United States Government Accountability Office

GAO

Report to the Chairman, Subcommittee on Energy and Resources, Committee on Government Reform, House of Representatives

September 2006

NUCLEAR ENERGY

Status of DOE's Effort to Develop the Next Generation Nuclear Plant

GAO
Accountability * Integrity * Reliability

GAO
Accountability·Integrity·Reliability

Highlights

Highlights of GAO-06-1056, a report to the Chairman, Subcommittee on Energy and Resources, Committee on Government Reform, House of Representatives

September 2006

NUCLEAR ENERGY

Status of DOE's Effort to Develop the Next Generation Nuclear Plant

Why GAO Did This Study

Under the administration's National Energy Policy, the Department of Energy (DOE) is promoting nuclear energy to meet increased U.S. energy demand. In 2003, DOE began developing the Next Generation Nuclear Plant, an advanced nuclear reactor that seeks to improve upon the current generation of operating commercial nuclear power plants. DOE intends to demonstrate the plant's commercial application both for generating electricity and for using process heat from the reactor for the production of hydrogen, which then would be used in fuel cells for the transportation sector. The Energy Policy Act of 2005 required plant design and construction to be completed by 2021.

GAO was asked to examine (1) the progress DOE has made in meeting its schedule for the Next Generation Nuclear Plant and (2) DOE's approach to ensuring the commercial viability of the project. To meet these objectives, GAO reviewed DOE's research and development (R&D) plans for the project and the reports of two independent project reviews, observed R&D activities, and interviewed DOE, Nuclear Regulatory Commission (NRC), and industry representatives.

www.gao.gov/cgi-bin/getrpt?GAO-06-1056.

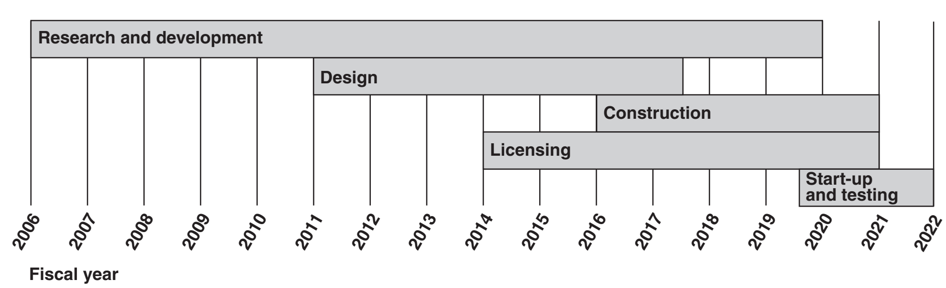
To view the full product, including the scope and methodology, click on the link above. For more information, contact Jim Wells at (202) 512-3841 or wellsj@gao.gov.

What GAO Found

DOE has prepared and begun to implement plans to meet its schedule to design and construct the Next Generation Nuclear Plant by 2021, as required by the Energy Policy Act of 2005. Initial R&D results are favorable, but DOE officials consider the schedule to be challenging, given the amount of R&D that remains to be conducted. For example, while researchers have successfully demonstrated in a laboratory setting the manufacturing of nuclear fuel for the reactor, the last of eight planned experiments to test fuel performance is not scheduled to conclude until 2019. DOE plans to initiate the design and construction phase, which also would continue R&D work, in fiscal year 2011, if the R&D results support proceeding with the project. The act also requires that DOE and NRC develop a licensing strategy for the plant by August 2008, and the two agencies are in the process of finalizing a memorandum of understanding to begin work on this requirement.

DOE is just beginning to obtain input from potential industry participants that would help determine the approach to ensuring the commercial viability of the Next Generation Nuclear Plant. In the interim, DOE is pursuing a more technologically advanced approach, compared with other options, for ensuring the plant's commercial viability, and DOE has implemented some (but not all) of the recommendations made by two advisory groups for improving the project. For example, as recommended by one advisory group, DOE lessened the need for R&D by lowering the reactor's planned operating temperature. In contrast, DOE has not accelerated its schedule for completing the plant, as recommended by the Nuclear Energy Research Advisory Committee. The recommendation was based on concern that the time frame for completing the plant is too long to be attractive for industry participation, given that other advanced reactors may be available sooner. However, DOE believes the approach proposed by the committee would increase the risk of designing a plant that ultimately would not be commercially viable. Historically, problems with DOE's management of other major projects call into question its ability to accelerate design and completion of the Next Generation Nuclear Plant.

DOE's Schedule for the Next Generation Nuclear Plant



Source: DOE.

Contents

Abbreviations

DOE	Department of Energy
NRC	Nuclear Regulatory Commission
R&D	research and development

United States Government Accountability Office
Washington, DC 20548

September 20, 2006

The Honorable Darrell E. Issa
Chairman
Subcommittee on Energy and Resources
Committee on Government Reform
House of Representatives

Dear Mr. Chairman:

Over the coming decades, energy demand in the United States is expected to continue a pattern of dramatic growth. According to the most recent data from the Department of Energy's (DOE) Energy Information Administration, electricity use is projected to rise by 50 percent between 2004 and 2030. To help meet the expected growth in electricity demand, DOE is engaged in a variety of efforts to promote the use of nuclear energy as part of the administration's National Energy Policy. In the near term, DOE is supporting the deployment of new commercial nuclear power plants that improve on the current fleet of plants operating in the United States. DOE is also engaged in long-term research and development (R&D) on advanced nuclear reactor designs that are intended to offer safety and other improvements over the current generation of nuclear power plants and expected to be ready for commercial deployment in the 2020-2030 time frame. In particular, DOE has engaged in R&D since fiscal year 2003 on what it refers to as the Next Generation Nuclear Plant, a project to demonstrate one of these advanced nuclear reactor designs.

