Central Systems

Funding Schedule by Activity

(dollars in thousands)

	FY 2003	FY 2004	FY 2005	$ Change	% Change
Central Systems					
Innovations for Existing Plants	21,556	21,729	18,050	-3,679	-16.9%
Advanced Systems	69,928	68,151	46,450	-21,701	-31.8%
Total, Central Systems	91,494	89,880	64,500	-25,380	-28.2%

Description

As part of the President's Coal Research Initiative, FutureGen is a Presidential Initiative to create an advanced, full-scale integrated facility that will utilize advanced coal gasification technology to produce electric power and hydrogen while capturing and sequestering carbon dioxide. The Central Systems Programs is to provide critical research for FutureGen to dramatically reduce coal power plant emissions and significantly improve efficiency to reduce carbon emissions.

Benefits

The Central Systems subprogram supports DOE's overarching mission to advance national energy security in an economic and environmentally sound manner by developing a cost-effective, high-efficient technological capability to eliminate environmental concerns associated with coal use. In the near term this means having the ability to meet all existing and anticipated environmental regulations at low cost. In the longer term, the aim is to nearly double coal power plant efficiencies (from 33% to 60%) at affordable costs of electricity while working towards zero emissions, allowing coal to remain a key strategic fuel for the Nation. The program mission is carried out in support of several key Presidential initiatives including the Coal Research Initiative, Clear Skies Initiative, Global Climate Change Initiative, and the FutureGen Initiative.

Background

The National Energy Policy recommends that the Department continue to develop advanced clean coal technology with a goal of deploying high efficiency coal power plants achieving zero emissions. Further, the President's Clear Skies Initiative is supported by the development of advanced emission control technology and related byproducts and water research as part of the research portfolio under Central Systems. The President's Climate Change Initiative over the longer term is supported through technology for advanced power plants that can nearly double the average efficiency of today's fleet of coal power plants, thereby significantly reducing carbon emissions. The growing national economy relies increasingly on electricity supply that is secure, affordable, and reliable. This is especially true in the face of concerns over national energy security as well as electricity generation market restructuring. In addition, compliance with more stringent environmental regulations requires reduced emissions from

electric power plants. Further, new technology is needed to develop much cleaner and more efficient plants to replace and augment an aging power generation infrastructure. Electricity demand from both natural gas and coal is projected to increase significantly through the year 2015 to meet increased energy demand in the U.S. (Annual Energy Outlook, 2003).

The program elements for Central Systems include technology developed for existing plants, advanced systems, FutureGen and Vision 21 are as follows:

- Innovations for Existing Plants (IEP) - The IEP program element has a near-to-mid term focus on improving overall power plant efficiency (thereby reducing carbon emission) and developing advanced cost-effective environmental control technologies for retrofitting to existing powerplants and other coal technologies including those developed in support of the FutureGen initiative such as Integrated Gasification Combined Cycle. The research is also directed at the environmentally sound use and disposal of coal byproducts and at novel systems and technologies to minimize the impact of electricity production on water availability and quality. The IEP program directly supports the goals and objectives of the President's February 14, 2002 Clear Skies Initiative that calls for substantial reductions in mercury, NO_x, and SO_2 emissions from power plants. Results of this advanced research are used by those who develop, design, manufacture and operate both existing and advanced systems across the entire spectrum of coal utilization technologies not only to improve efficiencies, but also to improve environmental performance. This program's crosscutting efforts address the cost-effective removal of pollutant causing contaminants from fossil fueled systems while maximizing the efficient recycling of all by products.

- Integrated Gasification Combined Cycle (IGCC) - The IGCC program supports both the President's Clear Skies Initiative and climate change goals by enhancing the thermal efficiency of converting coal to electricity, providing the potential for over 50% reduction in CO_2 compared to today's technologies, and through its performance goals of achieving near-zero emissions of SO_2, NO_x, mercury, and other pollutants. The IGCC program conducts research that fosters the development and deployment of fuel-flexible gasification-based processes for converting carbon-based feedstocks to electricity, steam, and a broad range of chemicals, including ultra-clean transportation fuels like hydrogen. In order to achieve the full potential of IGCC, significant advances must be made to reduce the capital and operating and maintenance costs and to improve both the reliability and the overall system availability. In FY 2005, the program will be more narrowly focused but will continue to develop technologies for gas stream purification to meet quality requirements for use with fuel cells and conversion processes; enhanced process efficiency; and reduced costs for producing oxygen. Development of technologies to cost effectively separate hydrogen from shifted synthesis gas and reduce gas emissions will continue at a substantially reduced level of effort. The successful accomplishment of these activities will enhance the commercialization prospects of advanced IGCC technologies for the production of electricity for use by utilities, independent power products, and other industrial stakeholders.

