

February 2009

CLEAN COAL

DOE's Decision to Restructure FutureGen Should Be Based on a Comprehensive Analysis of Costs, Benefits, and Risks



GAO

Accountability * Integrity * Reliability



Highlights of [GAO-09-248](#), a report to congressional requesters

Why GAO Did This Study

Coal-fired power plants generate about one-half of the nation's electricity and about one-third of its carbon dioxide (CO₂) emissions, which contribute to climate change. In 2003, the Department of Energy (DOE) initiated FutureGen—a commercial-scale, coal-fired power plant to incorporate integrated gasification combined cycle (IGCC), an advanced generating technology, with carbon capture and storage (CCS). The plant was to capture and store underground about 90 percent of its CO₂ emissions. DOE's cost share was 74 percent, and industry partners agreed to fund the rest. Concerned about escalating costs, DOE restructured FutureGen. GAO was asked to examine (1) the original and restructured programs' goals, (2) similarities and differences between the new FutureGen and other DOE CCS programs, and (3) if the restructuring decision was based on sufficient information.

GAO reviewed best practices for making programmatic decisions, FutureGen plans and budgets, and documents on the restructuring of FutureGen. GAO contacted DOE, industry partners, and experts.

What GAO Recommends

GAO recommends that DOE re-examine its restructuring decision, based on the comparative costs, benefits, and risks of the original and restructured programs, as well as other incremental options for modifying the original program. DOE provided technical comments but did not comment on the report's recommendations.

To view the full product, including the scope and methodology, click on [GAO-09-248](#). For more information, contact Mark E. Gaffigan at (202) 512-3841 or gaffiganm@gao.gov.

CLEAN COAL

DOE's Decision to Restructure FutureGen Should Be Based on a Comprehensive Analysis of Costs, Benefits, and Risks

What GAO Found

The original FutureGen program and the new restructured FutureGen program attempt to use CCS at coal-fired power plants to achieve near-zero CO₂ emissions and to make CCS economically viable. However, they take different approaches that could affect CCS's commercial advancement. First, the original program aimed at developing knowledge about the integration of IGCC and CCS at one plant; in contrast, the new program could provide opportunities to learn about CCS at different plants, such as conventional ones that use pulverized coal generating technology. Second, the original program was operated by a nonprofit consortium of energy companies at one plant, while the new program called for CCS projects at multiple commercial plants.

The new, restructured FutureGen differs from most DOE CCS programs. The new FutureGen would develop and integrate multiple CCS components at coal-fired plants (including CO₂ capture, transportation, and storage underground). Other programs concentrate on only one CCS component and/or a related component (e.g., capture or capture and compression). However, Round III of DOE's Clean Coal Power Initiative (CCPI) is a cost-shared partnership with industry that funds commercial CCS demonstrations at new and existing coal-fired plants. The new FutureGen is most like CCPI in that both fund CCS commercial demonstrations at several plants to accelerate CCS deployment and require that participants bear 50 percent of the costs, but DOE expects the new FutureGen to have more funding for commercial demonstrations than CCPI. Moreover, the new FutureGen targets a higher amount of CO₂ to be captured and stored (at least 1 million metric tons of CO₂ annually per plant) than CCPI (300,000 metric tons).

Contrary to best practices, DOE did not base its decision to restructure FutureGen on a comprehensive analysis of factors, such as the associated costs, benefits, and risks. DOE made its decision, largely, on the conclusion that costs for the original FutureGen had doubled and would escalate substantially. However, in its decision, DOE compared two cost estimates for the original FutureGen that were not comparable because DOE's \$950 million estimate was in constant 2004 dollars and the \$1.8 billion estimate of DOE's industry partners was inflated through 2017. As its restructuring decision did not consider a comprehensive analysis of costs, benefits, and risks, DOE has no assurance that the restructured FutureGen is the best option to advance CCS. In contrast to the restructuring decision, DOE's Office of Fossil Energy had identified and analyzed 13 options for incremental, cost-saving changes to the original program, such as reducing the CO₂ capture requirement. While the Office of Fossil Energy did not consider all of these options to be viable, it either recommended or noted several of them for consideration, with potential savings ranging from \$30 million to \$55 million each.

Contents

Letter		1
	Results in Brief	6
	Background	8
	The Goals of the Original and Restructured FutureGen Programs Are Largely Similar, but the Programs' Different Approaches May Lead to Different Results	12
	The Restructured FutureGen Differs from Most of the Other DOE Carbon Capture and Storage Programs, but It Is Similar to CCPI in Several Ways	17
	DOE Did Not Support Its Decision to Restructure FutureGen with Sufficient Information on Costs, Benefits, or Risks	24
	Conclusions	31
	Recommendations for Executive Action	32
	Agency Comments and Our Evaluation	32
Appendix I	Scope and Methodology	34
Appendix II	Budget Authority and Obligations for FutureGen	38
Appendix III	Comments from the Department of Energy	39
Appendix IV	GAO Contact and Staff Acknowledgments	48
Tables		
	Table 1: Storage and Emissions Goals for the Original and Restructured FutureGen Programs	13
	Table 2: Key Differences in the Approaches of the Original and Restructured FutureGen Programs	15
	Table 3: DOE Programs Supporting Carbon Capture and Storage	22
	Table 4: DOE Budget Authority and Obligations for FutureGen, Fiscal Years 2004 through 2008	38

Abbreviations

Alliance	FutureGen Industrial Alliance
Btu	British Thermal Units
CCPI	Clean Coal Power Initiative
CCS	carbon capture and storage
CO ₂	carbon dioxide
DOE	Department of Energy
EOR	enhanced oil recovery
FE	Office of Fossil Energy
IGCC	Integrated Gasification Combined Cycle
IPCC	Intergovernmental Panel on Climate Change
NEPA	National Environmental Policy Act of 1969
NETL	National Energy Technology Laboratory
syngas	synthesis gas

This is a work of the U.S. government and is not subject to copyright protection in the United States. The published product may be reproduced and distributed in its entirety without further permission from GAO. However, because this work may contain copyrighted images or other material, permission from the copyright holder may be necessary if you wish to reproduce this material separately.



United States Government Accountability Office
Washington, DC 20548

February 13, 2009

The Honorable Bart Gordon
Chairman
Committee on Science and Technology
House of Representatives

The Honorable Brian Baird
Chairman
Subcommittee on Energy and Environment
Committee on Science and Technology
House of Representatives

The Honorable Daniel Lipinski
House of Representatives

The Honorable Jerry Costello
House of Representatives

Key scientific assessments have underscored the urgency of reducing carbon dioxide (CO₂) emissions to help mitigate climate change. Given the United States' heavy reliance on coal-fired power plants, which emit significant quantities of CO₂, many of these scientific assessments have cited carbon capture and storage (CCS), a developing technology, as a crucial component of any strategy for addressing climate change. CCS involves separating CO₂ from other gases emitted in power plants; capturing the CO₂; compressing it into a liquid form; transporting it (for example, by pipeline) to suitable locations; injecting it into deep underground geologic formations, such as depleted oil reservoirs and saline formations, for long-term storage; and finally, monitoring the presence of the CO₂ at the storage site for a long period of time. Developing CCS is particularly important since total world CO₂ emissions are expected to increase significantly in the near future as the United States continues to use its large coal reserves and as rapidly developing countries, such as China and India, increasingly rely on coal to generate electricity. To date, however, CCS has not been demonstrated on a commercial scale at a power plant, although key stakeholders, such as the International Energy Agency, an organization that advises 28 member countries on energy policy, have noted the importance of commercial-scale demonstration projects for advancing the technology's widespread commercialization.

In 2003, the Department of Energy (DOE) announced its FutureGen program as a \$1 billion venture, partnering with the electric power industry to design, build, and operate the world's first coal-fired, zero-emissions power plant. In 2005, the FutureGen Industrial Alliance (Alliance), a nonprofit consortium of some of the largest coal producers and electric power companies in the world, formed to join DOE in this effort. The Alliance agreed to fund 26 percent of the program, and DOE agreed to fund the remaining 74 percent—of which DOE anticipated receiving funding contributions for about 8 percent of the program's total cost from foreign government partners. The agreement was subject to renegotiation and renewal or continuation by both DOE and the Alliance at various stages. In addition to FutureGen, DOE has other clean coal programs with CCS components. For example, Round III of the Clean Coal Power Initiative (CCPI) seeks cost-shared partnerships with industry to fund commercial CCS demonstration at coal-fired power plants.

FutureGen was originally conceived as a research and development project to integrate CCS with another developing technology—integrated gasification combined cycle (IGCC)—in a single power plant at commercial scale.¹ In IGCC power plants, coal is gasified to produce a synthesis gas (syngas), consisting primarily of hydrogen, carbon monoxide, and CO₂. In a process called precombustion CCS, the CO₂ is removed and separated from the syngas before the gas is burned in a combustion turbine to generate electricity. Through IGCC, electricity is generated more efficiently than through conventional pulverized coal-fired technology, the process most widely in use, because IGCC uses less coal to generate the same amount of electricity. In addition, oxygen-fired IGCC plants produce CO₂ as a concentrated gas stream at high pressure that may be captured and stored more easily and cheaply than CO₂ from a typical pulverized coal-fired power plant, which emits CO₂ that must be separated from other gases before storing. Construction on FutureGen was scheduled to begin in 2009, and operations were to begin in 2012. In that year, FutureGen was to begin capturing, storing, and monitoring the stored CO₂ for 3 to 5 years, and then continue monitoring the stored CO₂ for 2 more years. In addition, the FutureGen plant was being designed to serve

¹Currently, only two IGCC plants operate at commercial scale in the United States. In service since 1997, the Polk Station, near Mulberry, Florida, can provide 250 megawatts to the electric grid. The Wabash River Coal Gasification Repowering Project is the first full-size commercial gasification-combined cycle plant built in the United States, having begun operations in November 1995. The plant, located outside West Terre Haute, Indiana, can provide 262 megawatts to the electric grid.

as a living laboratory host facility for emerging clean coal research programs, including DOE's ongoing coal research program, to help develop advanced technologies that could (1) improve CCS and IGCC, and (2) advance research in other areas, such as hydrogen fuel cells.

By mid-2007, partly because of cost escalations for building power plants around the world, DOE had become increasingly concerned about potential escalating costs for FutureGen. For example, the price of cement, large quantities of which are required for building power plants, had increased by about 30 percent from 2004 to 2006, and certain labor costs for building power plants had increased by over 25 percent, or almost twice the rate of general inflation, from 2001 to 2007. In October 2007, to address these concerns, DOE began renegotiating its share of program costs with the Alliance. In December 2007, after DOE finished conducting the extensive environmental analyses required by the National Environmental Policy Act of 1969 (NEPA)² of four potential sites that took over a year, the Alliance announced that it had selected Mattoon, Illinois, for the location of FutureGen. However, DOE had not yet issued its NEPA Record of Decision.³ Further, DOE had advised the Alliance not to announce a site selection until the Record of Decision had been issued, as contemplated by the cooperative agreement. Subsequently, in January 2008, DOE announced that it would not continue its cooperative agreement with the Alliance and that it was going to take a different approach to FutureGen. DOE stated that this decision was based on concerns over potential cost escalations and the need to more quickly advance commercial technology.

DOE's new approach—the restructured FutureGen—focuses on demonstrating CCS at multiple new or existing commercial coal-fired power plants that may use IGCC or other types of coal plants, such as existing pulverized coal-fired power plants, which comprise 99 percent of all existing coal-fired power plants in the United States. Under the

²Pub. L. No. 91-190 (1970). Under the act, federal agencies must evaluate the likely environmental effects of their activities using an environmental assessment or, if the activity likely would significantly affect the environment, a more detailed environmental impact statement.

