives. Such activities include the development and evaluation of performance measurement and quality metrics for the Solar and Renewable Energy Programs. These activities are expected to achieve efficiency savings throughout the programs, and return to the taxpayer program cost savings far in excess of the expenditure. The support will enable adoption of sound business practices called forth under the Government Performance and Results Act (GPRA) of 1993 and the Government Management Reform (GMRA) Act of 1994. Other support services include activities such as mailroom and travel processing. Also includes assistance in the preparation of program planning materials and briefing materials. In FY 1999, a total of $1,900,000 was included for electricity restructuring activities including $1,500,000 in the original appropriation and $400,000 in the Omnibus Consolidated Appropriation Act. The Department has prepared a program			

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
plan to be sent to Congress which describes this program including the discrete role the Department has played that is not duplicative of services provided by the private sector, state governments, or other Federal agencies. Also, within the $1,500,000 for restructuring, funds were provided for financial and technical assistance to states undergoing restructuring, including $150,000 for electricity restructuring activities of the California Energy Commission. Starting in FY 2000, the electricity restructuring activities were budgeted in the Congressional Request under Solar Program Support.	5,486	3,435	2,595
Other Related Expenses			
# This activity includes the Working Capital Fund (WCF) and contractual services associated with landlord support of the Golden Field Office. Funding for the WCF in FY 1999 through FY 2001 is $1,690,000, $1,690,000, and $1,775,000 respectively. Rent is the largest component of the Working Capital Fund (FY 1999 through FY 2001 is $941,000, $958,000, and $986,000 respectively). The balance of the Other Related Expenses is for Golden landlord requirements such as rental payments to GSA, expendable office supplies and materials, telecommunications and utilities, training, purchase of goods and services from Government accounts, printing and graphics, postage, maintenance and service agreements, and publications. The total costs for the Golden Field Office are split between the Energy Supply Appropriation and the Interior and Related Agencies Appropriation.	1,880	1,880	1,970
Total, Solar and Renewable Resources Technologies Program Direction	18,100	17,720	18,159

Explanation of Funding Changes from FY 2000 to FY 2001

	FY 2001 vs. FY 2000 ($000)
Salaries and Benefits	
# Increase in salaries and benefits supports general pay increases, locality pay adjustments, promotions, and within-grade increases.	1,164
Travel	
# A nominal increase of 5% is primarily to support escalating airfare and lodging costs with offsets from alternatives to travel such as video-conferencing.	25
Support Services	
# Decrease reflects a reduced level of assistance for preparation of program planning materials and support for program briefings and presentations.	-840
Other Related Expenses	
# Increase supports activities such as additional computer workstations and network infrastructure technology upgrades to improve operational efficiencies, printing and reproduction, and funding for field office rent increase.	90
Total Funding Change, Solar and Renewable Resources Technologies Program Direction.	439

Support Services

(dollars in thousands)

	FY 1999	FY 2000	FY 2001	$ Change	% Change
Technical Support Services					
Economic and Environmental Analysis	2,826	945	945	0	0.0%
Feasibility of Design Considerations	0	0	0	0	0.0%
Total, Technical Support Services	2,826	945	945	0	0.0%
Management Support Services					
Management Studies	0	0	0	0	0.0%
Training and Education	0	0	0	0	0.0%
ADP Support	360	360	200	-160	-44.4%
Administrative Support Services	2,300	2,130	1,450	-680	0.0%
Total, Management Support Services	2,660	2,490	1,650	-840	-33.7%
Subtotal Support Services	5,486	3,435	2,595	-840	-24.5%
Use of Prior-Year Balances	0	0	0	0	0.0%
Total, Support Services	5,486[a]	3,435[a]	2,595[a]	-840	-24.5%

[a]Includes all funding for support service contractors, equipment, crosscutting activities, and Assistant Secretary initiatives.

Other Related Expenses

(dollars in thousands)

	FY 1999	FY 2000	FY 2001	$ Change	% Change
Training	5	5	5	0	0.0%
Working Capital Fund	1,690	1,690	1,775	85	5.0%
Printing and Reproduction	0	0	0	0	0.0%
Rental Space	120	120	120	0	0.0%
Software Procurement/Maintenance Activities/Capital Acquisitions	5	5	5	0	0.0%
Other	60	60	65	5	8.3%
Subtotal, Other Related Expenses	1,880	1,880	1,970	90	4.8%
Use of Prior-Year Balances	0	0	0	0	0.0%
Total, Other Related Expenses	1,880	1,880	1,970	90	4.8%

Departmental Energy Management Program

Mission Supporting Goals and Objectives

Program Mission

The mission of the Departmental Energy Management Program (DEMP) is to reduce energy and water consumption, improve energy efficiency, and reduce utility costs throughout the Department of Energy's (DOE) facilities and operations. This program will provide funding support to DOE sites for accomplishing energy management projects, expanding the use of private sector financing for energy management, and allow the Department to meet the requirements of Executive Order (EO) 13123.