In October 2004, DOE approved a decision to begin development of a full-scale demonstration of the Next Generation Nuclear Plant. DOE determined that a full-scale demonstration would best meet the need for new nuclear energy technology capable of being combined with a facility for producing hydrogen. Under the administration's National Hydrogen Fuel Initiative, hydrogen is envisioned to be used in fuel cells for the transportation sector as an alternative to imported oil. The demonstration plant is intended to establish the technical and commercial feasibility of producing both electricity and hydrogen from an advanced nuclear reactor. Because of the long-term nature of the project and the high risk and costs associated with the R&D required to build the plant, DOE determined that private industry would be unlikely to possess the resources or willingness to take on such a project without financial support from the federal government. DOE estimates the total cost of the plant (part of which is planned to be funded by industry) to be approximately $2.4 billion, which includes R&D, design, and construction. Of this amount, DOE has budgeted about $120 million for the project from fiscal year 2003 through fiscal year 2006.

Subsequent to DOE's initiation of R&D for the plant, the Energy Policy Act of 2005 formally established the Next Generation Nuclear Plant as a DOE project and set forth further requirements for the project's implementation.[1] In particular, the act calls for the project to be divided into two phases. In the first phase, DOE is to conduct R&D and select the initial design parameters for the plant by September 30, 2011. In the second phase, DOE is to continue R&D, develop a final design, construct the plant, and begin operation by September 30, 2021. The act designates DOE's Idaho National Laboratory as the lead laboratory and construction site for the plant and directs the laboratory to carry out cost-shared R&D, design, and construction activities with industrial partners.[2] In addition, the act requires that a license to construct and operate the demonstration plant be obtained from the Nuclear Regulatory Commission (NRC) and that DOE and NRC jointly submit a licensing strategy to the Congress by August 2008. This provision of the act is consistent with the Energy Reorganization Act of 1974, as amended, which provides NRC with licensing and regulatory authority over DOE's nuclear reactors operated for the purpose of demonstrating their suitability for commercial application.[3]

The advanced reactor design DOE has chosen for the Next Generation Nuclear Plant is the "very-high-temperature reactor." This reactor design is different from the current fleet of commercial nuclear power plants operating in the United States (or anticipated for near-term deployment) in a number of key aspects. For example, whereas the current fleet is composed of light water reactors cooled by water, the very-high-

[1] Pub. L. No. 109-58 (2005).

[2] Idaho National Laboratory, one of DOE's national laboratories operated under contract by Battelle Energy Alliance, LLC, was first established in 1949 as the National Reactor Testing Station for conducting nuclear reactor experiments. Since its establishment, 52 nuclear reactors have been designed and tested at the site. On February 1, 2005, two previous DOE laboratories at the site—the Idaho National Engineering and Environmental Laboratory and Argonne National Laboratory-West—became the Idaho National Laboratory. One of the laboratory's missions continues to be the development of advanced nuclear energy technologies.

[3] 42 U.S.C. § 5842.

temperature reactor would be cooled by helium gas. Additionally, as its name implies, the very-high-temperature reactor would operate at a much higher temperature than existing nuclear power plants—up to about 950 degrees Celsius (1,742 degrees Fahrenheit), or roughly three times the temperature of a light water reactor.[4] DOE chose the very-high-temperature reactor design from among six advanced reactor designs under development internationally. DOE is also conducting R&D on these other advanced reactor designs, which have unique characteristics that could allow their use in specialized circumstances, such as in developing countries or remote locations.

Despite the high temperature, there is general agreement that a gas-cooled reactor such as the very-high-temperature reactor offers the potential for improved safety. For example, a loss-of-coolant accident in a light water reactor has the potential to cause a meltdown of the reactor core, and light water reactors are designed with backup systems to provide emergency cooling. In contrast, the very-high-temperature reactor would be designed to be passively cooled in the event of a loss-of-coolant accident, eliminating the need for an active emergency cooling system. Other attractive features of the very-high-temperature reactor influenced DOE's decision to choose it as the design for the Next Generation Nuclear Plant. In particular, DOE considers the very-high-temperature reactor to be the nearest-term advanced nuclear reactor design that operates at temperatures high enough to generate the heat (called "process heat") needed to produce hydrogen. Furthermore, the very-high-temperature reactor design builds upon previous and current experience, both in the United States and abroad, with gas-cooled reactors. For example, DOE worked on high-temperature gas-cooled reactor technology throughout the 1980s and early 1990s, and two small gas-cooled reactors are currently in operation in China and Japan.