- Combustion Systems - This program was redirected in prior years to support advanced combustion hybrid concepts for Vision 21. In FY 2005, specific technologies from this category are included in the Gasification activity to enhance the integration of hybrid combustion/gasification concepts,

including support for the test activity at the Wilsonville Power Systems Development Facility (PSDF).

- Turbines - The Turbines Program is designed to enable the low cost implementation of the President's Climate Change, Clear Skies, and FutureGen initiatives. The focus is on developing enabling technology for high efficiency hydrogen syngas turbines for advance gasification systems that can be deployed in the near-term at $1000/kW, and for hydrogen turbines that will permit the design of zero emission FutureGen plants with carbon capture and sequestration. The focus is on key technologies needed to enable the development of advanced turbines that will operate with zero emissions, and higher efficiency when fueled with coal derived synthesis gas and hydrogen fuels. Developing turbines with superior performance that operate on coal derived synthesis gas and hydrogen is critical to the deployment of advanced power generation technologies such as integrated gasification combined cycle and FutureGen plants. The Turbine Program is an investment in secure U.S. electric power production which is clean, efficient, affordable and is fuel-flexible. These advances in turbine technology will make possible the continued use of coal, our Nation's largest domestic fossil energy resource.

  During FY 2003, DOE completed the concept studies to run ATS and other machines on coal syngas, as well as ATS machines in coal and natural gas based integrated hybrid power modules, demonstrated the Clean Energy Systems 10MW low-emission steam generator, demonstrated an integrated sensor suite for real-time monitoring of an advanced turbine's operational performance, and demonstrated in-situ single crystal blade welding and repair techniques. In FY 2004, the R&D will focus on combustor performance and design using coal derived syngas, models/simulation tools for low-emission combustion systems, and tools that can predict reliability, availability, and maintainability. In FY 2005, hybrids activities will focus on the continued development of sub-MW scale SECA fuel cell turbine hybrids, hybrids advanced cycles and component development, and systems and cost studies of advance zero emissions and/or hybrid systems. Additionally, work will be done through the University Turbine Systems Research Consortium to initiate studies concerning aerodynamics, materials, heat transfer and combustion for advanced hybrid systems. NETL will initiate the operation of a fuel cell/turbine hybrid simulation facility (HYPER Project). The hydrogen turbine work will include the initiation of work done through the University Turbine Systems Research Consortium targeted to resolve basic turbine issues associated with materials, combustion, and aero-thermal sciences that are applicable to hydrogen turbines in gasification. Work conducted at NETL will focus on performance validations of simulation of hydrogen combustor, measurements of flame electrical impedence in a full-scale combustor and development of test combustor concepts for syngas testing. Work at GE will be refocused to develop new methodology for advanced sensors and controls for coal/IGCC, and demonstrate the methodology in operating coal/IGCC power plants. Work initiated in FY 2004 with BBFA awards will continue on syngas combustion and cycle improvements a new designs for hydrogen turbines components with increased efficiencies and reduced emissions.

Vision 21 is a long-term concept, the ultimate manifestation of which is the FutureGen project. The Vision 21 concept will lead to the development of technologies that convert a combination of feedstocks (e.g., coal, natural gas, biomass, and opportunity fuels such as petroleum coke or heavy oil resid (refinery wastes) to electricity, heat (e.g., steam), and a suite of high-value products that may include

synthesis gas, hydrogen, chemicals, and saleable by-products (e.g., sulfur and ash or slag). Research and development continues on key enabling technologies, supporting R&D, and systems analyses, simulations and integration through the government/industry/laboratory/university cost-shared partnership based on the gasification route in the Vision 21 technology roadmap.

Detailed Justification

(dollars in thousands)

	FY 2003	FY 2004	FY 2005
Innovations for Existing Plants	**21,566**	**21,729**	**18,050**

The FY 2005 request emphasizes field testing and evaluation of retrofit mercury technology. In addition, research will be carried out in the development of NO_x, and acid gas (SO_3, HC1, and HF) control technologies, as well as in mercury emission, transport, and deposition assessment, technological solutions to emerging energy-water issues, determining $PM_{2.5}$ source-receptor relationships as they relate to coal-fired power plant emissions and human health, and environmental characterization of coal-combustion and gasification and other advanced power system byproducts. This research directly supports the goals of both the President's Clear Skies and FutureGen initiatives.