The management of utility costs includes the approval of DOE utility contracts and the management of the DOE Rate Intervention Program.

Program Goals and Objectives

The objective of the DEMP is to enable DOE to demonstrate leadership as a model program for energy management within the Federal government. Demonstrating leadership will be accomplished by achieving the following performance goals by fiscal year 2005:

- Reduce energy consumption in the Department's buildings by 40 percent compared to fiscal year 1985 energy use per square foot.
- Reduce the Department's cost for energy and utilities by 10 percent or $30 million annually compared to FY 1996 cost of energy and utilities.
- Phaseout the use of Class I ozone-depleting substances (ODS) by replacing up to 50 percent of our older and inefficient refrigeration and air-conditioning chiller systems.
- Reduce energy consumption in our surplus facilities by 30 percent compared to fiscal year 1996 energy use per square foot.
- Acquire ENERGY STAR labels for the majority of our office buildings that have metered data.
- Include green power purchases in all competitive power solicitations.
- Partner with Defense Logistics Agency or the General Services Administration for competitive procurement of electricity as deregulation of electricity occurs.
- Intervene in state deregulation cases to protect DOE consumer interests.

Strategic Approach

Under the direction of our Energy Management Steering Committee comprised of representatives from all of the DOE programs, the DEMP plans to fund energy projects and expand the use of private sector financing for energy management to meet the requirements of EO 13123. There is no direct funding source to support these activities at DOE sites. Funding is required for our DOE energy coordinators to identify projects, to verify or develop baselines for measuring energy savings, to approve design, construction, and other project management support for funded projects. Funding is also required to expand the use of private sector financing for energy management, and to administer these private sector contracts to ensure performance guarantees provide the required savings.

Much of the Department's success in optimizing the efficient use of energy at our sites is due to the trained energy coordinators in the field that have championed our DEMP activities. These professionals, with a track record of reducing costs, have been the target for elimination in many cost cutting measures across the Department. This has been due to the lack of direct funding through Congressional appropriations to support their activities and the emphasis on reducing overhead costs, which currently funds their activities at DOE sites.

Action must be taken now to help strengthen the energy management program at DOE facilities. The lack of appropriated funding for energy management at DOE sites since fiscal year 1995 has significantly reduced the number of DOE energy management professionals who contributed to the energy savings that were achieved under previous funding for energy management. These energy management activities are currently saving the Department over $100 million annually in utility costs through the energy retrofit projects and studies that were previously funded under the program.

In addition to supporting the direct costs for accomplishing energy projects, funding is also required to expand the use of private sector financing for additional energy projects at DOE sites. Model programs for energy management will be developed in areas that have not been traditionally addressed using private sector financing. Results achieved in initial efforts will be transferred to all applicable DOE sites. Model programs to reduce energy consumption in facilities and to eliminate chillers using Class I ozone depleting substances can be accomplished using private sector financing. Office buildings within the Department will be retrofitted to achieve ENERGY STAR labels. These model programs will significantly reduce the cost of operating our facilities. A recent study at one Departmental environmental restoration site estimated annual cost reductions of $88 million by deactivating and decommissioning our surplus facilities.

The annual cost of DOE utility contracts is $244,000,000. Identifiable savings from innovative utility contracts and rate interventions save DOE $15-30 million annually. Activities that support these functions include:

- Performance of options studies to identify lowest costs of providing utility services at field sites and laboratories;
- Negotiation of new utility contracts resulting in lowest costs to DOE; and
- Providing expert testimony in support of DOE's legal positions in rate interventions where DOE has intervened before state and federal regulatory commissions to protect DOE's consumer interests as a large user of electricity and natural gas.

Program Benefits

Metric	FY 2001	FY 2005	FY 2010	FY 2015	FY 2020
Energy Savings (Trillion BTUs)	5	12	18	26	33
Oil Savings (Trillion BTUs)	0.3	0.7	1	1.4	1.7
Energy Cost Saving (Million $s)	325	789	1253	1896	2538
Carbon Equivalent Reductions (Million Metric Tons) . .	0.11	245	0.381	0.545	0.71

These benefits correspond to providing electricity to 150,000 households in 2000; 350,000 households in 2005; 530,000 households in 2010; 760,000 households in 2015; and 1,000,000 households in 2020.

Performance Measures

FY 2001 Performance Measures

- Fund 20 energy management projects at Departmental sites.
- Reduce energy consumption in the Department's buildings by 38 percent as compared to fiscal year 1985 energy use per square foot.
- Accomplish two chiller replacements to phase out the use of Class 1 ODS.
- Accomplish energy savings in two facilities.
- Evaluate all DOE office buildings with metered data for ENERGY STAR labels, and develop metering plans for all remaining DOE office buildings.
- Acquire ENERGY STAR labels for two office buildings.
- Include green power purchases in all competitive power solicitations.
- Issue Secretarial directive on use of savings from new utility contracts for green power purchases.