³The cooperative agreement originally scheduled the final site announcement to take place on September 4, 2007, contingent upon DOE's August 1, 2007, publication of the Record of Decision. On November 9, 2007, DOE issued a press release announcing the completion of its final environmental impact statement for FutureGen and that DOE anticipated site selection would be made later that year.

restructured FutureGen, DOE would fund several projects proposed by industry, including entities such as electric power companies, to add CCS to commercial power plants. The plants would begin using CCS by the end of 2015; and, as planned under the original FutureGen, they would be required to capture, store, and monitor the stored CO₂ for 3 to 5 years, and to continue monitoring the stored CO₂ for an additional 2 years. In June 2008, DOE announced that it anticipated providing up to \$1.3 billion for the entire restructured FutureGen program, with certain caps in funding for each individual project. The original FutureGen was a DOE research and development project, but the restructured FutureGen is a DOE commercial demonstration project. Under the Energy Policy Act of 2005, a nonfederal source must generally fund not less than 20 percent of a DOE research and development project and not less than 50 percent of a DOE demonstration and commercial application project—that is, industry partners share more of the costs of demonstration projects.⁴ However, with both the original and restructured FutureGen, a nonfederal source must pay at least 50 percent of any demonstration component's cost.⁵ In October 2008, DOE received a small number of applications for the restructured FutureGen; however, some of these applications are for proposals outside of the restructured FutureGen's scope. DOE is currently assessing proposals received and had stated it expected to announce a selection of projects by December 2008; however, as of the beginning of February 2009, it had made no decision. DOE requested supplemental information from restructured FutureGen applicants which will be reviewed prior to any selection decision.⁶

While IGCC is a promising technology for generating electricity from coal, currently, coal-fired electricity is almost exclusively generated in existing pulverized coal-fired power plants. In these plants, pulverized coal is combusted in air to boil water, which raises steam that, in turn, is routed

⁴Pub. L. No. 109-58 (2005), *codified at* 42 U.S.C. § 16352.

⁵In addition, beginning in fiscal year 2005, costs for the initial planning and research stages were subject to a 20 percent nonfederal cost share. According to DOE, for the restructured FutureGen, not less than a 50 percent nonfederal cost-share for all stages will be required.

⁶DOE has identified certain details regarding the negotiations for both the original and the restructured FutureGen as sensitive or proprietary information. Due to the ongoing nature of these negotiations for the restructured FutureGen and the fact that disclosure of sensitive/proprietary information could adversely affect negotiations of these projects and related future projects, our discussion of some aspects of these negotiations is necessarily general.

to turbines to generate electricity. The CO₂ that results from burning coal is exhausted in the flue gas at atmospheric pressure.

In addition to generating electricity in pulverized coal-fired plants or utilizing IGCC technology, oxyfuel combustion is another developmental technology not yet deployed at a commercial scale that could burn pulverized coal to generate electricity. In oxyfuel combustion plants, coal would be burned in pure oxygen diluted with recycled CO₂ or water. Oxyfuel combustion technology could also be one of the technologies considered by DOE in its CCS research efforts, including the restructured FutureGen.

You asked us to examine (1) the goals of the original and restructured FutureGen programs, (2) the similarities and differences between the restructured FutureGen program and other DOE carbon capture and storage programs, and (3) the extent to which DOE used sufficient information to support its decision to restructure the FutureGen program.

In conducting our work, we reviewed FutureGen appropriations, cost estimates, budget justifications, and other DOE documents, including the cooperative agreement and proposed terms for renegotiating the agreement between DOE and the Alliance. We also met with officials from DOE's Office of Fossil Energy (FE), including the National Energy Technology Laboratory (NETL) and the Office of Clean Coal, in addition to officials from the Alliance. We conducted semi-structured interviews with 14 knowledgeable stakeholders from the electric power and coal industries, nonprofit research organizations, academia, and others to determine, among other things, the potential benefits of and key differences between the original and restructured FutureGen programs. We also reviewed public responses to DOE's request for information about the restructured FutureGen and its funding announcement. Finally, we reviewed our recent work and guidance on best practices for cost estimation, program management, and programmatic decision making. A more detailed description of our scope and methodology is presented in appendix I.

We conducted this performance audit from June 2008 to February 2009, in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Results in Brief

The overall goals of the original and restructured FutureGen programs are similar in that both programs aim to produce electricity from coal with near-zero emissions by using CCS and to make that process economically viable for the electric power industry. However, the two programs would take different approaches to achieving their goals resulting in, according to knowledgeable stakeholders, two largely distinct programs that could affect aspects of the commercial advancement of CCS differently in the following ways:

- *Type of information gained.* The original FutureGen aimed at developing knowledge about the integration of IGCC and CCS at one power plant. In contrast, the restructured FutureGen could provide opportunities to learn about CCS at different types of coal-fired power plants because the program would be open to coal-fired plants utilizing technologies other than IGCC, such as conventional pulverized coal and oxyfuel combustion. However, under the restructured program, learning about the integration of IGCC and CCS is only possible if DOE receives applications proposing IGCC and selects one for funding.
- *Speed of widespread commercialization of CCS.* It is unclear whether the original FutureGen program or the restructured program would advance the broader roll out of CCS across all of industry more quickly. According to DOE documents, the restructured program is to begin deploying CCS at one or more commercial facilities that generate power for sale in 2015, approximately 5 years earlier than the original program's commercial operations could begin. However, the original program would have begun generating, if not marketing, electricity in 2012. Also, unlike the restructured program, the original program through the Alliance would have included a wide variety of industry and international partnerships, thereby fostering widespread commercialization of CCS technology and the use of that technology.
- *Testing advanced technology.* The original FutureGen would have served as a living laboratory host facility for emerging technologies, aimed at the goal of near-zero emissions (such as hydrogen fuel cells), and for gaining broad industry acceptance for these technologies. In contrast, the restructured FutureGen would not include a facility for testing these technologies, and its ability to advance them would, therefore, be limited.

The restructured FutureGen differs in important ways from most of DOE's other CCS programs, with the exception of one program—Round III of CCPI. Both the restructured FutureGen and CCPI (1) fund the commercial demonstration of CCS at coal-fired power plants, and (2) require industry participants to bear at least 50 percent of costs. The restructured

FutureGen would potentially have more available funding for commercial demonstrations than CCPI, and the restructured FutureGen targets a higher amount of CO₂ to be stored (at least 1 million metric tons of CO₂ stored annually, per plant) than CCPI (300,000 metric tons of CO₂ stored or put to use annually, per plant). However, because CCPI's goals may be more realistic or attainable for commercial partners than those of the restructured FutureGen, CCPI may receive more proposals and, hence, more industry participation. Regarding the restructured program's differences from most of the other CCS programs, the restructured FutureGen would integrate key components of CCS at commercial coal-fired power plants, such as CO₂ capture, compression, transport, storage, and monitoring of stored CO₂; in contrast, most of DOE's other CCS programs concentrate on developing individual components of CCS, such as CO₂ storage, and/or an individual component and a related one, such as capture and compression.

DOE did not use sufficient information to support its decision to restructure FutureGen. According to our recent work and best practices, a decision to terminate or significantly restructure an ongoing program should be informed by timely and sufficient information on the costs, benefits, and risks of such a decision.⁷ DOE did not prepare a comprehensive analysis of the costs, benefits, and risks of its decision to replace the original FutureGen with the restructured program. DOE made its decision based, in large part, on its conclusion that construction and material costs for the original program would continue escalating substantially in the indefinite future and that life-cycle costs were likely to double. However, according to economic forecasting organizations, such as DOE's Energy Information Administration, significant cost escalations for building power plants, in general, do not typically continue in the long run. Also, DOE reached this conclusion by comparing its cost estimate for the original FutureGen (\$950 million in constant 2004 dollars) with the Alliance's 2006 estimated life-cycle costs for the program through 2017 (about \$1.8 billion, considering inflation). In explaining his decision to restructure FutureGen, the Secretary of Energy noted that the projected

⁷GAO, *Defense Acquisition: Termination Costs Are Generally Not a Compelling Reason to Continue Programs or Contracts That Otherwise Warrant Ending*, [GAO-08-379](#) (Washington, D.C.: Mar. 14, 2008); *Cost Assessment Guide: Best Practices for Estimating and Managing Program Costs—Exposure Draft*, [GAO-07-1134SP](#) (Washington, D.C.: July 2, 2007); *Standards for Internal Control in the Federal Government*, [GAO/AIMD-00-21.3.1](#) (Washington, D.C.: Nov. 1, 1999); and *Executive Guide: Leading Practices in Capital Decision-Making*, [GAO/AIMD-99-32](#) (Washington, D.C.: Dec. 1, 1998).

program cost had “nearly doubled,” from \$950 million to \$1.8 billion. However, that assertion did not take into account a major difference between the two estimates: one was based on constant dollars and the other on inflated dollars. Our analysis indicates that the Alliance’s estimate in constant 2005 dollars would be approximately \$1.3 billion—an increase of about \$370 million, or about 39 percent, over DOE’s estimate, not a near doubling of costs. As DOE’s restructuring decision was not based on a comprehensive analysis of the associated costs, benefits, and risks, DOE has no assurance that the restructured program is the best option to accomplish the goal of promoting the accelerated and widespread commercial advancement of CCS. In contrast to the restructuring decision, FE identified and analyzed 13 other options for incremental, cost-saving changes to the original program, such as reducing the CO₂ capture requirement. While FE did not consider all of these options to be viable, it either recommended or noted several of them for consideration, each with potential savings from \$30 million to \$55 million.

To help ensure the widespread commercial advancement of CCS while protecting taxpayer interests, we are recommending that, before implementing significant changes to FutureGen or before obligating additional funds for such purposes, the Secretary of Energy should direct DOE staff to prepare a comprehensive analysis comparing the relative costs, benefits, and risks of a range of options, including the original and restructured FutureGen programs and incremental options for modifying the original program.

In commenting on a draft of this report, DOE thanked us for the opportunity to review the draft. In its response, DOE did not provide comments on the report’s conclusions or recommendations. However, DOE provided us with technical comments, which we have incorporated into the report, as appropriate. See appendix III for DOE’s comments and our response to these comments.

Background

Global emissions of greenhouse gases, such as CO₂, from human activities have grown markedly since preindustrial times—since about the year 1750—with an increase of 70 percent from 1970 to 2004. Most scientists agree that increased greenhouse gases in the atmosphere are the primary cause of the rise in global temperatures in recent decades. The Intergovernmental Panel on Climate Change (IPCC) expects greenhouse gas emissions to continue to increase over the next few decades, resulting in a continued rise in global temperatures and related harmful impacts, including the flooding of large populated coastal areas, a reduction in the

production of some crops and livestock productivity, and a decrease in the availability of fresh water in certain parts of the world.

According to the National Academy of Sciences, CO₂ levels in the atmosphere are currently at their highest in at least 650,000 years and are continuing to rise. Global increases in concentrations of CO₂ in the atmosphere are due primarily to the burning of fossil fuels—such as petroleum and coal—for energy, industrial processes, and transportation. Coal is currently the world’s leading source of electricity, and the use of coal to generate electricity around the world is projected to double by 2030. Coal-fired power plants provide about one-half of the supply of electricity used in the United States, and DOE’s Energy Information Administration estimates that coal accounts for approximately one-third of the total CO₂ emissions in the United States. In addition, the International Energy Agency anticipates that the two largest developing countries—China and India—will drive increased demand for coal to meet their growing electricity needs. According to the International Energy Agency, these countries’ heavy reliance on coal has already contributed significantly to recent increases in global CO₂ emissions.

To prevent the anticipated increase in coal-fired electricity generation from emitting significant amounts of CO₂ into the atmosphere, many are suggesting CCS as a tool that allows for continued coal use, while mitigating its effect on the climate.⁸ CCS comprises several components: separating CO₂ from other gases emitted by the plant; capturing emitted CO₂; compressing the CO₂ into a fluid state to facilitate its transportation; transporting it to a storage location; injecting the CO₂ into geologic formations, such as depleted oil and gas reservoirs and saline formations, for storage; and monitoring the storage site to verify that the CO₂ remains in place. A successful CCS system must integrate all of these components.

Currently, three major approaches have been identified for capturing CO₂ at coal-fired power plants: (1) generating electricity using pulverized coal as a fuel in conventional power plants with postcombustion capture of CO₂, (2) generating electricity using IGCC technology with precombustion

⁸The International Energy Agency identifies CCS and other clean coal technologies as one of the most promising routes for mitigating emissions and notes that, “CCS could reconcile continued coal burning with the need to cut emissions in the longer term.” Similarly, the IPCC notes that CCS would help preserve existing energy infrastructure, thereby restraining the cost of emissions reductions.

capture of CO₂, and (3) using pulverized coal as a fuel in power plants that utilize oxyfuel combustion technology to generate power and capture CO₂.