Over the course of the last several years, two independent groups have reviewed DOE's plans for the Next Generation Nuclear Plant. The Independent Technology Review Group—coordinated by Idaho National Laboratory and composed of an international group experienced in the design, construction, and operation of nuclear systems—issued a report in 2004 on the design features and technological uncertainties of the very-

[4]The operating temperature refers to the temperature of the helium gas as it exits the reactor core.

high-temperature reactor.[5] The report concluded that the uncertainties associated with the project appeared manageable and that the objectives of the project could be achieved. In 2006, as required by the Energy Policy Act of 2005, DOE's Nuclear Energy Research Advisory Committee also completed an initial review of the Next Generation Nuclear Plant.[6] The advisory committee reviewed DOE's R&D plans in light of the Independent Technology Review Group's report and recommended that DOE accelerate the project. Both reviews also made recommendations to modify the project's R&D plans in order to ensure the success of the project.

In September 2005, DOE stated that the department had decided to focus on successfully completing critical R&D before committing to proceed with design and construction of the Next Generation Nuclear Plant. According to DOE, this decision was based on the recognition of the significant amount of R&D remaining, as indicated by the results of the independent review of the plant conducted in 2004 as well as DOE's discussions with industry. DOE stated that the R&D would address key technical uncertainties and that the results would be used to make a determination to initiate design activities. In the meantime, DOE has prioritized other nuclear initiatives over the Next Generation Nuclear Plant.

DOE is managing the Next Generation Nuclear Plant under its project management process for the acquisition of capital assets, which sets forth planning requirements that have to be met before DOE may begin design or construction activities. The goal of these requirements is to complete projects on schedule, within budget, and capable of meeting performance objectives. Our reviews of DOE's management of other major projects have found that project management has long been a significant challenge for DOE and is at high risk of waste and mismanagement.[7] In an effort to improve cost and schedule performance on major projects, DOE issued

[5] Idaho National Engineering and Environmental Laboratory, *Design Features and Technology Uncertainties for the Next Generation Nuclear Plant*, INEEL/EXT-04-01816 (Idaho Falls, Idaho; June 30, 2004).

[6] The Nuclear Energy Research Advisory Committee was established in 1998 to provide independent advice to DOE on complex science and technical issues associated with the planning, management, and implementation of DOE's nuclear energy program.

[7] GAO, *High-Risk Series: An Update*, GAO-05-207 (Washington, D.C.: January 2005); and *High-Risk Series: An Update*, GAO-03-119 (Washington, D.C.: January 2003).

new policy and guidance on managing and controlling projects in 2000, but performance problems continue on major projects. For example, we testified in April 2006 that DOE's fast-track approach to designing and building the Waste Treatment Plant Project (at DOE's Hanford site in southeastern Washington state) increases the risk that the completed facilities may require major rework to operate safely and effectively and could increase the project's costs.[8]

In the context of these issues, you asked us to (1) determine what progress DOE has made in meeting its schedule for the Next Generation Nuclear Plant and (2) examine DOE's approach to ensuring the commercial viability of the project, including how DOE has implemented the recommendations of advisory groups.

To address these objectives, we analyzed DOE's project plans, interviewed DOE and Idaho National Laboratory officials about progress made in meeting key R&D milestones, and observed R&D efforts at Idaho National Laboratory. Furthermore, we reviewed the two independent assessments of the project, issued by the Independent Technology Review Group and DOE's Nuclear Energy Research Advisory Committee, and how DOE had responded to their recommendations. We interviewed DOE and Idaho National Laboratory officials regarding the assessments and the advantages and disadvantages of alternative approaches proposed by the two independent reviews for design and construction of the plant. We also reviewed NRC documentation related to the development of a licensing strategy for the Next Generation Nuclear Plant, and we interviewed DOE and NRC officials regarding licensing issues. Finally, we attended the American Nuclear Society's 2006 annual meeting, which included a number of sessions on nuclear fuels and materials R&D related to advanced nuclear energy systems, including the Next Generation Nuclear Plant. Because of the project's long time frame, we focused primarily on DOE's progress in meeting near-term milestones, specifically in completing the first phase of the project as defined in the Energy Policy Act of 2005. (App. I presents a detailed discussion of our scope and methodology.) We performed our work from April to September 2006 in accordance with generally accepted government auditing standards.

[8]GAO, *Hanford Waste Treatment Plant: Contractor and DOE Management Problems Have Led to Higher Costs, Construction Delays, and Safety Concerns*, GAO-06-602T (Washington, D.C.: Apr. 6, 2006).

Results in Brief

DOE has prepared R&D plans designed to support design and construction of the Next Generation Nuclear Plant by fiscal year 2021, as set forth in the Energy Policy Act of 2005. DOE officials said they consider this schedule to be challenging, given the amount of R&D that remains to be conducted. For example, DOE officials told us that researchers have successfully demonstrated in a laboratory setting the manufacturing of nuclear fuel for the reactor, which is critical to the plant's operation. The first of eight planned experiments to irradiate the fuel in order to test how well it performs will not begin until early in fiscal year 2007, and the final experiment is not scheduled to end until fiscal year 2019. R&D on other critical components of the plant—for example, materials capable of withstanding the high operating temperature planned for the plant and the technology for producing hydrogen using heat generated by the reactor—is also at an early stage. Consistent with the time frame set forth in the Energy Policy Act of 2005, DOE plans to initiate the second phase in fiscal year 2011, but only if the R&D results support proceeding with design and construction of the plant. With regard to meeting the schedule for licensing the Next Generation Nuclear Plant, DOE and NRC are in the process of finalizing a memorandum of understanding so that the two agencies can work together to develop a licensing strategy by August 2008, as required by the Energy Policy Act of 2005. The act authorizes DOE to transfer funding to NRC for the purpose of developing a licensing strategy, and NRC has determined that it will participate in the project to the extent that DOE provides funding to support NRC's efforts. DOE plans to transfer funds to NRC once the memorandum of understanding between the two agencies is finalized. In the long term, NRC will need to address "skill gaps" related to its capability to license a gas-cooled reactor such as the Next Generation Nuclear Plant. An assessment completed in 2001 identified these skill gaps, but NRC has taken limited action to address them because until recently it had not anticipated receiving a license application for a gas-cooled reactor.