- **Super Clean Systems** **1,485** **1,466** **1,485**

  In FY 2005, Super Clean Systems research focuses on reducing nitrogen oxide (NO_x) emissions from coal-based power plants in direct support of the Clear Skies Initiative. Work will continue on development of ultra low-NO_x combustor for integrated gasification combined cycle systems resulting from FY 2002 Broad Based solicitation. Research will also continue under FY 2004 targeted solicitation to develop advanced combustion NO_x control technology, novel catalysts and non-ammonia reagents for SCR systems, and advanced "smart systems" to achieve a mid-term (2010) emission target of <0.10 lbs/mmBtu and a long-term (2020) target of <0.01 lbs/mmBtu. *Participants include: Argonne National Lab, Precision Combustion, TBD.*

  In FY 2004, Super Clean Systems research focuses on reducing emissions of primary oxides associated with NO_x and SO_x pollution in support of the Clear Skies Initiative. The work will complete Ultra-low NO_x Burner development, and continue development and pilot-scale testing of novel NO_x control technology concepts selected under the FY 2002 Broad Based Solicitation and under an FY 2003 targeted solicitation. *Participants include: Argonne National Lab, GTI, Praxair, Wiley, Precision Combustion, TBD.*

  FY 2003 funding continued development of ultra-low NO_x combustion systems, oxygen-enhanced combustion, Methane-deNO_x technology, and approaches to controlling NO_x in cyclone boilers.

(dollars in thousands)

FY 2003	FY 2004	FY 2005

- **Fine Particulate Control/Air Toxics**..... **14,217** **13,689** **9,949**

  In FY 2005, focus on continuation of Phase II field testing of advanced mercury control technologies selected under FY 2003 targeted solicitation capable of achieving 50-70% mercury removal in direct support of Clear Skies Initiative, including a second round of awards made in late FY 2004. Research directed at lower-rank coals and balance-of-plant issues. Complete pilot-scale testing of novel mercury/multi-pollutant control concepts capable of >90% mercury capture. Complete mercury, trace metal, and fine particulate transport and deposition model for upper Ohio River valley region. Continue assessment of relationship between emissions from coal-fired power plants and human health. Continue study of mercury emission, transport, and deposition as it relates to local "hot spots" and global mercury inventory. Initiate acid gas control technology research. *Participants include: Brookhaven National Lab, Argonne National Lab, Lawrence Berkley National Lab, ATS, SRI, University of Utah, TVA, TBD.*

  FY 2004, In support of Clear Skies Initiative, continue Phase II field testing of advanced mercury control technologies to achieve 50-70% mercury removal directed at lower rank coals and balance-of-plant issues. Continue bench- and pilot-scale development of novel technology to achieve 90%+ mercury capture. Develop fine particulate and acid gas control and sensor technology selected under FY 2002 solicitation. Continue with more comprehensive modeling assessment of fine particulate and mercury source-receptor relationships. Continue projects selected in FY 2003 to address energy-water issues. *Participants include: Brookhaven National Lab, Argonne National Lab, Lawrence Berkley National Lab, ATS, CONSOL, URS, CMU, SRI, Powerspan, Apogee, TVA, UMD, BNL, LBL, RBD.*

  FY 2003 funding continued field testing of two advanced mercury control technologies - sorbent injection and wet-FGD enhancement - to achieve 50-70% mercury control and continued pilot-scale development of six novel mercury control concepts capable of achieving +90% control. Completed pilot-scale development and testing of additives to improve fine particulate capture in ESPs, alkaline injection for controlling acid gas emissions, and an advanced fine particle separation technology. Completed collection of ambient $PM_{2.5}$ samples from the upper Ohio River Valley region. Initiated development of on-line continuous SO_3 analyzer and study of in-plume mercury reactions. *Participants included: ATS, LSR, CONSOL, ADA-ES, MTI, Southern Research Institute, CMU, URS, UNDEERC, Apogee, REI, Powerspan, GE-EERC, BNL, ANL, TVA..*

- **In-House**..... **3,663** **3,911** **3,960**

  In FY 2005, continue development of novel mercury control concepts and mercury emission characterization using 500 lb/hour combustion unit. Continue CFD modeling of mercury emission and control, issue analysis, by-product characterization, and water-related research in support of FutureGen and Clear Skies. Provide for customer service and business activities. *Participants include: NETL.*

(dollars in thousands)

FY 2003	FY 2004	FY 2005

FY 2004, Research and systems analysis was conducted on novel multi-pollutant control, mercury control and characterization, by-product characterization, and water-related issues in support of zero-emissions for FutureGen and Clear Skies. Provide for customer service and business activities. *Participants include: NETL.*

FY 2003 funding continued development of mercury control technologies and characterization of mercury emissions in 500 lb/hour combustor and collection of ambient $PM_{2.5}$ data from Pittsburgh campus monitoring site. Initiate computational fluid dynamic (CFD) modeling of mercury emission and control. Continued evaluation of mercury and other metal leachates from coal combustion byproducts. *Participants included: NETL.*