- *Postcombustion capture and pulverized coal-fired power plants:* Pulverized coal-fired power plants, which comprise 99 percent of all existing coal-fired power plants in the United States, burn pulverized coal to boil water, which raises steam that, in turn, is routed to turbines to generate electricity. The CO₂ that results from burning coal is exhausted in the flue gas at atmospheric pressure and a concentration of 10 to 15 volume percent. Postcombustion capture of CO₂ occurs after the coal is burned. The technology for capturing the CO₂ could be retrofitted onto existing power plants. However, according to DOE, the postcombustion capture of CO₂ is a challenging approach because (1) the low pressure and dilute concentration dictate a high actual volume of gas to be treated; (2) trace impurities in the flue gas tend to reduce the effectiveness of the CO₂ adsorbing processes; and (3) compressing captured CO₂ from atmospheric pressure to pipeline pressure (about 1,200 to 2,000 pounds per square inch) requires a large amount (an estimated 20 to 40 percent) of the electric power generated by the power plant.⁹
- *Precombustion capture and IGCC power plants:* This approach would be used at coal plants that use IGCC, a technology for generating electricity that has been deployed on a commercial scale at only two coal-fired power plants in the United States. In an IGCC plant, coal is gasified through a thermochemical process to break it down into its chemical constituents and produce a synthesis gas (syngas) which consists mostly of hydrogen, carbon monoxide, and CO₂.¹⁰ The syngas is then treated to remove contaminants, such as ammonia and mercury, and burned in a combustion turbine to generate electricity. Precombustion capture in IGCC plants can occur because the CO₂ in the syngas is at a very high pressure, which allows it to be captured before the combustion of the syngas.

⁹Regardless of the approach used to generate electricity and capture CO₂, additional electricity, often referred to as the energy penalty or parasitic power, is required for capture and compression.

¹⁰ICGG plants can be either air-blown or oxygen-blown, referring to the way in which oxygen is introduced into the gasifier. The syngas produced in an air-blown gasifier consists primarily of inert nitrogen, along with hydrogen, carbon monoxide, low levels of CO₂, and water vapor. In oxygen-blown gasification, the syngas is comprised of the same primary components, but has very little nitrogen and is, therefore, more concentrated in respect to the other components.

-
- *Oxyfuel combustion*: Oxyfuel combustion, which is in its developmental stages, is a technology that is being developed for using coal to generate electricity that could reduce CO₂ emissions. According to DOE, oxyfuel combustion could be applied to existing pulverized coal-fired plants. Oxyfuel combustion burns coal using pure oxygen diluted with recycled CO₂ or water. As a result, oxyfuel combustion emits primarily CO₂ and water vapor, with some excess oxygen, facilitating the capture of the CO₂ by condensing the water in the exhaust stream. Because separating out the CO₂ is not necessary under this approach, the CO₂ capture consists essentially of drying and compressing the CO₂. However, depending on the level of excess oxygen and other trace components, some additional gas cleanup may be required to make the CO₂ suitable for transportation.

After being captured, the CO₂ would be transported, likely via pipeline, to a storage site and injected at depths of over 800 meters (or about 2,600 feet) into underground geologic formations (such as depleted oil reservoirs and saline formations), thought to be conducive for isolating the CO₂ for hundreds to thousands of years. We reported in 2008 that among the barriers to CCS deployment are regulatory and legal uncertainties regarding the liability for CO₂ leakage and the ownership of CO₂, once injected. Once injected, the CO₂ must be monitored to ensure it does not escape into the environment.¹¹

On February 27, 2003, the President announced FutureGen as a cost-shared project between DOE and industry to create the world's first coal-fired, zero emissions electricity and hydrogen production power plant. The production of hydrogen was to support the President's Hydrogen Fuel Initiative to create a hydrogen economy for transportation. The original FutureGen plant was planned to operate at a commercial scale as a 275 megawatt IGCC facility that would capture and store at least 1 million metric tons of CO₂ per year. In December 2005, DOE signed a cooperative agreement with the nonprofit Alliance.¹² Pursuant to the agreement, the

¹¹GAO, *Climate Change: Federal Actions Will Greatly Affect the Viability of Carbon Capture and Storage As a Key Mitigation Option*, [GAO-08-1080](#) (Washington, D.C.: Sept. 30, 2008).

¹²The Alliance is currently comprised of the following 11 companies that produce coal or generate coal-fueled power on six continents: American Electric Power, Anglo American LLC, BHP Billiton, China Huaneng Group, CONSOL Energy Inc., E.ON U.S., Foundation Coal Corporation, Peabody Energy, Rio Tinto Energy America, Southern Company, and Xstrata Coal Pty Limited. The Alliance membership continues to be open to U.S. and international companies that produce coal or electricity from coal as a significant business activity.

Alliance was to design, construct, and operate the FutureGen plant, and DOE was to provide project oversight, conduct the environmental analyses required by NEPA, and coordinate the participation of foreign governments.¹³ The project was to run through November 2017 and operate as the cleanest fossil fuel-fired power plant in the world. After completion of the formal project, the FutureGen plant was expected to continue operating for the typical lifespan of a power plant—usually 30 to 50 years—generating electricity and providing a platform for energy research. On January 30, 2008, DOE announced that it had decided to take the FutureGen program in a different direction. DOE stated that it would demonstrate CCS at multiple commercial-scale power plants, including retaining the integration of CCS and IGCC. DOE referred to this new approach as the restructured FutureGen program. In June 2008, in a funding announcement for the restructured program, DOE stated that it expected it would have about \$290 million available through fiscal year 2009 for its share of funding for the program. (See app. II for an overview of DOE budget authority and obligations for FutureGen.)

The Goals of the Original and Restructured FutureGen Programs Are Largely Similar, but the Programs' Different Approaches May Lead to Different Results

The overall goals of the original and restructured FutureGen programs are largely similar in that both programs seek to produce electricity from coal with near-zero emissions by using CCS, and to make that process economically viable for the electric power industry. However, the programs outline different approaches for achieving their goals, which could affect the commercial advancement of CCS differently in several ways.

¹³In 2006 and 2007, DOE received funding contributions for FutureGen from the governments of India and South Korea.

With a Few Key Exceptions, the Goals of the Original and Restructured Programs Are Largely Similar

Both the original and restructured programs aim to establish the feasibility and economic viability of producing electricity from coal with near-zero emissions by employing CCS. The programs’ goals for storing CO₂ and limiting other emissions, such as mercury and sulfur, are also similar; except that the requirement for the amount of carbon to be captured has been reduced from 90 percent in the original program to 81 percent in the restructured program (see table 1).

Table 1: Storage and Emissions Goals for the Original and Restructured FutureGen Programs

Storage and emissions goals	Original FutureGen	Restructured FutureGen
Carbon	Capture at least 90% ^a	Capture at least 81% ^a
CO ₂	Store at least 1 MMT/year ^b	Store at least 1 MMT/year ^b
Sulfur	Remove at least 99%	Remove at least 99% ^c
Mercury	Remove at least 90%	Remove at least 90% ^d
Btu NOx	Reduce to less than .05 lb/million	Reduce to less than .05 lb/million
Btu particulate matter	Reduce to less than .005 lb/million	Reduce to less than .005 lb/million

Source: GAO analysis of DOE program documents.

^aThe original FutureGen program’s goal is to capture 90 percent of the CO₂ in the total plant gas stream, while the restructured FutureGen program requires capture of 81 percent of the carbon in the total plant gas stream. According to DOE officials, the carbon capture goal of the restructured program includes the capture of CO₂, as well as other carbon-based gases—such as methane (CH₄), another greenhouse gas. DOE officials explained that they changed the measure from CO₂ to carbon for clarification purposes and because the restructured FutureGen was designed to accommodate a range of gasification and combustion technology configurations. Also, while the goal for the restructured FutureGen states 90 percent carbon capture, the minimal performance requirement is 81 percent of carbon.

^bPer demonstration unit or plant.

^cBased on the sulfur content of the coal, or less than 0.04 lbs/million Btu if there is low sulfur concentration in the coal.

^dBased on the mercury content of the coal.

Knowledgeable stakeholders told us that this decrease in carbon capture is of modest significance and that a goal of 81 percent is still very ambitious and costly. DOE received similar feedback in responses to its request for information from the public about its plan to restructure FutureGen. Eighteen of the 49 respondents indicated that the 90 percent

goal would be too restrictive for industry participants because of the additional energy required to capture and compress CO₂, often referred to as the energy penalty, and the fact that no power plant to date has been designed to operate with the conditions necessary to achieve a 90 percent capture. Some respondents suggested setting a lower capture goal, such as 65 percent, and adopting an incremental approach over time to reach 90 percent that would eventually allow industry to obtain baseline data and demonstrate reliability and widespread confidence in CCS. One respondent wrote that the “90% capture level was appropriate for a ‘living laboratory’ like the originally proposed FutureGen project but a 30% level is most suitable for a commercial IGCC facility.”

Both the original and restructured programs would operate plants at a commercial size.¹⁴ However, the restructured program, a DOE commercial demonstration project, seeks to accelerate the commercial deployment of CCS (that is, generating and selling electricity to earn profits) by implementing CCS at one or more commercial facilities by 2015—approximately five years earlier than the original program’s commercial operations could begin. The original program, a DOE research and development project, would begin generating electricity in 2012, a few years earlier than the restructured FutureGen; but, it could not begin operating as a profit-seeking commercial facility until after the nonprofit Alliance sells it, which is currently anticipated to occur in 2020. Knowledgeable stakeholders told us that the restructured program’s time line for the commercial deployment of its project(s) might be ambitious because legal and environmental issues related to siting and permitting, in particular for CCS, could slow implementation. They also stated that the required NEPA analyses, which must be completed prior to beginning construction, could take up to 3 years. In contrast, DOE had completed its NEPA analyses for the original FutureGen. Moreover, the governments of the two states—Texas and Illinois—where the four finalist sites for the original FutureGen were located, had agreed to assume liability for the injected CO₂. DOE officials told us that, unlike the original program, a primary goal of the restructured FutureGen was to facilitate the siting and permitting process for CCS by implementing multiple projects in different locations.

¹⁴According to DOE, if a non-IGCC plant is selected under the restructured FutureGen, it is only required to be at a scale sufficient to prove commercial viability and be designed to produce and capture 1 million tons of CO₂ per year. IGCC plants would be required to produce at least 300 megawatts of gross electricity output.

The Different Approaches for Achieving Goals Could Have Different Impacts on the Commercial Advancement of CCS

Because of the different approaches for achieving their goals, the original and restructured FutureGen programs could have different impacts on the commercial advancement of CCS (see table 2).

Table 2: Key Differences in the Approaches of the Original and Restructured FutureGen Programs

Original FutureGen	Restructured FutureGen as currently designed
Only includes IGCC.	May or may not include IGCC; IGCC was identified as a goal, but its inclusion in the program depends on the applications received and selected.
Accelerated deployment of CCS at commercial facilities is not a goal.	Accelerated deployment of CCS at commercial facilities is a goal.
Includes a living laboratory host facility for advanced technologies, such as fuel cells.	Does not include a living laboratory host facility for advanced technologies.
Project would be operated by a nonprofit consortium of 11 industry partners (FutureGen Industrial Alliance).	Each project could be operated by a nonprofit or for-profit entity.
Research and development project (DOE cost share capped at 74%).	Demonstration project (DOE cost share capped at 50%).
Consists of one plant.	Potential for multiple sites, depending on the applications received and selected.
Includes international involvement.	No international involvement.

Source: GAO analysis of DOE program documents.