DOE's approach to ensuring the commercial viability of the Next Generation Nuclear Plant is to significantly advance existing gas-cooled reactor technology in order to support the development of a plant design that utilities and other end users will be interested in deploying to help meet the nation's energy needs. For example, if successful, DOE's R&D would enable the reactor to operate at a higher temperature compared with other high-temperature gas-cooled reactors, which would result in more efficient fuel use and hydrogen production and thus a more economically attractive plant. In addition, DOE is seeking input from industry on the design of the plant and the business considerations for deploying it. In some cases, DOE officials' views on how best to achieve the technological advances and ensure the commercial viability of the plant differ from the two independent advisory groups that have reviewed DOE's plans, and DOE has implemented some (but not all) of the advisory groups' recommendations. For example, in accordance with a recommendation of the Independent Technology Review Group, DOE lessened the need for R&D on advanced materials by lowering the planned operating temperature of the reactor from 1,000 degrees Celsius to no more than 950 degrees Celsius. In contrast, DOE has not implemented recommendations to scale back other planned technological advances or accelerate its schedule for completing the plant. The Nuclear Energy Research Advisory Committee had recommended accelerating the schedule to make the plant more attractive to industry compared with other advanced gas-cooled reactors that may be available sooner and thus attract greater industry participation. Idaho National Laboratory, the project integrator for the Next Generation Nuclear Plant, has also proposed accelerating the schedule, but to a lesser extent. In particular, the laboratory's proposed scheduled would begin design earlier than planned by DOE and, as a result, require more funding in the near term. DOE believes accelerating the project would increase project risk—for example, the risk of cost overruns or not meeting project specifications—and require significant additional resources that are not in keeping with the department's current priorities. According to DOE officials, additional R&D conducted early in the project would reduce overall project risk but would require additional resources. However, DOE has limited funding for nuclear energy R&D and has given other projects, such as developing the capability to recycle fuel from existing nuclear power plants, priority over the Next Generation Nuclear Plant.

In commenting on a draft of this report, DOE and NRC commended the accuracy of the report and provided technical comments, which we incorporated, as appropriate.

Background

One of DOE's strategic goals is to promote a diverse supply of reliable, affordable, and environmentally sound energy. To that end, DOE is promoting further reliance on nuclear energy under the administration's

National Energy Policy.[9] According to DOE officials, the department has three priorities for promoting nuclear energy:

- The first priority is the deployment of new advanced light water reactors under the Nuclear Power 2010 program. Announced in 2002, this program is a cost-shared effort with industry to identify sites for new plants; develop and bring to market advanced technologies based on the current fleet of light water reactors; and demonstrate new NRC regulatory processes for combining the construction and operating licensing of new plants.[10]

- The second priority is the Global Nuclear Energy Partnership, launched in February 2006. The objectives of the partnership are to demonstrate and deploy new technologies to recycle nuclear fuel and minimize nuclear waste, and to enable developing nations to acquire and use nuclear energy while minimizing the risk of nuclear proliferation.

- The third priority is R&D on the Next Generation Nuclear Plant. In addition to promoting nuclear energy, this project is intended to support the president's National Hydrogen Fuel Initiative by demonstrating an advanced nuclear energy system capable of also producing hydrogen for use in fuel cells in the transportation sector. DOE's Office of Nuclear Energy is conducting R&D on the Next Generation Nuclear Plant and ultimately will be responsible for the design and construction of the plant. According to DOE officials, the department remains committed to the Next Generation Nuclear Plant even though the Global Nuclear Energy Partnership has assumed a higher priority since its announcement in February 2006.

DOE is engaged in R&D on the Next Generation Nuclear Plant as part of a larger international effort to develop advanced nuclear reactors (Generation IV reactors) that are intended to offer safety and other improvements over the current generation of nuclear power plants (Generation III reactors). DOE coordinates its R&D on advanced nuclear reactors through the Generation IV International Forum, chartered in 2001

[9]While DOE is the federal agency tasked with promoting nuclear energy, NRC is responsible for ensuring public health and safety with regard to nuclear power. NRC's current regulatory activities include reactor safety oversight, license renewal of existing plants, and licensing of new reactors, including the Next Generation Nuclear Plant.

[10]The previous method required a licensee to obtain a construction license and later obtain an operating license.

to establish a framework for international cooperation in R&D on the next generation of nuclear energy systems.[11] In 2002, the Generation IV International Forum (together with DOE's Nuclear Energy Research Advisory Committee) published *A Technology Roadmap for Generation IV Nuclear Energy Systems*, which identified the six most promising nuclear energy systems for further research and potential deployment by about 2030. The six technologies were chosen based upon a series of goals covering four broad areas: sustainability, such as minimizing the amount of nuclear waste produced by the reactor; the economic attractiveness of the reactor; safety and reliability; and decreased likelihood of material being diverted to weapons programs.