- **Waste Management** **1,980** **2,445** **2,475**

In FY 2005, assess potential environmental impacts of coal combustion and advanced combustion/gasification byproducts and solid residues, focusing on mercury and other trace metals, in support of both FutureGen and Clear Skies. Continue characterization of coal byproducts from Phase II mercury control technology field testing initiated under FY 2004 targeted solicitation. Conduct joint industry/government R&D activities to maximize recycle use of coal utilization byproducts for various market applications, and facilitate technology transfer. Complete development of byproduct treatment and separation technology selected under FY 2003 Broad Based solicitation. Continue advanced concepts and technologies selected under the FY 2003 targeted solicitation to manage power plant water use. *Participants include: Argonne National Lab, WVU, PPL, UNDEERC, University of Kentucky.*

FY 2004, Continue assessment of environmental impacts of coal combustion and gasification byproducts and solid residues, focusing on mercury and other trace metals. Conduct joint industry/government R&D activities to maximize recycle use of coal utilization byproducts for various market applications, and facilitate technology transfer. Continue development of byproduct treatment and separation technology selected under FY 2003 Broad Based solicitation. Initiate projects selected under the FY 2003 targeted solicitation to maximize water utilization efficiency with minimal environmental impact. *Participants include: WVU, PPL, UNDEERC.*

FY 2003 funding continued development of ozone-based unburned carbon separation technology and evaluation of mercury leaching and volatilization from coal byproducts. Initiated assessment of coal drying technology to reduce cooling water makeup requirements. Continued development of high-volume applications for coal byproducts. *Participants included: University of Kentucky, PPL Generation, EPRI, UNDEERC, Lehigh University, CONSOL, WVU.*

- **Vision 21** **0** **0** **0**

Beginning in FY 2003 and continuing in FY 2004 and FY 2005, activities that are focused on efficiency issues are addressed under the Advanced Research Materials program.

(dollars in thousands)

	FY 2003	FY 2004	FY 2005
• **Program Support**	**221**	**218**	**181**
Fund technical and program management support.			
Advanced Systems	**69,928**	**68,151**	**46,450**
Advanced Systems focus on the development of critical enabling technologies and systems for new, cost-competitive plants with increasingly higher efficiencies and inherent ultra-low emissions that support the President's Clear Skies and Global Climate Change, and FutureGen initiatives, leading ultimately to near-zero emission Vision 21 power plants compatible with carbon sequestration.			
Integrated Gasification Combined Cycle	**43,301**	**50,372**	**34,450**
• **Gasification Systems Technology**	**20,352**	**29,334**	**15,305**

Gasification: In FY 2005, the primary focus of the Power Systems Development Unit (PSDF) will be on preparation of the facility for testing advanced Vision 21 modules while continuing to characterize the operation of the oxygen-blown transport gasifier on a range of coal feedstocks including lignite. Validation of the CFD model for the transport gasifier will continue using performance data from the PSDF, the Transport Reactor Development Unit (TRDU), and the cold model at NETL.

Gas Cleaning/Conditioning: In FY 2005, R&D will focus on achieving near-zero emissions from gasification-based systems. Operation of the Gas Process Development Unit for obtaining scale-up data for the design of transport desulfurizer using the RT13 sorbent at moderate temperatures will be completed. Validation of the transport desulfurizer CFD model will be completed using performance data from the GPDU and integrated testing with a 2.5 ton/day pilot-scale coal gasifier. Continue R&D to develop advanced concepts for removing mercury, ammonia, and chlorides to near-zero levels suitable for use in fuel cell and synthesis gas conversion applications. Construction of a skid-mounted unit of the Selective Catalytic Oxidation of Hydrogen Sulfide (SCOHS) process will be initiated. A go/no decision on field testing of the Single-step Sulfur Reduction Process (SSRP) will be made based on prior experimental and economic performance. *Participants include: SCS, NETL, UNDEERC, Fluent, RTI.*

Gasification: In FY 2004, continue to develop and test the oxygen-blown transport gasifier and associated particulate control devices at the PSDF to reduce cost and improve reliability of gasifier technology. Primary focus at the PSDF will be on oxygen-blown operations to provide options for producing hydrogen and capturing CO_2 and multi-fuel capability to enhance the applicability of the technology. Validate the oxygen-blown transport gasifier CFD model using data generated from the PSDF and the Transport Reactor Development Unit (TRDU) using various coal feedstocks. Utilize the TRDU to pre-screen coal feedstocks, alternative feed

systems, and process conditions to provide guidance for testing at the PSDF. Develop advanced materials for refractories and thermocouples to improve refractory performance and improve gasifier reliability. Test prototype refractory bricks in a commercial coal gasifier to demonstrate performance under actual operating conditions, and begin to install a novel high temperature measurement device to demonstrate improved gasifier performance and process control. Continue development of other advanced technologies such as burner flame monitoring, refractory wear monitoring, diffusion coatings, etc. to improve the reliability, availability, and performance of gasifiers. Investigate fundamental pre-competitive technology issues and needs to improve gasification process performance and reliability through the Gasification Technology Research Consortium.