The type of information gained from the programs may vary. First, the original program would have developed knowledge about CCS at IGCC plants, while the restructured program could allow for opportunities to learn about CCS at both IGCC and other types of coal plants. Knowledgeable stakeholders whom we contacted stated that DOE could benefit by taking advantage of the opportunity under the restructured FutureGen program to learn about CCS at multiple types of plants. They explained that opportunities to learn from multiple plant sites in different regions with various technologies would provide a wide range of knowledge about the implementation of CCS in various contexts. Similarly, 30 of 49 respondents to DOE’s request for information about the restructured program indicated that it would be beneficial if the restructured program were to include both IGCC and other types of coal plants. In addition to other organizations, such as the National Academy of

Sciences, we have noted that the benefits of learning about CCS technologies are also applicable to existing pulverized coal-fired plants, since they account for an overwhelming share (about 99 percent) of the world's coal-fired power plants.¹⁵ However, one of the intended benefits of the restructured program—providing opportunities to learn from multiple plants about various technologies—may not be fully realized since DOE received only a small number of applications. If an application for IGCC has not been received or is not selected, the loss of an IGCC plant with integrated CCS capability is significant because, according to the draft strategic planning document for the restructured program, demonstrating this technology is a key solution for reducing atmospheric CO₂ emissions from coal-fired power plants. Comments submitted to DOE and knowledgeable stakeholders we interviewed indicated that the carbon capture goal for the restructured program was too restrictive for commercial facilities. One stakeholder stated that the restructured program goals might be overly optimistic about what commercial projects are willing to do. As a result of receiving only a small number of applications, the restructured program is not as likely to develop as broad a base of knowledge as it could have if more applications were received.

Second, it is unclear whether the original FutureGen program or the restructured program could have advanced the broader roll out of CCS more quickly across all of industry. According to DOE documents, the restructured program is intended to begin deploying CCS at one or more commercial facilities in 2015, approximately five years earlier than the original program's commercial operations (that is, generating and selling electricity) could begin. The original program, a DOE research and development project, would have begun generating electricity in 2012, a few years earlier than the restructured FutureGen, but it could not have begun operating as a profit-seeking commercial facility until after the nonprofit Alliance sold it, which was anticipated to occur in 2020. Moreover, unlike the restructured program, the original FutureGen would have included a wide variety of industry partners (including foreign government partners, which are absent from the restructured program). In addition, more industry partners could have joined the Alliance and its 11 members over the course of the original program. As a result of its wider participation, the original FutureGen could potentially have advanced the broader roll out of CCS across all of industry and internationally, instead of at only a few commercial facilities, more quickly

¹⁵ [GAO-08-1080](#).

than the restructured program. DOE officials told us that the original program would likely improve the global advancement of CCS more quickly than the restructured program due to its various international partnerships. They stated that DOE is developing an approach to recoup the loss of international involvement that resulted from restructuring FutureGen.

Third, the restructured program will not serve as a living laboratory host facility for technologies emerging from energy research and development programs aimed at the goal of near-zero emissions and for gaining broad industry acceptance for these technologies. The original FutureGen plant was to be designed with the ability to test various technologies that are scalable to full size, such as fuel cells, advanced gasification, and membrane air separation systems. Without the opportunity to test these emerging research and development technologies, the restructured FutureGen might result in a slower advancement of CCS than the original program may have yielded. According to the cooperative agreement between DOE and the Alliance, emerging technologies, such as fuel cells, could have been tested at the original program's living laboratory host facility. In a September 2007 presentation to DOE's Deputy Secretary, NETL noted the impact of removing the living laboratory, saying it would "significantly delay the availability of the technology for commercial deployment" and have a "significant programmatic impact." DOE officials told us that they have not yet determined where these technologies will be tested.

The Restructured FutureGen Differs from Most of the Other DOE Carbon Capture and Storage Programs, but It Is Similar to CCPI in Several Ways

DOE manages a portfolio of clean coal programs that research and develop CCS technology or demonstrate its application. Focusing on commercial coal-fired power plants, the restructured FutureGen would integrate key components of CCS, such as CO₂ capture, compression, transport, storage, and monitoring of CO₂ at the storage location. However, the restructured FutureGen is similar in some ways to Round III of CCPI, but CCPI's goals are more modest than those of the restructured FutureGen and, hence, may be more achievable for industry partners. The other CCS programs include the (1) Regional Carbon Sequestration Partnerships, (2) Innovations for Existing Plants Program, (3) Advanced Turbines Program, (4) Advanced Integrated Gasification Combined Cycle Program, and (5) Round III of the Title 17 Incentives for Innovative Technologies Loan Guarantee Program (Loan Guarantee Program). Four of these five CCS programs do not integrate all key components of CCS and concentrate on developing one or two related components of CCS,

such as CO₂ separation, CO₂ storage, or CO₂ capture with related compression.

The Restructured FutureGen Program Is Similar to Round III of CCPI in Several Ways, but CCPI's Goals May be More Achievable for Industry Partners

Both the restructured FutureGen and CCPI are cost-shared partnerships with industry, in which DOE funds no more than 50 percent of the costs. Like the restructured FutureGen, Round III of the CCPI program funds the commercial demonstration of CCS at coal-fired power plants.¹⁶ Round III of CCPI seeks to demonstrate, at a commercial scale, advanced coal-based technologies that capture and store carbon, or put CO₂ emissions to beneficial reuse, such as to enhance oil recovery.¹⁷ The proposals for Round III of CCPI were due to DOE by January 15, 2009, and DOE expects to announce its selections in July 2009.

In public comments on DOE's request for information and the draft funding announcement for the restructured FutureGen, two respondents noted the similarity between the restructured FutureGen and CCPI. They suggested that DOE explain the linkages and possibly combine the programs. However, important differences exist in the two programs' goals. First, while both programs have annual requirements for the capture of CO₂ emissions, the restructured FutureGen requires 1 million metric tons of CO₂ per plant, while CCPI requires 300,000 metric tons of CO₂ per plant. Knowledgeable stakeholders told us that CCPI's goal of capturing 300,000 metric tons of CO₂ is more realistic and attainable by commercial facilities than the restructured FutureGen's goal of 1 million metric tons. Another noteworthy distinction is that the restructured FutureGen requires the 1 million metric tons of CO₂ emissions to be stored in saline formations, whereas the 300,000 metric tons of CO₂ emissions that CCPI requires to be captured can either be stored or be put to beneficial reuse, such as to enhance oil recovery. The latter opens up more options for industry partners and can serve as an attractive opportunity for increasing revenue in the project by selling the CO₂. Finally, because CCPI's goals

¹⁶While the first two rounds of CCPI did not focus on CCS, Round III does so through projects that capture and store CO₂ or put CO₂ to beneficial reuse. Round I was broadly focused on advancing technologies in coal-fired power generation that would result in efficiency, as well as environmental and economic improvements. Round II was focused on gasification technology and mercury control.

¹⁷According to DOE, most oil is produced in three distinct phases: primary, secondary, and tertiary, or enhanced oil recovery (EOR). The definition of tertiary or EOR is that a substance, such as CO₂, is added to the reservoir after secondary recovery in order to increase production. The purpose of EOR is to increase oil production, primarily through an increase in temperature, pressure, or an enhancement of the oil's ability to flow through the reservoir.

may be more realistic or attainable for commercial partners, more proposals may be submitted to CCPI than the restructured FutureGen. For example, two officials from electric utility companies said that, despite the potentially greater amount of funding available through the restructured FutureGen (\$1.3 billion, subject to future appropriations) than CCPI (\$440 million, subject to future appropriations), their companies would apply for CCPI over the restructured program because they could meet CCPI's goals.

The Restructured FutureGen Differs from Most Other DOE CCS Programs

The restructured FutureGen and other DOE CCS programs strive to reduce CO₂ emissions by advancing CCS. However, while most of these programs do not integrate all key components of CCS, the restructured FutureGen integrates all key components of CCS. The other CCS programs include the (1) Regional Carbon Sequestration Partnerships, (2) Innovations for Existing Plants Program, (3) Advanced Turbines Program, (4) Advanced Integrated Gasification Combined Cycle Program, and (5) Round III of the Title 17 Incentives for Innovative Technologies Loan Guarantee Program.

The Regional Carbon Sequestration Partnerships seek to develop the technology, infrastructure, and regulations necessary to implement CO₂ storage.¹⁸ The 7 regional partnerships are composed of over 350 organizations, 42 states, 4 Canadian provinces, and 3 Native American tribes. Now entering Phase III,¹⁹ the regional partnerships are working to implement 7 large-scale projects that will demonstrate the long-term, effective, and safe storage of CO₂ in the major underground geologic formations throughout the United States and portions of Canada. The CO₂ stored through the projects can come from coal-fired power plants or

¹⁸We reported in [GAO-08-1080](#) that the regional partnerships program appears to be placing more emphasis on demonstrations of CO₂ capture at coal-fired power plants. Specifically, a DOE official identified three projects being planned to capture CO₂ from coal-fired power plants, including possibly capturing 500,000 metric tons of CO₂ from a coal-fired power plant in North Dakota. Program shifts were also evident in the Innovations for Existing Plants and CCPI programs. We recommended that DOE continue its recent budgetary practice of helping to ensure that greater emphasis is placed on supporting technologies that can reduce greenhouse gas emissions at existing coal-fired power plants.

¹⁹Phase I of the regional partnerships, the Characterization Phase (2003-2005), focused on describing the potential for CO₂ storage in deep oil-, gas-, coal-, and saline-bearing formations. Phase II, the Validation Phase (2005-2009), is implementing 25 small-scale geologic storage tests. Phase III, the Deployment Phase (2008-2017), is a continuation of the Phase II small-scale tests, but at a much larger scale.

other sources, such as ethanol production plants. The injection of CO₂ into geologic formations will continue over several years, and the monitoring will continue through 2017.

The Innovations for Existing Plants Program focuses on developing CO₂ capture and compression technologies to assist existing coal-fired power plants.²⁰ Through this program, DOE is providing \$36 million in funding for 15 projects to develop new and cost-effective CO₂ capture technologies for existing power plants. According to DOE, all 15 projects selected have received funding. The projects will be implemented across 11 states and will last for 2 to 3 years. Projects will focus on five areas of interest for CO₂ capture: membranes, solvents, sorbents, oxyfuel combustion, and chemical looping.

The Advanced Turbines Program focuses on creating the technology base for turbines that will permit the design of IGCC plants with CCS that can operate at near-zero emissions, thereby facilitating CO₂ capture. According to DOE, the development of new turbines technology could improve applications of IGCC by reducing the costs of producing electricity from coal.

Similarly, the Advanced Integrated Gasification Combined Cycle Program also focuses on one aspect of CCS—developing gasification technology to enable CO₂ capture. The program aims to develop advanced gasification technologies to enable CO₂ capture with minimal impact on the cost of electricity. DOE reports that by 2012, gasification technology will be integrated at pilot scale with CO₂ separation, capture, and sequestration into near-zero atmospheric emissions configurations that can, ultimately, provide electricity with less than a 10 percent increase in cost.

Finally, Round III of the Title 17 Incentives for Innovative Technologies Loan Guarantee Program will provide up to \$8 billion in loan guarantees for energy projects that satisfy three criteria: avoid, reduce, or sequester air pollutants or greenhouse gases; employ new or significantly improved technologies, compared with commercial technologies in service at the time the guarantee is issued; and provide a reasonable prospect of

²⁰In response to language in the Explanatory Statement accompanying its fiscal year 2008 appropriation, DOE has shifted the focus of the Innovations for Existing Plants program to research and development on CO₂ capture technologies that can be retrofitted to existing pulverized coal-fired power plants.

repayment.²¹ Initial applications for Round III of the program were due to DOE in December 2008. We recently reported on DOE's progress in (1) issuing final regulations to govern this program, (2) taking actions to help ensure that the program is managed effectively and to maintain accountability, and (3) determining whether there were inherent risks due to the nature and characteristics of this program that may affect DOE's ability to make the program pay for itself and support a broad spectrum of innovative energy technologies.²² Table 3 summarizes the comparison of DOE programs supporting CCS.

²¹Federal loan guarantee programs help borrowers obtain access to credit with more favorable terms than they may otherwise obtain in private lending markets because the federal government guarantees to pay lenders if the borrowers default, which makes extending credit more attractive to lenders.

²²GAO, *Department of Energy: New Loan Guarantee Program Should Complete Activities Necessary for Effective and Accountable Program Management*, [GAO-08-750](#) (Washington, D.C.: July 7, 2008).