DOE has selected one of the six Generation IV systems—the very-high-temperature reactor—as the design for its Next Generation Nuclear Plant, in part because it is considered to be the nearest-term reactor design that also has the capability to produce hydrogen. According to DOE officials, the very-high-temperature reactor is also the design with the greatest level of participation among the Generation IV members. Furthermore, the very-high-temperature reactor builds on previous experience with gas-cooled reactors. For example, DOE conducted R&D on gas-cooled reactors throughout the 1980s and early 1990s, and two gas-cooled reactors have previously been built and operated in the United States.[12] If successful, the Next Generation Nuclear Plant would represent an improvement over these previous reactors. One of the earlier reactors was smaller than the Next Generation Nuclear Plant, and the other experienced numerous technical problems during its operating life, such as problems with moisture entering the reactor. In addition, the Next Generation Nuclear Plant is intended to produce much higher outlet temperatures, enabling high-temperature applications such as the production of hydrogen.

The basic technology for the very-high-temperature reactor also builds on previous efforts overseas, in particular high-temperature gas-cooled reactor technology developed in England and Germany in the 1960s. In addition, the technologies for the Next Generation Nuclear Plant are being

[11]Members of the Generation IV International Forum include Argentina, Brazil, Canada, the European Atomic Energy Community (Euratom), France, Japan, South Africa, South Korea, Switzerland, the United Kingdom, and the United States. In July 2006, DOE announced that China and Russia are also expected to join the forum.

[12]The Peach Bottom Unit One reactor was in operation in Pennsylvania from 1967 to 1974, and the Fort St. Vrain reactor was in operation in Colorado from 1979 to 1989.

advanced in projects at General Atomics in the United States, the AREVA company in France, and at the Pebble Bed Modular Reactor company in South Africa. Furthermore, Japan and China have built small reactors that are demonstrating the feasibility of some of the planned Next Generation Nuclear Plant components and materials.

DOE Has Made Initial Progress Toward Meeting Near-Term Milestones for the Next Generation Nuclear Plant

DOE has developed a schedule for the R&D, design, and construction of the Next Generation Nuclear Plant that is intended to meet the requirements of the Energy Policy Act of 2005. While initial R&D results are favorable, DOE officials consider this schedule to be challenging given the amount of R&D that remains to be conducted. To meet the requirement to develop a licensing strategy for the plant by August 2008, DOE and NRC are in the process of finalizing a memorandum of understanding so that the two agencies can work together.

DOE Has Developed an Overall Schedule to Initiate the Process of Selecting a Final Design in Fiscal Year 2011 and Complete the Plant in Fiscal Year 2021

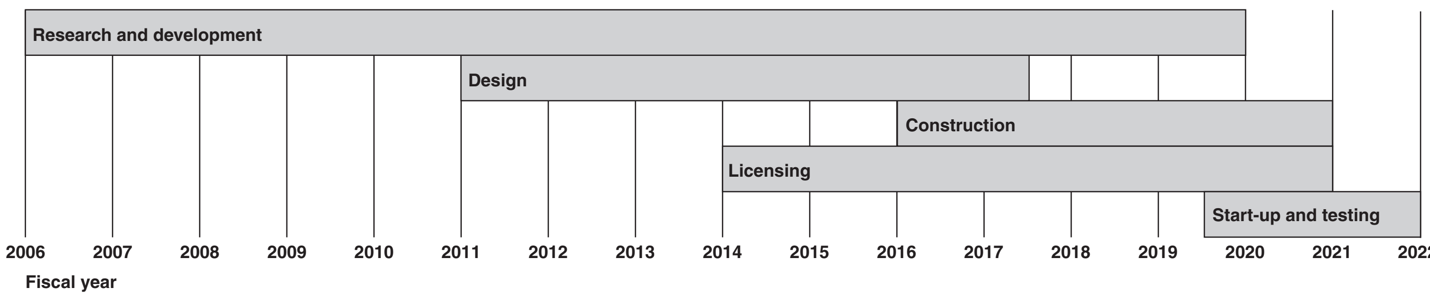
DOE has scheduled the Next Generation Nuclear Plant project to meet the requirements of the Energy Policy Act of 2005, which divides the project into two phases. For the first phase, DOE has been conducting R&D on fuels, materials, and hydrogen production. The R&D program is scheduled to continue through fiscal year 2019. DOE also recently announced its intent to fund several studies on preconceptual, or early, designs for the plant. DOE plans to use the studies, which are expected to be completed by May 2007, to establish initial design parameters for the plant and to further guide R&D efforts.

DOE is planning to begin the second phase in fiscal year 2011 by issuing a request for proposal that will set forth the design parameters for the plant. Under DOE's project management process, DOE must make a decision to go ahead with the project before issuing the request for proposal. If R&D results at that time do not support the decision to proceed, DOE may cancel the project.[13] Assuming a request for proposal is issued, DOE is planning to choose a design from among those submitted by reactor vendors by 2013. Construction is scheduled to begin in fiscal year 2016, and the plant is expected to be operational by 2021. In addition, DOE is planning for the appropriate licensing applications for the plant to be

[13]Similar decisions to proceed with or cancel the project must also be made at other key points, such as before construction begins.

submitted for NRC review and approval during the second phase of the project. See figure 1 for the overall Next Generation Nuclear Plant project schedule.