Gas Cleaning/Conditioning: In FY 2004, efforts are directed to obtaining near-zero emissions from gasification based systems including construction of a gas cleanup module at PSDF to pave the way for Vision 21 testing of advanced modules for carbon capture and near-zero emission gas cleaning technologies. Development of advanced sorbents for achieving ultra-low sulfur levels of all contaminants at moderate temperatures. Operate the Gas Process Development Unit's (GPDU) using the RT13 sorbent at moderate temperatures in the transport mode to provide design data for scale-up of the technology. Continue validation of the transport desulfurizer CFD model using data from the GPDU and data generated in a pilot-scale test facility integrated with a coal gasifier. Develop the novel Selective Catalytic Oxidation of Hydrogen Sulfide (SCOHS) technology and begin bench-scale evaluations for proof-of-concept testing of the technology to demonstrate ultra-low sulfur emissions at reduced cleanup costs. *Participants include: SCS, NETL, UNDEERC, Fluent, RTI, Albany, ChevronTexaco, VPI, FluoreScience, IET, GTI, GEC, MSE, SRI, and Comb Spec.*

In FY 2003, the transport gasifier and associated particulate control devices will be further developed under oxygen-blown conditions at the PDSF. The TRDU will pre-screen coal feedstocks and process conditions for testing at the PDSF. Bituminous coals will be processed at the PSDF to determine the applicability of the gasifier for high rank coals. A new dry coal feed system will be evaluated to reduce cost and improve performance over conventional lock hopper feed systems. Performance of new refractory bricks under simulated gasifier conditions will be evaluated, and if successful, bricks will be installed in high wear areas of Eastman Chemicals' coal gasifier in Kingsport, TN. Development of technologies to improve the reliability, availability, and performance of gasifiers will continue with testing of one high-temperature measurement device on the TECO IGCC gasifier. The Gas Process Development Facility (GPDU) will be operated using the EXSO3 sorbent developed previously for hot gas desulfurization and will transition to lower temperature operations to support the scale-up of the RT13 sorbent. Development of the Selective Catalytic Oxidation of Hydrogen Sulfide (SCOHS) process will continue to confirm process performance at the laboratory scale in preparation for future bench-scale testing.

(dollars in thousands)

FY 2003	FY 2004	FY 2005

- **Systems Analysis/Product Integration** **2,843** **3,912** **4,000**

  In FY 2005, work will continue on assessing the economics of advanced Vision 21 process concepts and establishing performance targets for novel process concepts in the R&D program. Work at the PSDF will focus on developing integration strategies for advanced process concepts and developing experimental programs, cost, and schedules for testing the various technologies. The final reports on the final phases of the Early Entrance Coproduction Plant project for the production of electricity, fuels, and hydrogen will be prepared. Engineering support will be provided as needed for the development and evaluation of the FutureGen project. The update of the worldwide gasification database with the latest plant project announcements will be completed. *Participants include: NETL, CTC, E2S, Mitretek, SCS, ChevronTexaco, GE, Praxair, Parsons, GTC.*

  In FY 2004, complete engineering designs of Early Entrance Coproduction Plants for clean fuels like hydrogen and high efficiency power productions as pre-Vision 21 concepts. Continue systems analyses for research guidance and product outreach activities. Update the worldwide gasification database. Establish size of standardized IGCC plants from market analysis and begin design of modular unit to reduce plant cost, shorten plant startup schedule, and improve system reliability. *Participants include: NETL, CTC, E2S, Mitretek, SFA, Pacific, Texaco, Parsons, WMPI, GE, KBR, Praxair.*

  In FY 2003, work is continuing on risk mitigation for the Early Entrance Co-production Plants and the results were used to update the preliminary process design and analysis. The co-production design optimization study is being completed and a comprehensive report will be issued. Systems studies are being conducted to evaluate the cost and performance improvements of all technologies being developed and will be used to develop a comprehensive program roadmap. The biannual update of the world-wide gasification database was performed. *Participants included: NETL, CTC, E2S, Mitretek, SFA Pacific, ChevronTexaco, Parsons, WMPI, GE, KBR, Praxair, Global Energy, Dow Corning, Dow Chemical, Siemens Westinghouse, Methanex, Nexant.*

- **Vision 21**..... **19,662** **16,622** **14,800**

  In FY 2005, efforts will focus on the development of novel technologies that lead to ultra-high efficiencies, the production of hydrogen for ultra-clean fuels, and the elimination of all environmental issues that present barriers to the continued use of coal, including reductions of SO_2, NO_x, CO_2 particulates, and trace elements such as mercury, arsenic, cadmium, and selenium. Laboratory testing of improved materials for membrane-based air separation technologies and life testing of commercial membrane elements will be completed. The design of a 25-50 ton/day air separation module for integrated testing with a gas turbine and coal gasifier to address overall system performance and integration issues will begin. Development of novel process concepts for the production of hydrogen and the capture of CO_2 for sequestration will