Table 3: DOE Programs Supporting Carbon Capture and Storage

	Restructured FutureGen	Clean Coal Power Initiative (Round III)	Regional Carbon Sequestration Partnerships
Description	Demonstration of capture and storage of CO ₂ .	Demonstration of capture and storage, or beneficial reuse, of CO ₂ .	Demonstration of CO ₂ storage in geologic formations.
Integrates all key CCS components ^a	Yes	Yes	No ^b
Commercial site	Yes	Yes	No
Demonstration or R&D	Demonstration	Demonstration	R&D
DOE cost share	50% ^c	50% ^c	80% ^d
Carbon storage required (amount and location)	Yes, storage required. At least 1 million metric tons/year of CO ₂ must be stored in a saline formation and any excess of 1 million metric tons/year can be put to beneficial reuse, such as for enhanced oil recovery.	No, storage not required. 300,000 metric tons/year can either be stored or put to beneficial reuse, such as for enhanced oil recovery.	Yes, storage required. Some will store up to 1 million metric tons/year in geologic formations.

Innovations for Existing Plants Program	Advanced Turbines Program	Advanced Integrated Gasification Combined Cycle Program	Loan Guarantees (Round III)
Develops CO ₂ capture and compression technologies for pulverized coal power plants, which represent the majority of existing coal plants.	Creation of new turbines for IGCC plants that will include CCS and facilitate near-zero atmospheric emissions.	Supports the development of advanced gasification technologies to enable CO ₂ capture with minimal impact on the cost of electricity.	Loan guarantees for activities at retrofitted and new facilities that incorporate carbon capture and sequestration, other beneficial uses of carbon, or advanced coal gasification.
No	No	No	Possible
No	No	No	Yes
R&D	R&D	R&D	n/a
80%	80%	80%	n/a
n/a	n/a	n/a	n/a

Source: GAO analysis of DOE program documents.

^aKey components include capture, compression, transport, storage and measurement, monitoring and verification.

^bThe Regional Partnerships will conduct large-scale geological sequestration testing that will require the participants to secure sufficient quantities of CO₂ needed to demonstrate CO₂ storage, monitoring, and verification. However, while DOE will cost share in the acquisition of CO₂, it will not fund the development and/or testing of CO₂ capture technologies under the Regional Partnership program.

^cDOE cost sharing is generally capped at 50 percent. According to DOE officials, it is quite common under DOE's commercial demonstration programs for the Government cost share to be well below 50 percent of the total project cost.

^dDOE cost sharing is generally capped at 80 percent. Private sector cost sharing under the seven Regional Partnerships averages 34 percent.

DOE Did Not Support Its Decision to Restructure FutureGen with Sufficient Information on Costs, Benefits, or Risks

According to our recent work and best practices, a decision to terminate or significantly restructure an ongoing program should typically be informed by timely and sufficient information on the costs, benefits, and risks of such a decision. While DOE had reason to be concerned about the escalating costs of the original FutureGen, it made its decision to cancel that program and replace it with the restructured FutureGen based, in large part, on a comparison of cost estimates that were not comparable. That is, it compared one estimate that was in current dollars with one that was in constant dollars. In restructuring FutureGen, DOE did not sufficiently analyze the costs, benefits, and risks of canceling the original FutureGen and replacing it with a significantly restructured program. A comprehensive analysis could have helped DOE determine how the costs, benefits, and risks of the restructured FutureGen compared with those of the original FutureGen. Because it did not conduct such an analysis, DOE cannot be assured that the restructured program is the best option to accelerate the widespread commercial advancement of CCS more quickly than the original program. Other options, rather than dramatically restructuring the program, were possible that could have preserved some of the benefits of the original program, including ensuring the integration of IGCC and CCS at the FutureGen facility. For example, FE identified and analyzed 13 other options for incremental, cost-saving changes to the original program, such as reducing the CO₂ capture requirement. While FE did not consider all of these options to be viable, it recommended or noted several of them for consideration with potential savings from \$30 million to \$55 million each.

DOE Decided to Restructure FutureGen Based, in Large Part, on a Comparison of Cost Estimates that Were Not Comparable

In January 2007, as part of its initial conceptual design report for the original FutureGen, the Alliance estimated the cost of the original program at about \$1.8 billion. The Alliance's report explained that this estimate included inflation through 2017—the last year of the anticipated life of the program—and was the equivalent of almost \$1.4 billion in constant 2006 dollars. This report also stated that, after subtracting anticipated revenue from program activities, such as the sale of electricity, the estimate was similar to DOE's 2004 estimate of \$950 million. However, DOE officials told us that DOE's estimate did not subtract anticipated revenue. In March 2007, after approving the Alliance's cost estimate, DOE renewed the cooperative agreement with the Alliance to proceed with developing a preliminary design for FutureGen by June 2008, including a revised cost estimate and a risk analysis. The preliminary design was to be based on a specific site and technology for the program—information that has an important impact on the program's overall cost because labor expenses

vary from location to location, and technology costs and designs, such as for turbines, vary depending on the specific manufacturer and vendor.

The March 2007 renewed cooperative agreement listed approximately \$1.8 billion as the current estimated cost of the project. However, senior DOE officials soon began to express concerns about escalating program costs, and they directed FE officials to develop recommendations for controlling costs. In September 2007, FE officials presented several recommendations for incremental changes to control costs to the Deputy Secretary of Energy; they also noted various measures already in place for controlling costs, such as monthly progress reports and a risk management program. Importantly, none of the recommendations indicated that DOE should cancel the original program and restructure FutureGen; moreover, FE officials told us that they did not prepare any analysis or recommendations for senior DOE officials that resembled what was to become the restructured program.

According to DOE, following this presentation, senior DOE officials directed FE to negotiate with the Alliance new cost sharing arrangements under the cooperative agreement, which was scheduled for continuation in June 2008. The Alliance agreed to meet to renegotiate the terms of the cooperative agreement. Over the course of several meetings, the parties discussed various funding scenarios and exchanged proposed term sheets. Subsequently, however, the Alliance and DOE did not reach agreement. In December 2007, the Alliance sent a letter to DOE stating that it preferred to proceed under the existing cooperative agreement until FutureGen's costs and risks could be assessed with input from the preliminary design report and cost estimate that were due by June 2008.

Also in December 2007, the Secretary of Energy briefed senior presidential advisers that the estimated cost of FutureGen had nearly doubled—from \$950 million to \$1.8 billion—and that costs were expected to continue rising. In addition, according to the briefing documents, DOE planned to end its partnership with the Alliance and was developing a new strategy for FutureGen that would cap the government's financial exposure. The briefing documents explained that DOE's new approach for FutureGen would fund only the CCS-related technology associated with multiple commercial IGCC plants, rather than the entire construction of a single plant with CCS. Around this time, according to DOE officials, senior DOE officials directed FE to develop the restructured FutureGen program. In response, these officials told us, many high-level offices within DOE collaborated on developing a draft strategic planning document for the restructured program. According to these officials, the draft strategic

planning document that they finalized in January 2008 was the first complete document about the restructured FutureGen. On January 30, 2008, DOE publicly announced that it was restructuring FutureGen to provide a ceiling on federal contributions and that the restructured program was a more cost-effective approach. On this same day, DOE notified the Alliance that it was restructuring FutureGen and would not continue its cooperative agreement with the Alliance. DOE informed the Alliance that it was restructuring FutureGen in response to serious concerns over substantial escalation in projected costs, including what the agency concluded would be the likely continued escalation of the costs. DOE officials also stated that they disapproved of the Alliance's decision to announce the selection of a project site before DOE issued its NEPA Record of Decision. According to DOE, prior to the site selection announcement and without knowledge of the Alliance's choice of site, DOE had asked the Alliance not to go forward with the announcement and further advised the Alliance against making an announcement until the Record of Decision had been issued. DOE officials also said that, in their negotiations on measures that could limit DOE's financial exposure, they lost confidence in the ability of the Alliance to fund its share of the project cost.

Although comparing cost estimates can provide valuable insight about the impact of escalating costs on a project, DOE based its decision to restructure FutureGen, in large part, on a comparison of cost estimates that were not actually comparable. That is, in 2004, DOE had estimated that the cost of the original FutureGen would be \$950 million in constant 2004 dollars. In contrast, the Alliance's 2007 estimate of about \$1.8 billion was in current dollars, which reflected inflation over the course of the program from 2005 through 2017.²³ In explaining his decision to restructure FutureGen to senior presidential advisers, the Secretary of Energy indicated that the projected program costs had "nearly doubled," from \$950 million to \$1.8 billion. However, comparing constant dollars, which exclude inflation, with current dollars, which reflect inflation, is misleading. Our calculations show that the Alliance's current dollar estimate of roughly \$1.8 billion is equivalent to approximately \$1.3 billion

²³The Alliance estimate was \$1.785 billion, in current dollars, from 2005 through 2017.

in constant 2005 dollars—an increase in total program costs of about \$370 million, or about 39 percent—not a near doubling of costs.²⁴

In addition, the cost estimates by DOE and the Alliance were prepared early in the project and, as a result, were based on conceptual designs for FutureGen, including power plant case studies and a blanket 10 percent increase incorporated into the Alliance's estimate to allow for the first-of-a-kind nature of some of the plant's components and integration issues. However, neither estimate considered costs for specific types of technology or a specific location. If DOE had waited approximately 6 months for the Alliance's technology-specific and site-specific cost estimate, due by June 2008 as part of its preliminary design report, before deciding whether to restructure the program, it would have had the benefit of more current and complete information, including the latest information on escalating costs, when making decisions about how to move forward with FutureGen.²⁵ In addition, regarding FutureGen's total cost, the March 2007 cooperative agreement stated that DOE and the Alliance recognized that many uncertainties—such as plant design, site selection, and market conditions—still existed in developing a firm cost estimate.²⁶

In May 2008, the Secretary of Energy testified before Congress that FutureGen was conceived as a \$950 million venture and that its estimated cost had increased to roughly \$1.8 billion; however, the Secretary's

²⁴We selected constant fiscal year 2005 dollars for illustrative purposes. However, our review of DOE's documentation pertaining to its \$950 million cost estimate for the original FutureGen shows that DOE considered base year constant dollars for the estimate from several years, ranging from late quarter 2003 dollars, to fiscal year 2004 dollars, and fiscal year 2005 dollars. We asked DOE to confirm the base year for its cost estimate, and department officials responded that several versions of the estimate had been prepared using fiscal year 2003 and fiscal year 2004 dollars. When we pointed out the existence of an additional estimate in fiscal year 2005 dollars, DOE officials informed us that they would clarify which constant year dollars DOE had used. However, as of January, 2009, DOE had not yet fully clarified this information for us.

²⁵The Alliance has decided to continue preparing the preliminary cost estimate, and it anticipates completing and releasing the estimate by early 2009.

²⁶The cooperative agreement also stated that DOE and the Alliance agreed in principle to, ultimately, cap DOE's share of costs at \$700 million in constant 2004 dollars—approximately 74 percent of DOE's cost estimate—and it required the Alliance to develop, by June 2008, a proposal for the terms of such a cap. The cap was to be adjusted for unanticipated cost escalation upon each scheduled renewal or continuation of the cooperative agreement, based on a suitable index of actual costs negotiated by DOE and the Alliance.

prepared statement did not indicate that the first estimate was in constant dollars, while the second was in current dollars.²⁷ The Secretary also testified that DOE believed its costs would continue to escalate. We requested that DOE provide us with the analysis that supported DOE's anticipated escalation. In October 2008, DOE officials told us that the ongoing cost escalations were unprecedented and that they had looked internally across various indexes, including the Bureau of Labor Statistics, to get a sense of prospective escalation. However, they stated that they did not have any written or comprehensive analysis. They added that they did not prepare a position paper, study, or generate any analysis examining current or future escalation for the decision to restructure FutureGen. Moreover, economic forecasting organizations, such as DOE's Energy Information Administration, have found that significant cost escalations, such as those for building power plants over the past several years, do not typically continue in the long run.²⁸

A Comprehensive Analysis Could Have Helped DOE Determine How the Costs, Benefits, and Risks of the Restructured FutureGen Compared with Those of Other Options

DOE did not prepare a comprehensive analysis comparing the relative costs, benefits, and risks of the original and restructured FutureGen programs before making the decision to replace the original program with the restructured FutureGen. On two different occasions, DOE officials told us that the agency did not prepare such an analysis. These officials told us that the Secretary of Energy's May 2008 congressional testimony included the agency's official explanation for why it decided to restructure FutureGen. In September 2008, we asked DOE to provide us with additional information, including the agency's official position on why it decided to restructure FutureGen, all the factors upon which DOE based the decision, the extent to which the decision was based on documented supporting analysis, and a copy of any such analysis. In January 2009, after we sent a draft of this report to DOE for review and comment, DOE responded to our request for additional information, stating that the detailed analysis supporting its decision to restructure FutureGen could be found in the draft strategic planning document for the restructured program and that this document discussed the factors considered by DOE in making the decision to restructure FutureGen. However, as previously

²⁷U.S. Senate. Committee on Appropriations, Testimony of Samuel W. Bodman, Secretary of Energy, U.S. Department of Energy, before the Subcommittee on Energy and Water Development, May 8, 2008.