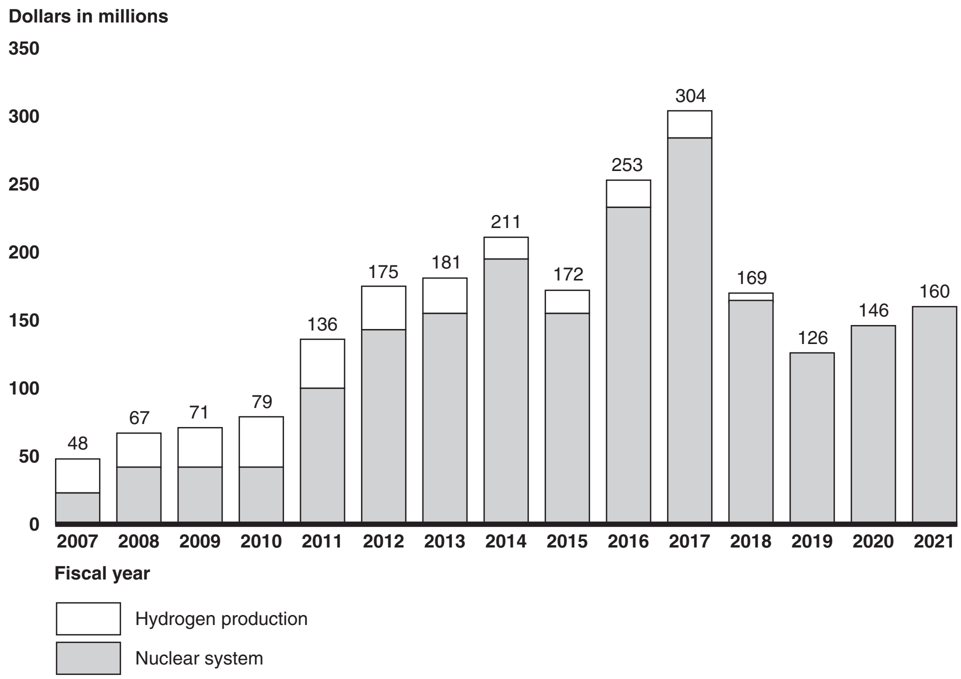
Figure 1: Next Generation Nuclear Plant Project Schedule



Source: DOE.

As scheduled by DOE, the Next Generation Nuclear Plant project is expected to cost approximately $2.4 billion, part of which is to be funded by industry. According to DOE officials, the department budgeted about $120 million for the project from fiscal years 2003 through 2006. This amount includes about $80 million for R&D on the nuclear system of the plant and about $40 million for R&D on the hydrogen production system. In addition to funding amounts already provided, figure 2 shows remaining year-to-year cost projections for the project for fiscal years 2007 through 2021. The projections are based on estimates developed by Idaho National Laboratory, which adapted a cost estimate created by the General Atomics company for its high-temperature gas-cooled reactor design. The projections account for differences between the General Atomics design and the very-high-temperature reactor and include an estimate of the cost of designing and building the hydrogen plant. According to DOE officials, the laboratory's figures are preliminary but provide an order-of-magnitude estimate of the funding required for R&D, design, and construction.

Figure 2: Remaining Year-to-Year Projected Costs of DOE's Next Generation Nuclear Plant Project, Fiscal Years 2007-2021



Sources: DOE and Idaho National Laboratory.

Note: Developing and constructing the hydrogen production facility is projected to cost $289 million, while the reactor system is projected to cost approximately $2 billion—a total of almost $2.3 billion from 2007 through 2021. These amounts do not include operating the Next Generation Nuclear Plant.

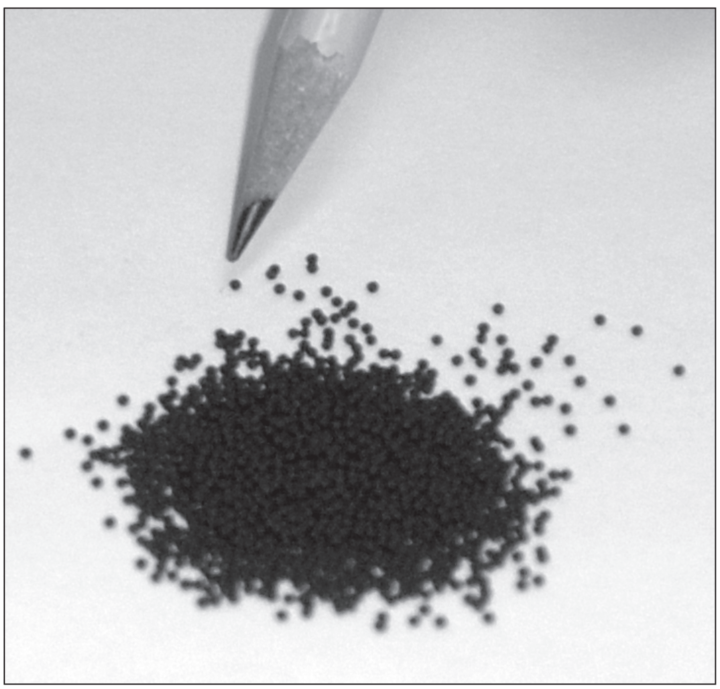
DOE Has Made Initial Progress Developing Fuel and Materials Needed for the Plant