(dollars in thousands)

FY 2003	FY 2004	FY 2005

continue at a minimal level. Work on developing improved membranes for hydrogen/ CO_2 separation will continue with focus on developing and optimizing the membrane fabrication process and addressing performance characteristics under actual process conditions. Continue fabrication of a skid-mounted process unit to demonstrate they hydrate process for separation of hydrogen and CO_2 from shifted synthesis gas. Testing of an advanced polymer membrane that removes CO_2, and H_2S from either a raw or shifted synthesis gas stream in conjunction with a pilot-scale coal gasifier will be completed. Complete a 500 hour integrated test of the transport desulfurizer, the direct sulfur reduction process, and advanced technologies for the removal of mercury, ammonia, and chlorides in conjunction with a 2.5 ton/day pilot-scale coal gasifier to assess technology performance on coal-derived synthesis gas. *Participants include: APCI, Praxair, ANL, Concepts NREC, Ceramatec, ChevronTexaco, PSU, Penn, Nexant, RTI, Medal, Protech, IGT, Siemens-Westinghouse, NETL, Eltron, Coorstech, Noram, Sud Chemie, SIR, KBR.*

In FY 2004, to achieve the Vision 21 program goals, develop novel technologies that lead to ultra-high efficiencies, near-zero emissions, carbon capture for sequestration and the production of hydrogen for ultra-clean fuels and powers. Scale-up and test ceramic membrane modules for advanced air separation at the 1-5 ton/day scale to reduce the cost of oxygen and pave the way for the economical capture of CO_2. Begin initial planning of 50 ton/day membrane modules for integration with a gasifier and gas turbine. Investigate improved membrane materials, fabrication techniques, and module design for H_2/CO_2 separations to address capture of CO_2 and for producing low-cost hydrogen from coal. Conduct life testing of advanced ceramic hydrogen membranes and develop conceptual process designs. Construct a polymer hydrogen membrane module for integrated testing with a pilot-scale coal gasifier to address performance under actual process conditions. Construct skid-mounted unit for the development of the low temperature hydrate technology to demonstrate effective carbon management by separating hydrogen and carbon dioxide and begin preliminary site evaluation for integration with a gasifier. Investigate advanced gas cleaning technologies to meet near-zero emission requirements in response to the Clean Skies Initiative. Begin testing of an advanced sulfur cleanup technology integrated with a pilot-scale coal gasifier to evaluate process performance under realistic conditions. Construct skid-mounted process units for mercury, ammonia, and chloride control for possible integrated testing with a pilot-scale coal gasifier. Complete conceptual design and economic analysis of a novel coal gasification concept for producing hydrogen and sequestration-ready CO_2 that has potential for cost reductions over conventional approaches. *Participants include: APCI, Praxair, ANL, Concepts NREC, Ceramatec, ChevronTexaco, PSU, Penn, Bechtel, LANL, RTI, Medal, Protech, IGT, Siemens-Westinghouse, NETL, GEERC, INT, Eltron, Coors, INEEL, Sud Chemie, SRI, ORNL, McDermott, KBR.*

In FY 2003, negotiations with ChevronTexaco will be completed on the testing of the RT13 advanced transport sorbent integrated with their pilot-scale coal gasifier. The transport desulfurizer module will be designed, constructed, and installed in preparation for a 500-1000 hour test run. Investigation of ammonia, chloride, and mercury removal approaches will focus on

(dollars in thousands)

obtaining sufficient performance and process data to design modules for integration with a pilot-scale coal gasifier. Laboratory scale testing of advanced ceramic air separation membranes will be completed to provide process design data for the 1-5 TPD engineering-scale unit and to finalize the design of the commercial-scale modules. Preliminary investigations of potential sites for integrated testing of the membrane modules with a gasifier and gas turbine will commence. Development of ceramic-based H_2/CO_2 membranes will focus on further increases in H_2 flux to achieve commercially relevant flux targets. Development of the polymer-based membrane for H_2/CO_2 separation will focus on further testing of the membrane to improve CO_2 flux and to obtain engineering data for the design of a module for integration with a pilot-scale coal gasifier. Engineering data will be obtained from a laboratory-scale flow unit for the CO_2 hydrate process to establish the design basis for a skid-mounted unit. Initial study on the feasibility of a novel gasification concept for producing hydrogen and sequestration-ready CO_2 will be completed. *Participants included: APCI, Praxair, ANL, Concepts NREC, Ceramatec, ChevronTexaco, PSU, Penn, Bechtel, LANL, RTI, Medal, Protech, IGT, Siemens-Westinghouse, NETL, REI, GEERC, INT, Eltron, Coors, INEEL, Sud Chemie, SRI, ORNL, McDermott, KBR.*

• **Program Support**	**444**	**504**	**345**

Fund technical and program management support.