²⁸These findings are for building power plants, in general, and do not specifically address FutureGen.

discussed in our findings, the draft strategic planning document was not completed in time to inform the decision to restructure FutureGen. In addition, we do not consider the draft strategic planning document to be comprehensive because it did not assess:

1. whether costs for the original FutureGen would escalate substantially in the future;
2. the relative costs, benefits, and risks for all of the types of plants for which the restructured FutureGen was eligible to receive proposals, such as conventional pulverized-coal and oxyfuel combustion plants, but only contemplated proposals for IGCC plants;
3. the risk that industry respondents might not propose an IGCC plant for the restructured FutureGen;
4. the risk that industry respondents might not propose enough viable projects for the restructured FutureGen;
5. the costs, benefits, and risks of making incremental changes to the original FutureGen alongside the relative costs, benefits, and risks of the restructured FutureGen; and
6. any potential overlap between the restructured FutureGen and other DOE programs.

A comprehensive analysis could have supported DOE's decision making in several ways. First, it could have helped DOE assess the risk that industry respondents to DOE's request for applications under the restructured FutureGen might not propose an IGCC plant. DOE received public comments indicating that such an outcome was possible because IGCC is not yet prevalent in the industry—only two commercial IGCC plants currently operate in the United States—and other technologies may provide better opportunities to meet the restructured program's requirements, among other reasons. Applying CCS at existing, conventional pulverized coal-fired plants is important because those plants comprise almost all operating coal-fired plants in the United States and abroad. However, according to DOE, IGCC plants integrated with CCS are important for reducing CO₂ emissions in the future. Both DOE's press release announcing the restructured program and the updated draft strategic planning document, dated July 1, 2008, that DOE provided Congress indicated that the restructured program would include IGCC. The funding announcement for the restructured FutureGen highlighted the

important contribution that an IGCC plant integrated with CCS would make toward the nation's energy needs, such as providing continued fuel diversity for generating electricity and mitigating dependence on more expensive and less secure sources of energy. As late as May 2008, the Secretary of Energy indicated in congressional testimony that the restructured program would likely include IGCC, stating that advances in technology and the market, in addition to regulatory uncertainty, would provide incentives for industry to begin deploying commercial-scale IGCC plants with CCS.

In addition, a comprehensive analysis could have helped DOE assess the risk that industry respondents might not propose enough viable projects from which DOE could then assess and make multiple selections. Such an analysis could also have helped DOE assess whether the new cost-share arrangement would provide sufficient incentive for enough proposals to be selective. In the draft planning documents and press release announcing the restructured program, DOE stated that it restructured FutureGen, in part, because market conditions had changed in such a way that DOE could fund multiple industry projects and accomplish even more widespread commercialization of CCS and related information sharing across the industry than what would have been accomplished by the Alliance's consortium of 11 coal producers and electric power companies. However, DOE only received a small number of applications and some proposed projects were outside the restructured FutureGen's scope. As a result, widespread commercialization and information sharing seem less likely than under the original program. DOE also asserted that the restructured program would hasten the time frame for full-scale commercial operation of CCS. However, even if DOE accepts all applicable applications, the restructured program could implement CCS sooner than the original program at only a few commercial sites rather than, as stated before, on a more widespread and international scale.

Finally, DOE also could have used a comprehensive analysis to help compare the relative costs, benefits, and risks of the restructured FutureGen with those of making incremental and other changes to the original program in order to control or offset costs. For example, prior to the decision to restructure FutureGen, FE identified and analyzed 13 options for changes to the original program, such as reducing the CO₂ capture requirement, which aimed at reducing costs while continuing to retain some of the original program's key benefits. DOE noted that some of the potential changes would have a detrimental impact on the original program's objectives, while other potential changes would not significantly impact project objectives. Of these changes, FE either

recommended or noted that DOE should be willing to consider several options with potential savings from \$30 million to \$55 million each. Some of these scenarios were broached during negotiations with the Alliance in the fall of 2007.

Conclusions

According to DOE, electric power industry, academic, and other officials and experts, for the foreseeable future, coal, which is abundant and relatively inexpensive, will remain a significant fuel for the generation of electric power in the United States and the world. However, coal-fired power plants are also a significant source of CO₂ and other emissions responsible for climate change. Hence, for at least the near-term, any government policies that seriously address climate change will need to have a goal of significantly reducing CO₂ and other emissions from coal-fired power plants. CCS, while still in its infancy, can be a promising technology to achieve these purposes. By integrating IGCC and CCS technology at a living laboratory host facility, DOE's FutureGen program was intended to address significant technological, cost, and regulatory issues associated with the implementation of CCS at a new plant. However, in early 2008, citing concerns about a "doubling of costs," DOE abruptly canceled the original FutureGen program and announced a dramatic restructuring. The restructuring cast aside the initial concept and substituted a request for multiple projects to be proposed by industry that would retain the goal of capturing and sequestering 1 million metric tons of CO₂, and would accept technologies other than IGCC. The restructured FutureGen left open the possibility of successfully applying CCS technology to existing conventional, pulverized coal-fired power plants—an important goal in its own right, since those plants account for almost all of the coal-fired generating capacity in the United States and abroad. However, there are already existing programs to address CCS at existing plants, and the decision to remove the FutureGen program's specific focus on cutting edge technology (IGCC) at new plants was not well explained.

In at least two ways, DOE's decision, which affected potentially up to \$1.3 billion in federal funding, was not well considered. First, the decision was made on the basis of a flawed comparison of life-cycle costs for the original FutureGen, in that DOE compared an estimate of constant dollars to an estimate of inflated dollars. Second, the decision was not based on a systematic and comprehensive comparison of the costs, benefits, and risks of the original FutureGen versus the restructured FutureGen. An expanded analysis of the costs, benefits, and risks of the original FutureGen compared with a range of modifications to the program could have included incremental changes to the original FutureGen program that

could have preserved some of its original goals and benefits while mitigating costs. Such an analysis might also have detailed the risk that DOE would receive only a small number of applications and that those applications might not include IGCC. The analysis could also have considered whether DOE's \$1.3 billion contribution for total program funding presents the best option for advancing the overall goals of CCS in both existing and future plants.

Recommendations for Executive Action

To help ensure that important decisions about the FutureGen program reflect an adequate knowledge of the potential costs, benefits, and risks of viable options, and to promote the attainment of the goals of the program while protecting taxpayer interests, we are making the following two recommendations to the Secretary of Energy:

1. Before implementing significant changes to FutureGen or before obligating additional funds for such purposes, the Secretary of Energy should direct DOE staff to prepare a comprehensive analysis that compares the relative costs, benefits, and risks of a range of options that includes (1) the original FutureGen program, (2) incremental changes to the original program, and (3) the restructured FutureGen program.
2. In addition, the Secretary should consider the results of the comprehensive analysis and base any decisions that would alter the original FutureGen on the most advantageous mix of costs, benefits, and risks resulting from implementing a combination of the options that have been evaluated.

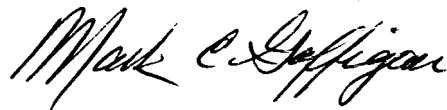
Agency Comments and Our Evaluation

We provided a draft of this report to the Secretary of Energy for review and comment. DOE did not comment on the recommendations and conclusions of the report; however, it provided technical and clarifying comments, most of which we have incorporated, as appropriate. For example, we revised the report to reflect DOE's comment that it had reached its decision to restructure FutureGen, based on concerns about increasing costs associated with constructing the original FutureGen project and that it had attempted to negotiate a more favorable cost sharing agreement with the Alliance. However, DOE added that it had stopped those negotiations because it believed that the Alliance would not be able to financially partner with DOE to complete the project. We also revised the report to reflect information provided by DOE about the role of IGCC in the original and restructured FutureGen efforts, the type of

knowledge likely to be disseminated by the original and restructured FutureGen efforts, and budget and appropriation data for FutureGen, beginning in fiscal year 2004. DOE's comments are reprinted in appendix III, along with our responses.

As agreed with your offices, unless you publicly announce the contents of this report earlier, we plan no further distribution until 30 days from the report date. At that time, we will send copies of this report to the Secretary of Energy, the DOE Office of the Inspector General, and interested congressional committees. This report also will be available at no charge at GAO's Web site at <http://www.gao.gov>.

If you or your staffs have any questions about this report, please contact me at (202) 512-3841 or gaffiganm@gao.gov. Contact points for our Office of Congressional Relations and our Office of Public Affairs may be found on the last page of this report. GAO staff who made major contributions to this report are listed in appendix IV.



Mark Gaffigan
Director, Natural Resources and Environment

Appendix I: Scope and Methodology

We examined (1) the goals of the original and restructured FutureGen programs, (2) the similarities and differences between the restructured FutureGen and other Department of Energy (DOE) carbon capture and storage programs, and (3) the extent to which DOE used sufficient information to support its decision to restructure the FutureGen program.

To examine the goals of the original and restructured FutureGen programs, including the results of the different approaches for meeting these goals, we reviewed relevant appropriations and agency documents, including budget justifications from fiscal years 2005 through 2009; the program plan for FutureGen that DOE submitted to Congress in 2004; the cooperative agreement between DOE and the FutureGen Industrial Alliance (Alliance), and its subsequent renewals; DOE's draft strategic planning documents and funding announcement for the restructured program; and public responses to DOE's request for information about the restructured FutureGen and its funding announcement. We also reviewed congressional testimony about FutureGen and related topics by officials from the Alliance; DOE, including the Secretary of Energy; and other knowledgeable stakeholders, such as academic and industry researchers. In addition, we met with and reviewed documents provided by officials and researchers from DOE, the Alliance, industry, nonprofit research organizations, and academia. In particular, we interviewed DOE officials from the Office of Fossil Energy's (FE) National Energy Technology Laboratory (NETL) and Office of Clean Coal. Finally, we conducted semi-structured interviews with knowledgeable stakeholders from the electric power and coal industries, nonprofit research organizations, and academia, among others. During the interviews, we discussed the goals, approaches, and anticipated results of the original and restructured FutureGen programs. Our method for conducting these interviews, including how we selected the knowledgeable stakeholders, appears in the next paragraph.

We conducted semi-structured interviews with 14 knowledgeable stakeholders from the electric power and coal industries, nonprofit research organizations, and academia, among others. We selected a nonprobability sample of stakeholders and stakeholder organizations using a "snowball sampling" technique, whereby each stakeholder we interviewed identified additional stakeholders and stakeholder

organizations for us to contact.¹ Specifically, we identified the first three stakeholders to interview from previous, related GAO work and a group of contributors toward key scientific assessments of climate change and clean coal technology.² We then used feedback from these interviews to identify additional stakeholders to interview, and so on, being certain to interview every stakeholder or a knowledgeable official from every stakeholder organization identified by at least two other stakeholders. We also ensured that we selected stakeholders from electric power companies both within and outside the Alliance to obtain a range of industry perspectives. Over the course of our work, we conducted semi-structured interviews with knowledgeable stakeholders from the following organizations: American Electric Power, Carnegie Mellon University, the Coal Utilization Research Council, Duke Energy, Duke University, the Electric Power Research Institute, the Massachusetts Institute of Technology, the National Association of Regulatory Utility Commissioners, the National Mining Association, Resources for the Future, and Southern Company. We used a semi-structured interview guide to interview these stakeholders and facilitate analysis of what they identified as the key similarities, benefits, and differences between the original and restructured FutureGen programs, in addition to DOE's other carbon capture and storage (CCS) programs. These semi-structured interviews allowed us to obtain information addressing all three of our objectives.