FY 2002 - 2005 Performance Measures

- Retrofit two DOE office buildings to meet ENERGY STAR labeling requirements.
- Accomplish a minimum of 10 chiller replacements to phaseout the use of Class 1 ODS.
- Accomplish energy savings in 10 facilities.
- Acquire ENERGY STAR labels for the majority of office buildings that have metered data and can be retrofit to meet this requirement.
- Reduce energy consumption in the Department's buildings by 40 percent as compared to fiscal year 1985 energy use per square foot.

Significant Accomplishments and Program Shifts

Significant Accomplishments

- Under appropriations that were previously provided from FY 1979-1995, energy audits and retrofit projects were completed that are currently saving the Department over $100 million annually in avoided energy and utility costs.
- The Department has reduced its energy consumption per square foot in buildings by 37 percent as compared to FY 1985, already achieving the FY 2005 goal of Executive Order 12902.
- ESPCs were accomplished at Richland's Hanford site, Lawrence Berkeley National Laboratory, Lawrence Livermore National Laboratory, and the Department's Forrestal Building.
- Savannah River Operations Office entered into an ESPC.
- Managed rate interventions in Nevada, Idaho, and Illinois due to restructuring: DOE opposed allocation of distribution facilities costs to DOE sites receiving electricity at transmission level voltages - savings of $3-5 million will recur annually by avoiding distribution costs.
- New contracts provisions for four Oakland Operations Office laboratories have saved $1 million since May 1999, by "selling" available capacity in the unregulated California market.
- Partnered with Defense Energy Support Center for competitive procurements in New Jersey Pennsylvania, Illinois, and California. New contracts for Fermi National Accelerator Laboratory and Argonne National Laboratory will reduce electricity costs by $2.2 million/year.
- Partnered with Western Area Power Administration in filing complaint to the Federal Energy Regulatory Commission to lower electricity costs at Sandia/Kirtland Air Force Base by $5 million annually.

Program Shifts

This new funding request will assist the Department in meeting the mandates of Executive Order 13123 for energy saving goals. The Department will benefit from the replacement of aging energy systems in our facilities.

Program Completion

Success of the DEMP Program will be measured by the ability of our Departmental sites to acquire energy management infrastructure through direct funding of energy products or expanding the use of private sector financing and to reduce energy and operating costs in accordance with our performance goals. The goal of a 40 percent reduction in buildings energy consumption by fiscal year 2005 will be the primary measure that will demonstrate this progress. However, the program will not be considered to be complete until all energy retrofit projects that have less than a ten year payback have been accomplished at all Departmental sites in accordance with the requirement of the Energy Policy Act of 1992.

Funding Schedule

(dollars in thousands)

	FY 1999	FY 2000	FY 2001	$ Change	% Change
Energy Management Project Support	0	0	3,900	3,900	>999%
Energy Management Model Program Development.	0	0	1,100	1,100	>999%
Total, DEMP Program	0	0	5,000	5,000	>999%

Detailed Program Justification

(dollars in thousands)

	FY 1999	FY 2000	FY 2001
Energy Management Project Support			
# Provides support at various DOE facilities for energy projects to increase the investment in energy efficiency in DOE facilities, and provide annual savings of 50 billion Btus. Funding will be provided to projects which are identified through a DOE wide competition and selected to maximize DOE's return on investment. This program of quick payback retrofit projects for DOE facilities reduces outyear utility costs, provides a rate of return exceeding 25 percent on the dollars invested and will help meet the requirements for EO 13123. This funding may also be leveraged to maximize DOE's return on investment, and to incorporate emerging energy savings technologies at DOE sites to provide the leadership DOE must demonstrate in energy efficiency in the areas related to the generation and use of energy.	0	0	3,900
Total, Energy Management Project Support.	0	0	3,900

	(dollars in thousands)		
	FY 1999	FY 2000	FY 2001
Energy Management Model Program Development			
Provides support at various DOE facilities to develop model programs for energy management in new areas that have not been previously addressed, and to meet the requirements of EO 13123. Results achieved from these initial efforts will be transferred to all applicable DOE sites:			
# Develop appropriate guidance and identify candidate sites for replacing chillers and for reducing energy consumption in contaminated surplus facilities by expanding the use of private sector financing.	0	0	600
# Evaluate all DOE office buildings with metered data for ENERGY STAR labels, develop plans for buildings that do not have current metered data for evaluation, and implement other requirements of EO 13123.	0	0	500
Total Energy Management Model Program Development.	0	0	1,100
Total, Departmental Energy Management Program	0	0	5,000

Explanation of Funding Changes from FY 2000 to FY 2001

	FY 2001 vs. FY 2000 ($000)
Energy Management Project Support	
# Initiate support for energy projects at various DOE facilities, through a DOE wide competition for projects that will be selected to maximize DOE's return on investment.	3,900
Energy Management Model Program Development	
# Initiate support at DOE facilities to develop model programs for energy management in new areas and to meet the requirements of EO 13123, including acquiring Energy Star labels, reducing energy consumption in facilities and replacing chillers that use Class I ozone depleting substances.	1,100
Total Funding Change, Departmental Energy Management Program.	5,000