Combustion Systems	**10,097**	**4,939**	**0**
• **Gas Stream Cleanup**	**5,310**	**1,350**	**0**

In FY 2005, there are no activities planned.

In FY 2004, efforts are directed toward completing key cleanup projects for qualifying candle filters in pressurized applications, improving environmental control technology in CFB systems, and development of ammonia free NO_x control systems. *Participants include: Foster Wheeler, WKU Research Foundation.*

FY 2003 funding continued development of hot gas filters, a number of hot gas filter materials, certain designs validated and a broad fail safe development initiated at the PSDF. Pilot plant testing of partial gasification Vision 21 modules was undertaken and the first tests of various coal and biomass were completed, including one run oxygen in place of air. *Participants included: Southern Co.*

• **Hybrid Combustion**	**4,227**	**3,539**	**0**

In FY 2005, there are no activities planned.

In FY 2004, efforts will be focused on the development of novel technology in hybrid combustion-gasification; catalytic unmixed combustion of coal; high pressure coal combustion kinetics and continuous pressure feeds for solid feedstocks to validate the engineering, economic

and environmental viability to meet Vision 21 performance targets. *Participants include: Foster Wheeler, ALSTOM, GEGR, Stamet, Fluent, Inc.*

FY 2003 funding continued development of Vision 21 hybrid system enhancements and design optimization studies were undertaken as well as development of novel hybrid concepts. Two hybrid site specific repowering studies were completed and accepted by participating utilities. *Participants included: NETL, Alstom*

- **Vision 21** **457** **0** **0**

This activity was concluded in FY 2004 and folded into the gasification activity.

In FY 2003, Vision 21 combustion kinetic studies and testing were initiated and development of viable codes were undertaken. Investigations were begun into the feasibility of enabling Vision 21 combustion technologies such as chemical looping. *Participates included: Fluent.*

- **Program Support**..... **103** **50** **0**

Fund technical and program management support.

Turbines **16,530** **12,840** **12,000**

- **Vision 21** **2,921** **0** **0**

In FY 2005, funding for this activity provides for the development and deployment of syngas/hydrogen turbines for FutureGen power systems. All work in this key activity, will be conducted within the Next Generations Turbines subprogram area. Funding activities will be directed towards the reduction of NO_x emissions, efficiency improvements and technical issues associated with the combustion of high hydrogen fuels. Support for SECA based Vision 21 fuel cell hybrids will be continued under the Distributed Generation Fuel Cell Program.

In FY 2004, this activity is continued in the Next Generation Turbines subprogram described below.

In FY 2003, conducted enabling R&D for coal-based turbine systems, and initiated an accelerated effort to determine the path forward for SECA based turbine hybrids.

- **Next Generation Turbines** **13,440** **12,712** **11,880**

In FY 2005, the DOE-Office of Fossil Energy will transition the Turbine Program, which is focused on the adaptation of existing advanced turbines for applications to coal derived synthesis gas, to a Syngas/Hydrogen Turbine Program. The Syngas/Hydrogen Turbine Program is designed to support the successful deployment of FutureGen type power systems. FutureGen plants will allow the continued use of coal our nation's largest source of fossil fuel and provide options for the capture and sequestration of carbon dioxide. This transition can be accomplished

in a seamless fashion due to the similarities of technical issues associated with the combustion of coal derived synthesis gas and coal derived hydrogen. These similarities when compared to natural gas include one-third the heat content, higher flame speeds and typically higher post combustion moisture content. The lower heat content, higher flame speed and high post combustion moisture content offer significant technical challenge to develop highly efficient and clean burning combustion turbines for FutureGen applications.

The FY 2005 program will build upon work initiated in FY 2004 to address technical issues and ultimately provide turbine designs capable of burning up to 100% hydrogen in a 2008 time frame. These turbines could then be applied to FutureGen designs. The relevant technical issues are driven by the need to produce highly efficient systems with near zero emissions of NO_x emission to less than 3 ppm is being addressed through fuel pre-mixing and catalytic combustion concepts. Turbine efficiency will be addressed by optimizing F- and G-class machines for hydrogen combustion that yields higher first stage turbine inlet temperature and machines that are fully integrated with the air separation unit and steam cycle. It is expected that work to improve efficiency will address better thermal barrier coatings, better methods for blade cooling, optimizing the mass throughout and aerodynamics, and extending or realizing the full torque limitations of existing machines.