To examine the similarities and differences between the restructured FutureGen and other DOE CCS programs, we reviewed agency documents, including budget justifications from fiscal years 2005 through 2009; DOE's Carbon Sequestration Technology Roadmap and Program

¹The information gathered from these semi-structured interviews cannot be used to generalize findings to, or make inferences about, the entire population of knowledgeable stakeholders on FutureGen and clean coal technology. Although the sample provides some variety, it is unlikely to capture the full variability of knowledgeable stakeholders and it cannot provide comprehensive insight into the views of any one group of knowledgeable stakeholders. This is because, in a nonprobability sample, some elements of the population being interviewed have no chance, or an unknown chance, of being selected as part of the sample. However, the information gathered during these semi-structured interviews allows us to discuss various stakeholder views on FutureGen and clean coal technology, and it provides important context overall. It also helps us interpret the documentation and testimonial evidence we have collected.

²Massachusetts Institute of Technology, *The Future of Coal: Options for a Carbon-Constrained World* (Cambridge, MA, 2007) and IPCC, *IPCC Special Report on Carbon Dioxide Capture and Storage* (Montreal, Canada, Sept. 2005).

Plan; the program plan for FutureGen that DOE submitted to Congress in 2004; DOE's draft strategic planning documents and funding announcement for the restructured program; and relevant laws. We met with and discussed these programs with officials from NETL and FE's Office of Clean Coal. We also conducted semi-structured interviews with knowledgeable stakeholders from the electric power and coal industries, nonprofit research organizations, and academia, among others. During these interviews, we discussed the relationship between the restructured FutureGen and DOE's other CCS programs. Finally, we reviewed public responses to DOE's request for information about the restructured FutureGen and DOE's funding announcements for the restructured FutureGen and Round III of the Clean Coal Power Initiative.

To examine the extent to which DOE used sufficient information to support its decision to restructure the FutureGen program, we reviewed documents from DOE and the Alliance, including cost estimates; the cooperative agreement and subsequent updates to it; letters, presentations, and proposals documenting the renegotiation of terms for the cooperative agreement; proposed incremental changes for controlling costs; and the draft strategic planning documents and funding announcement for the restructured program. We also reviewed congressional testimony about FutureGen and related topics by officials from the Alliance; DOE, including the Secretary of Energy; and other knowledgeable stakeholders, such as academic and industry researchers. We met with and discussed the information used to support the decision to restructure FutureGen with officials from NETL and FE's Office of Clean Coal. In addition, we discussed and reviewed analyses of the costs for building coal-fired, electric power plants with officials and researchers from industry, academia, and government, including DOE's Energy Information Administration. Moreover, we discussed these costs during semi-structured interviews with knowledgeable stakeholders from the electric power and coal industries, nonprofit research organizations, and academia, among others. We also reviewed public responses to DOE's request for information about the restructured FutureGen and its funding announcement. Finally, we reviewed our recent work and guidance on best practices for cost estimation, program management, and programmatic decision making, as well as guidance from DOE and the Office of Management and Budget.

We conducted this performance audit from June 2008 to February 2009, in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and

conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Appendix II: Budget Authority and Obligations for FutureGen

Table 4: DOE Budget Authority and Obligations for FutureGen, Fiscal Years 2004 through 2008

Dollars in millions

Fiscal year	DOE budget authority for FutureGen	Adjusted DOE budgetary resources	DOE obligations for its cooperative agreement with the FutureGen Industrial Alliance	Remaining budgetary resources
2004	\$9	\$8.64		
2005	\$18	\$17.26		
2006	\$18	\$17.33		
2007	\$54	\$52.50		
2008	\$75	\$74.32		
Total	\$174^a	\$170.05^b	\$39.11^c	\$130.94^{d,e}

Source: DOE.

^aAll FutureGen budget authority was no-year authority, which means the authority is available for obligation for an indefinite time period. DOE has requested \$156 million for FutureGen in its budget justification for fiscal year 2009.

^bAccording to DOE, the department adjusted its program budget for several factors. In fiscal years 2004 through 2008, the program's budget authority was adjusted for the Small Business Innovation Research program and/or the Small Business Technology Transfer program. Moreover, the FutureGen budget for fiscal years 2004 and 2005 also included the Interior and Omnibus reduction, and in fiscal years 2004 and 2006, FutureGen's budget authority included a general rescission.

^cAccording to DOE, the agency has spent over \$22 million on obligations for the original FutureGen, via its cooperative agreement with the FutureGen Industrial Alliance. In addition, DOE anticipates reserving an additional \$2.5 million for final close-out costs related to these obligations pending invoicing from the Alliance. Depending on the actual amount of these final close-out costs, DOE estimates that it could deobligate approximately \$14.5 million of its obligations for the original FutureGen, after which time these funds would be available for the restructured FutureGen.

^dAccording to DOE, the agency has additional obligations and expenditures for support contracts related to FutureGen that fall outside the scope of its cooperative agreement with the Alliance. The expenditures and remaining obligations for these contracts total approximately \$7.8 million.

^eDOE officials told us that, after accounting for all anticipated expenditures on the original FutureGen, they expect the agency to have approximately \$293 million available for the restructured FutureGen in unobligated balances of unexpired budget authority, brought forward from prior years (i.e., carryover), including the \$156 million budget request for fiscal year 2009.

Appendix III: Comments from the Department of Energy

Note: GAO comments supplementing those in the report text appear at the end of this appendix.



Department of Energy
Washington, DC 20585

February 4, 2009

Mr. Mark E. Gaffigan
Director
Natural Resources and Environment Team
U.S. Government Accountability Office
441 G Street, NW, Mail 2T23A
Washington, DC 20548

Dear Mr. Gaffigan:

Thank you for the opportunity to review the Government Accountability Office (GAO) draft report entitled, "DOE's Decision to Restructure FutureGen Should Be Based on a Comprehensive Analysis of Costs, Benefits, and Risks" (GAO-09-248). Enclosed please find the U.S. Department of Energy's comments on the draft report.

If you have any questions or comments please contact Mr. Jarad Daniels of my staff at (202) 485-7355.

Sincerely,

A handwritten signature in black ink, appearing to read "Victor K. Der".

Victor K. Der
Acting Assistant Secretary
Office of Fossil Energy

Enclosure:
DOE Comments on Draft GAO Report



Printed with soy ink on recycled paper

See comment 1.
Now on pp. 8 and 24.

See comment 2.
Now on pp. 2, 17, and 18.

See comment 3.
Now on pp. 3 and 26.

Department of Energy Comments on GAO “DOE’s Decision to Restructure FutureGen Should be Based on a Comprehensive Analysis of Costs, Benefits, and Risks” (GAO-09-248) (GAO Draft Report)

This responds to your request for comments by the Department of Energy on the above-referenced GAO Draft Report.

1. The draft report uses inconsistent terminology to characterize the 13 options for incremental changes developed by the Office of Fossil Energy. The summary page, page 9, and the discussion on page 27 make it appear that all 13 options were viable without jeopardizing the project objective. In reality, some of the 13 options were not considered viable or recommended by Fossil Energy and were rejected by the Department as a whole.

At each of these locations (the summary page, last sentence of the third paragraph; page 9, the first full sentence; and page 27 second to last sentence of the first paragraph), DOE recommends GAO delete the number “13.” Not all of the 13 options would have preserved the original project objectives nor were all recommended. Additionally on page 27, the last sentence of the first paragraph is incorrect and should either be deleted or the sentence should start with “Some of these options.”

The discussion on page 33 is more accurate in that it states that DOE considered some of the potential changes within the list of 13 to have a detrimental impact on the original project objectives and pursued the remaining changes during negotiations with the Alliance. To the extent GAO believes discussion of the FE options is appropriate, DOE recommends that the report consistently present the options as they are characterized on page 33.

2. On page two, suggest that the last sentence of the carryover paragraph be changed to reflect that only Round III of the CCPI focused on carbon capture and sequestration and that selections have not yet been made. Suggested revision would read:

For example, DOE’s Clean Coal Power Initiative (CCPI) Round III Funding Opportunity Announcement will result in cost-shared partnerships with industry for projects that demonstrate carbon capture from coal-fired plants with sequestration or beneficial reuse.

3. On page 3, in the first full paragraph, the draft report states:

In December 2007, after DOE finished conducting the extensive environmental analyses required by the National Environmental Policy Act of 1969... of four potential sites that took over a year, the Alliance announced that it had selected Mattoon, Illinois, for the location of FutureGen.

In order to accurately depict the context of activities at the time, the report text should be revised. The above-quoted sentence implies that DOE completed its NEPA responsibilities prior to the Alliance announcement of the Mattoon site, and that is not the case. For projects requiring an environmental impact statement, an agency's NEPA review culminates with a Record of Decision. DOE had not issued a Record of Decision at the time the Alliance, over the Department's objection, chose to announce its site selection. The chronology of activities set out in the Cooperative Agreement clearly provided for the issuance of a Record of Decision first. This context should be provided for in the text of the GAO report.

See comment 4.
Now footnote 5.

4. On page 4, DOE recommends changing footnote 4 to read:

In addition, for original FutureGen, costs for the initial planning and research stages were subject to a 20 percent nonfederal cost-share.

As drafted by GAO, the footnote sentence applies to both the original and restructured approaches, but should only apply to the original FutureGen. For Restructured FutureGen, DOE mandated not less than 50 percent private sector cost-share for all stages.

Since Fiscal Year 2005, the requirements for cost sharing of the original FutureGen has been set out in statute:

Provided further, That the initial planning and research stages of the FutureGen project shall include a matching requirement from non-Federal sources of at least 20 percent of the costs: Provided further, That any demonstration component of such project shall require a matching requirement from non-Federal sources of at least 50 percent of the costs of the component . . .

See, e.g., Pub. L. No. 108-447.

See comment 5.

5. On pages 6 and 18, the draft report suggests that the technology transfer potential was greater under the original FutureGen because the non-profit Alliance would own new inventions and was willing to share its knowledge industry-wide. GAO contrasts the original FutureGen with the Restructured program where GAO believes for-profit recipients would be more reluctant to disseminate information. In fact, the intellectual property policies and provisions for each effort are essentially the same. For both the original and Restructured program, most new inventions would likely be generated by for-profit subcontractor/vendors supplying technology to the project. Ownership of these inventions would be granted to the subcontractors/vendors either by law for small businesses or nonprofits, or through a DOE patent waiver for large businesses. Inventions by the Alliance were far less likely since they were to have subcontracted for most technology development efforts. Furthermore, as with original FutureGen, DOE will require Restructured FutureGen recipients to disseminate the results of the project. Accordingly, the underlying assumptions for GAO's conclusions and comparisons about

technology transfer potential are in part faulty. Please see DOE's comments on GAO's draft statement of facts.

In the same section on page 6, and in the first line on page 19, the draft reports states that the Alliance was comprised of utilities, mining companies, and "others." To the best of DOE's knowledge, the Alliance was comprised only of utilities and mining companies both domestic and foreign.

6. In the first line on page 8, CO₂ should have a subscript rather than a superscript.

7. On page 13 in the first paragraph, the draft report states:

On January 30, 2008, about a month after the Alliance announced that it had selected Mattoon, Illinois, for the site of the FutureGen plant, DOE announced that it had decided to take the FutureGen program in a different direction.

We believe the statement set out above needs to be put in context. Prior to the announcement and without knowledge of the Alliance's choice of site, DOE asked the Alliance not to go forward with an announcement and further advised the Alliance that an announcement at that time was inadvisable in light of the ongoing DOE-Alliance discussions.