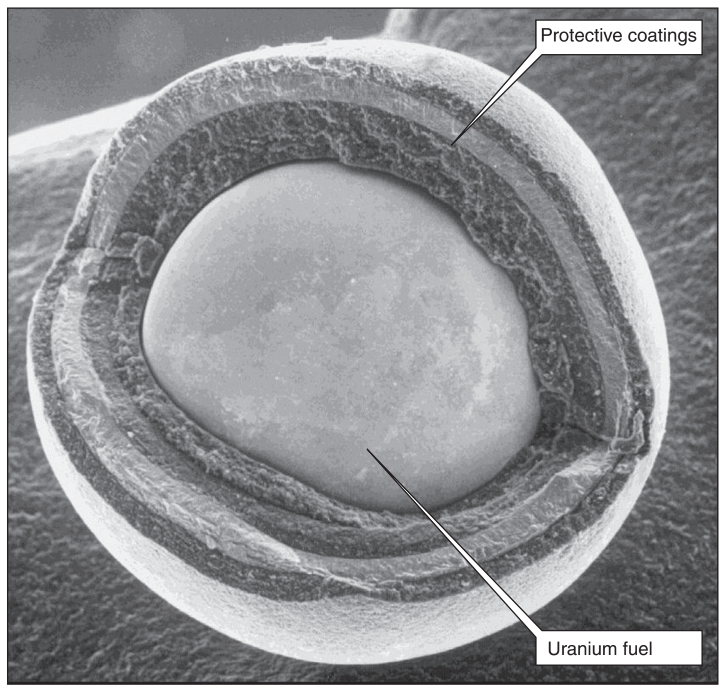
Initial research results since DOE initiated R&D on the Next Generation Nuclear Plant project in 2003 are favorable, but the most important R&D has yet to be done. For example, DOE is planning a series of eight fuel tests in the Advanced Test Reactor at Idaho National Laboratory.[14] Each test is a time-consuming process that requires first fabricating the fuel specimens, then irradiating the fuel for several years, and finally conducting the postirradiation examination and safety tests. DOE is at the beginning of this process. In particular, DOE officials said they have successfully fabricated the fuel for the first test and addressed previous manufacturing problems with U.S. fuel development efforts in which contaminants weakened the coated particle fuel. (As shown in fig. 3,

[14]The Advanced Test Reactor has been in operation since 1967 and is designed to study the effects of intense radiation on reactor materials and fuels. The reactor is capable of simulating years of radiation exposure in a matter of weeks or months.

coated particle fuel is composed of a small uranium kernel that is coated with several protective layers.) However, the irradiation testing of the fuel in the Advanced Test Reactor has not yet begun. The first test is scheduled to begin early in fiscal year 2007 and to be completed in fiscal year 2009. The eighth and final test is scheduled to begin in fiscal year 2015, and the fuel testing program is scheduled to conclude in fiscal year 2019. As a result, DOE will not have the final results from all of its fuel tests before both design and construction begin.[15] While DOE has carefully planned the fuel tests and expects favorable results, a DOE official acknowledged that they do not know if the fuel tests will ultimately be successful.

Figure 3: Actual Size and Magnified Views of the Coated Particle Fuel for the Next Generation Nuclear Plant





Sources: General Atomics (left); DOE (right).

[15]Under DOE's fuel R&D plan, the results from the first six tests would be available before construction begins, and the results from the final two tests would be available before completion of the plant.

Other key areas in which DOE is at the beginning stages of R&D include the hydrogen production system for the plant and materials development and testing:

- Idaho National Laboratory successfully completed a 1,000-hour laboratory-scale test of one of two potential hydrogen production systems in early 2006, and DOE needs to conduct additional R&D to determine which of the two systems is the most promising.[16] In particular, DOE is planning to build small demonstrations of one or both systems by fiscal year 2011 in order to further test their performance and their ability to be scaled up to larger systems. DOE ultimately plans to complete a commercial-scale hydrogen production system for demonstration by fiscal year 2019, which will allow time to test the system before linking it to the very-high-temperature reactor.

- DOE has selected and procured samples of graphite—the major structural component of the reactor core that will house the fuel and channel the flow of helium gas—and designed experiments for testing the safety and performance of the graphite samples. This activity is essential because the graphite used in earlier gas-cooled reactors in the United States is no longer in production. The selection and procurement of the graphite samples is a significant accomplishment because DOE had to choose from many possible graphite candidates, and manufacturing each sample can take 6 to 9 months. Nevertheless, much of the required graphite R&D has not yet begun and will not be completed for many years. For example, the first test to irradiate graphite samples in the Advanced Test Reactor in Idaho is scheduled to begin in November 2007, and according to DOE's most recent materials R&D plan, final graphite studies will be completed in fiscal year 2015.

If DOE's R&D program is successful and the Next Generation Nuclear Plant is designed and built, there are additional areas of R&D that will ultimately be required. For example, the very-high-temperature reactor

[16]One system, the thermochemical cycle, uses a series of chemical reactions to convert water to hydrogen and oxygen. The other system, high-temperature electrolysis, uses electricity to produce hydrogen from steam. In August 2006, DOE announced its intent to fund two projects to partner with industry to study the economic feasibility of producing hydrogen at existing commercial nuclear power plants. According to a DOE official, whereas the projects at existing plants would use existing technology for electrolysis of water, the high-temperature electrolysis being studied for the Next Generation Nuclear Plant would be based on electrolysis of steam, which is expected to be a more efficient and economical means of producing hydrogen.

design would produce large amounts of irradiated graphite waste, and DOE has not yet determined how it would dispose of the graphite.