New work will be initiated to further resolve technical issues associated with the use of hydrogen fuels from FutureGen power plants. Work initiated in FY 2004 will continue as appropriate on high hydrogen fuel combustion for NO_x reduction and efficiency improvements. This work includes GE's efforts to assess premixing issues associated with high hydrogen fuels and integration issues of F-class machines in coal based plants. Work by Pratt & Whitney and Siemens Westinghouse will continue to explore catalytic combustion for NO_x reduction through the extension of the lean premix limit through hydrogen doping. Work will continue and new work initiated through the University Turbine Systems Research Consortium concerning aerodynamics, materials, heat transfer and combustion of coal derived syngas and hydrogen fuels. NETL will continue the simulation and validation of combustion phenomena associated high hydrogen content fuels. Funding for the operation of a fuel cell/turbine hybrid simulation facility (HYPER Project) will continue under the Turbine Program. *Participants include: GE, Siemens Westinghouse, Clemson-University Turbine Systems Research Consortium, NETL, TBD.*

FY 2004, the Turbine Program continues to focus on key technologies needed to enable the development of advanced turbines that will operate cleanly and efficiently when fueled with coal derived synthesis gas and high hydrogen content fuels. Developing turbine technology to operate on coal derived synthesis gas and hydrogen is critical to the development of advanced power generation technologies such as integrated gasification combined cycle and deployment in FutureGen systems. Turbine R&D will focus on the adaptation of existing F- and G-class machines for application to coal-derived synthesis gas. Studies will be initiated to identify candidate technical approaches and combustion turbines for optimization/modification in IGCC

(dollars in thousands)

FY 2003	FY 2004	FY 2005

systems. These studies will determine the technologies and modifications needed to meet goals for the near zero emissions, higher efficiency and machines that produce a lower cost of electricity for application to coal derived syngas and hydrogen fuels. These scoping studies will provide the direction, scope and approach for activities to follow in FY 2005-FY 2008. *Participants include: GE, SWPC, Praxair, EPRI, NETL, UTSR-SCIES, Florida Turbine Tech., ORNL, ANL, and TBD.*

In FY 2003, completed studies to assess ATS and other machines for operation on coal syngas, as well as ATS machines in coal and natural gas based integrated hybrid power modules, completed demonstration of low-emission steam generator, demonstrate an integrated sensor suite for real-time monitoring of an advanced turbine's operational performance, and demonstrated in-situ single crystal blade welding and repair techniques. *Participants included: GE, SWPC, Solar, EPRI, NETL, SCIES, U. of CA-Irvine, CFD Research, ORNL, ANL.*

- **Program Support**..... **169** **128** **120**

  Fund technical and program management support.

Total, Central Systems..... **91,494** **89,880** **64,500**

Explanation of Funding Changes

	FY 2005 vs. FY 2004 ($000)
Innovations for Existing Plants	
• Decrease in Fine Particulate Control/Air Toxics funding available for projects to be selected under Round II of FY 2004 Phase II Hg Field Testing solicitation focused on low-rank coals, smaller bituminous coal units, cost and performance data, and balance-of-plant issues	-3,740
• Increase in Super Clean Systems funding available for Advanced NO_x Control Technology solicitation	+19
• Increase in In-House Research funding available for Hg control technology development and coal combustion byproducts characterization	+49
• Increase in Waste Management funding available for characterization of coal byproducts from Phase II Hg field testing projects	+30
• Program Support	-37
Total, Innovations for Existing Plants	**-3,679**
Advanced Systems	
Integrated Gasification Combined Cycle (IGCC)	
• Decrease in Gasification Systems Technology key activity will significantly reduce or terminate all projects focusing on advanced gasification concepts and improving the reliability and performance of gasifier technology through the development of advanced materials and instrumentation	-14,029
• Increase in Systems Analysis/Production Integration	+88
• Decrease in Vision 21 key activity will significantly reduce the level of effort on projects focusing on the development of advanced hydrogen/carbon dioxide separation technologies for carbon sequestration	-1,822
• Program Direction	-159
Total, Integrated Gasification Combined Cycle	**-15,922**

	FY 2005 vs. FY 2004 ($000)
Combustion Systems	
• Decrease in Gas Stream Cleanup activities as existing projects are concluded	-1,350
• Decrease in Hybrid Combustion activities as existing projects are concluded	-3,539
• Program Direction	-50
Total, Combustion Systems	**-4,939**
Turbines	
• Increase in Vision 21result of turbines for hybrids initiatives	+3,600
• Decrease in Next Generation Turbines due to restructuring to focus on hydrogen turbines	-3,600
• Program Support	-840
Total, Turbines	**-840**
Total, Advanced Systems	**-21,701**
Total Funding Change, Central Systems	**-25,380**