By mid-2007, in part because of an overall climate of cost escalations for building power plants around the world, DOE managers had become increasingly concerned about actual and potential escalating costs for FutureGen, and DOE had signaled to the FutureGen Alliance that DOE had serious concerns about the sustainability of the project. During September 2007, DOE began negotiating with the Alliance to develop a mutually acceptable cost-sharing formula to deal with the prospect of further cost-growth.

In December 2007, after analyzing four potential sites for the original FutureGen, the FutureGen Alliance announced that it had selected Mattoon, Illinois, for the location of the original FutureGen. The Alliance announced the site in advance to DOE's issuance of a record of decision (ROD) to complete DOE's review under the National Environmental Policy Act (NEPA) and contrary to DOE's advice. Announcement of the Alliance's selection of a site prior to the ROD was inconsistent with the schedule set out in the Cooperative Agreement.

Only after months of unsuccessful negotiations with the FutureGen Alliance regarding cost sharing for cost growth did DOE announce, on January 30, 2008, that it would not proceed beyond the then current budget period with the FutureGen Alliance, and that it planned to take a different approach to FutureGen. DOE's rationale for this decision was based on DOE's interest in maximizing the role of private sector innovation, providing a ceiling on federal contributions, and accelerating and increasing the use of clean energy technologies to help meet the growing demand for energy while also mitigating greenhouse gas emissions. The selected location of the site had no bearing on DOE's determination.

See comment 6.

See comment 7.
Now on pp. 3 and 26.

See comment 8.
Now on p. 14.

8. On page 16, the first sentence of the first full paragraph states:

Both the original and restructured programs would operate plants at commercial size (about 300 megawatts).

Under the restructured program, IGCC plants were expected to have a nominal capacity of 300 megawatts, but, as set out in the Funding Opportunity Announcement, non-IGCC projects needed only to be at a scale sufficient to prove commercial viability and be designed to produce and capture 1 million tons of CO₂ per year.

See comment 9.
Now on p. 15.

9. On page 17, in Table 2, under original FutureGen, the word “includes” should be deleted in the first row since the original program was exclusively focused on IGCC.

See comment 10.

10. On page 19, DOE recommends GAO strike the words “in new inventions it would likely own” from the last sentence of the first paragraph. Inclusion of this phrase would actually limit the scope which can also more broadly include non-patentable technical data.

See comment 11.
See comment 2.
Now on pp. 2, 17, and 18.

11. On page 21, the words “Round III” should be added after “Clean Coal Power Initiative” in the underlined heading since only the third round of CCPI has focused on carbon sequestration.

See comment 12.
Now on p. 23.

12. On page 25, change footnote “d” to read “DOE cost sharing is generally capped at 80 percent.” Alternately, delete the first sentence of the footnote.

See comment 13.
Now on p. 25.

13. On page 28, DOE recommends that GAO revise the first sentence of the last paragraph to read:

Following this presentation, senior DOE officials directed FE to negotiate with the Alliance new cost sharing arrangements under the cooperative agreement, which was subject to a continuation decision in June 2008.

See comment 14.

14. On page 29, in the fourth to last sentence of the first full paragraph, DOE recommends that GAO replace the word “renewing” with “continuing” for technical accuracy.

See comment 15.
Now on p. 26.

15. On page 29, the second to last sentence of the first full paragraph, as currently drafted, erroneously suggests that DOE officials disapproved of the selection of Mattoon for the project site. The sentence implies that DOE’s determination was influenced by the Alliance’s selection of the Mattoon site, and that is not the case. Prior to the announcement and without knowledge of the Alliance’s choice of site, DOE asked the Alliance not to go forward with an announcement and further advised the Alliance that an

announcement was inadvisable. The selected location of the site had no bearing on DOE's determination to restructure the program.

DOE recommends that the second to last sentence of the first full paragraph be revised into two sentences as follows:

DOE officials also stated that they disapproved of the Alliance's decision to announce the selection of a project site. Prior to the announcement and without knowledge of the Alliance's choice of site, DOE asked the Alliance not to go forward with an announcement and further advised the Alliance that an announcement was inadvisable. DOE had not issued its NEPA Record of Decision and was continuing its attempts to negotiate with the Alliance.

See comment 16.
Now on p. 26.

16. On page 29, the sentence at the end of the first paragraph should be modified to make it clear that DOE lost confidence in the ability of the Alliance to fund its share of the project cost, rather than confidence in the Alliance member companies or their representatives.

See comment 17.
Now on p. 29.

17. On page 32, the third to last sentence of the first paragraph suggests that the draft strategic planning document was developed in July 2008, and that is not correct. The document was transmitted to Congress in response to a document request in July of 2008. In addition, we would also like to clarify a point regarding DOE's position on the role of CCS, including IGCC with CCS, in reducing CO₂ in the future. Therefore the sentence should be changed to read as follows:

However, according to DOE, plants with CCS, including those with IGCC integrated with CCS, are important options for reducing CO₂ emissions in the future, and DOE's press release announcing the restructured program and the draft strategic planning document that DOE provided to Congress in July 2008 indicated that the restructured program would include IGCC.

See comment 18.
Now on pp. 28, 29,
and 38.

18. On page 32, footnote 30 and on page 40, table II.2 footnotes b and c, the draft report states: "DOE had not yet provided" the information or response that GAO had requested. As of the date of these comments, DOE understands that it has either already provided the relevant documentation, and has referred GAO back to those documents, or has since provided the documentation. DOE understands that all information has been provided.

See comment 19.
Now on p. 38.

19. On page 40, we noticed several errors in the Tables contained in Appendix II. **Table II.1**

The correct FutureGen appropriations for Fiscal Year 2004 through 2008 are as follows:

2004	\$9,000,000
2005	\$18,000,000
2006	\$18,000,000
2007	\$54,000,000

Total \$174,000,000

These above-stated amounts are not yet adjusted for rescissions or the SBIR/STTR offset. Hence, the actual amount available to DOE for FutureGen, as depicted in Table II.2, is less than \$174,000,000. Under the "Appropriated" column in Table II.1, the Fiscal Year 2007 amount should be changed from \$18,000,000 to \$54,000,000. The total should be changed accordingly. Under the heading "Directed" in Table II.1, the Fiscal Year 2007 amount of \$257,000,000 should be deleted as this was deferred budget authority under the Clean Coal Technology Program that was not made available to the Department for FutureGen. The last column should be updated to reflect the changes in the first two columns.

Table II.2

The calculations for the Fiscal Year 2006 Budget are as follows:

Appropriation Act	\$18,000,000
General Rescission 1%	(180,000)
SBIR Assessment	(441,000)
STTR Assessment	(53,000)
FY-2006 Available	\$17,326,000

The Fiscal Year 2006 amount in Table II.2 should be changed from \$17,820,000 to \$17,326,000 and the Total changed to \$170,045,000.

The following are GAO's comments on the Department of Energy's letter dated February 4, 2009.

GAO's Comments

1. We modified our report to address DOE's concerns about our discussion of the 13 options for incremental changes.
2. We modified our report to add clarifying information on Round III of the Clean Coal Power Initiative.
3. We added clarifying information about the timing of the site selection announcement and the release of DOE's NEPA Record of Decision.
4. We revised the footnote to state that, according to DOE, not less than a 50 percent nonfederal cost share will be required for all of the restructured FutureGen's stages.
5. We have revised the report to remove the referenced discussion.
6. We made DOE's editorial correction.
7. The report does not state or imply that the location of the site was the reason for the program's restructuring, but rather states that DOE's restructuring decision was based on a desire to contain costs in a time of increasing cost pressures. However, we revised the report to clarify that the Alliance announced its site selection decision before DOE's Record of Decision was released—which has not happened, as of the date of this report.
8. DOE clarifies that under the restructured program, IGCC plants are expected to have a nominal capacity of 300 megawatts, but non-IGCC projects need only be at a scale sufficient to prove commercial viability and be designed to produce and capture 1 million tons of CO₂ per year. We revised the report to reflect this information.
9. As suggested by DOE, we revised table 2 to reflect that the original FutureGen program focused exclusively on IGCC.
10. As indicated in our response to comment 5, we have revised the report to remove the referenced text.
11. We made appropriate revisions to the report to reflect that Round III of the Clean Coal Power Initiative focuses on carbon sequestration.

12. We revised table note “d” to table 3, to state that DOE’s cost sharing is generally capped at 80 percent.
13. We revised the report to clarify that senior DOE officials directed FE to negotiate new cost sharing arrangements under the cooperative agreement with the Alliance.
14. We revised the report to use the word “continue” in place of “renew” wherever it would more accurately reflect the various stages of the cooperative agreement.
15. Our draft report did not insinuate or state that DOE did not favor the Mattoon, Illinois, site or that DOE’s restructuring decision was based on a disapproval of the Alliance’s site selection announcement. Rather, our report states that DOE’s decision was based on a desire to limit its exposure to increased costs. However, as suggested by DOE, we clarified the report by adding that DOE had instructed the Alliance to not announce the site selection before DOE could release the Record of Decision.
16. We agree with DOE and revised the report to clarify that DOE lost confidence in the ability of the Alliance to fund its share of the project cost, rather than that DOE lost confidence in the Alliance members or their representatives.
17. We revised the report to clarify that both DOE’s press release announcing the restructured program and the updated draft strategic document, dated July 1, 2008, that DOE provided Congress indicated that the restructured program would include IGCC.
18. DOE provided information regarding the official basis for restructuring the FutureGen program and its budget authority, obligations, and expenditures that we incorporated into our report, including table 4 and its table notes. We also included in the report an additional assessment of documents, to which DOE referred as providing the basis for its decision to restructure FutureGen.
19. Regarding the tables in appendix II of the draft report, DOE provided updated FutureGen appropriations information for fiscal years 2004 and 2007 and certain calculations for the fiscal year 2006 FutureGen budget. In response, we merged tables 4 and 5 from the draft to create one table in the final report, and we adjusted the figures and calculations for the data that DOE provided.

Appendix IV: GAO Contact and Staff Acknowledgments

GAO Contact

Mark Gaffigan, (202) 512-3841 or gaffiganm@gao.gov

Staff Acknowledgments

In addition to the contact named above, Ernie Hazera (Assistant Director), Nancy Crothers, Cindy Gilbert, Chad M. Gorman, Angela Miles, Karen Richey, Michael Sagalow, and Jeanette M. Soares made key contributions to this report. Harold Brumm, Jr., and Timothy Persons also made important contributions.

GAO's Mission

The Government Accountability Office, the audit, evaluation, and investigative arm of Congress, exists to support Congress in meeting its constitutional responsibilities and to help improve the performance and accountability of the federal government for the American people. GAO examines the use of public funds; evaluates federal programs and policies; and provides analyses, recommendations, and other assistance to help Congress make informed oversight, policy, and funding decisions. GAO's commitment to good government is reflected in its core values of accountability, integrity, and reliability.

Obtaining Copies of GAO Reports and Testimony

The fastest and easiest way to obtain copies of GAO documents at no cost is through GAO's Web site (www.gao.gov). Each weekday afternoon, GAO posts on its Web site newly released reports, testimony, and correspondence. To have GAO e-mail you a list of newly posted products, go to www.gao.gov and select "E-mail Updates."

Order by Phone

The price of each GAO publication reflects GAO's actual cost of production and distribution and depends on the number of pages in the publication and whether the publication is printed in color or black and white. Pricing and ordering information is posted on GAO's Web site, <http://www.gao.gov/ordering.htm>.

Place orders by calling (202) 512-6000, toll free (866) 801-7077, or TDD (202) 512-2537.

Orders may be paid for using American Express, Discover Card, MasterCard, Visa, check, or money order. Call for additional information.

To Report Fraud, Waste, and Abuse in Federal Programs

Contact:

Web site: www.gao.gov/fraudnet/fraudnet.htm

E-mail: fraudnet@gao.gov

Automated answering system: (800) 424-5454 or (202) 512-7470

Congressional Relations

Ralph Dawn, Managing Director, dawnr@gao.gov, (202) 512-4400
U.S. Government Accountability Office, 441 G Street NW, Room 7125
Washington, DC 20548

Public Affairs

Chuck Young, Managing Director, youngc1@gao.gov, (202) 512-4800
U.S. Government Accountability Office, 441 G Street NW, Room 7149
Washington, DC 20548