DOE and NRC Have Started Work on a Licensing Strategy

DOE and NRC are in the process of finalizing a memorandum of understanding to develop a licensing strategy. As required by the Energy Policy Act of 2005, DOE and NRC are to jointly submit a licensing strategy by August 2008.[17] The act requires the licensing strategy to include, among other things, ways in which current NRC licensing requirements will need to be adapted to the Next Generation Nuclear Plant and other R&D activities that may be required on the part of NRC in order to review a license application. The memorandum of understanding between the two agencies will establish a framework to develop a licensing strategy and will include organizational responsibilities, procedures for agency interaction, planned work products, and funding responsibilities. NRC drafted a memorandum of understanding and submitted it to DOE, but its approval has been delayed by additional negotiations between the two agencies on the details of the agreement. As a result, according to the program manager for the Next Generation Nuclear Plant, DOE has yet to transfer funds to NRC for the purpose of developing a licensing strategy, as authorized by the Energy Policy Act of 2005, even though DOE has approved a transfer of $250,000 for fiscal year 2006 and plans to transfer $2 million in fiscal year 2007.

Although they approved the draft memorandum of understanding, the NRC commissioners have expressed concerns about allocating agency resources to the Next Generation Nuclear Plant project because the agency anticipates an influx of up to 18 license applications for new light water reactors in the near future. As a result, NRC has determined that these upcoming applications will have priority over the Next Generation Nuclear Plant in order to ensure their timely review and approval. Furthermore, NRC has determined that it will participate in the Next Generation Nuclear Plant project only to the extent that DOE funding will support.

Nevertheless, NRC has taken certain actions that will support licensing the Next Generation Nuclear Plant. In particular, NRC has been developing a

[17]The act also directs DOE to seek NRC's active participation throughout the duration of the project—for example, to avoid design decisions that would compromise safety or impair the accessibility of safety-related components for inspection and maintenance.

licensing process that could be used for advanced nuclear reactor designs and that would provide an alternative to its current licensing framework. Under the current framework of regulations, an application for an advanced reactor design must first undergo a detailed review by NRC in order to determine which technical requirements, originally developed specifically for light water reactors, are also applicable to advanced reactors. Furthermore, NRC must determine whether the license application presents issues that are not addressed by the current framework. In an effort to provide an alternative to this process, NRC issued a proposal in May 2006 (for public review and comment) for licensing requirements that would be "technology neutral" while still focusing on reactor safety and performance. Under the new technology-neutral framework, the licensing process would establish general safety requirements that could be applied either to light water reactors or non-light-water reactors, such as the Next Generation Nuclear Plant. These high-level safety requirements would be supplemented by technology-specific regulatory guidance.

Aside from developing a licensing strategy, NRC will need to enhance its technical capability to review a license application for a gas-cooled reactor, such as the Next Generation Nuclear Plant. In 2001, NRC completed an assessment of its readiness to review license applications for advanced reactors. The assessment identified skill gaps in areas such as accident analysis, fuel, and graphite, which apply to gas-cooled reactors.[18] Furthermore, it identified a "critical" skill gap in inspecting the construction of a gas-cooled reactor. As a result of the 2001 assessment, NRC issued a detailed plan in 2003 to address gaps in expertise and analytical tools needed to license advanced reactors, including gas-cooled reactors. However, since issuing the plan, NRC has taken limited steps to enhance its technical capability related to gas-cooled reactors because, until recently, it had not anticipated receiving a license application for a gas-cooled reactor. In addition to training NRC employees, NRC officials said that they plan to rely on expertise from industry, DOE national laboratories, and international research programs, and that how and when these gaps are addressed will ultimately depend on the schedule and technology selected for the Next Generation Nuclear Plant. Furthermore, NRC officials said that addressing these skill gaps will be difficult given

[18]As defined in the *Future Licensing and Inspection Readiness Assessment*, published by NRC in September 2001, skill gaps occur when individuals with technical expertise are working in other areas within the agency, are near retirement or are expected to leave the agency, or do not exist in the agency.

the potential influx of license applications for advanced light water reactors.

DOE Is Pursuing a More Technologically Advanced Approach Compared with Other Options in an Effort to Ensure the Plant's Commercial Viability

DOE is beginning to obtain input from potential industry participants that would help DOE determine its approach to ensuring the commercial viability of the Next Generation Nuclear Plant. In the interim, DOE is pursuing a more technologically advanced approach compared with the recommendations of the Independent Technology Review Group and the Nuclear Energy Research Advisory Committee. DOE has implemented some of the recommendations to scale back the technological advancements being pursued, but DOE officials said that a number of the recommendations would not help ensure the commercial viability of the project. In particular, DOE has not implemented the recommendation to accelerate design and completion of the plant.

The Plant Must Be Commercially Viable and Attract Utilities That Would Build the Plants to Help Meet the Nation's Energy Needs

The objective of designing a commercially viable Next Generation Nuclear Plant is recognized in the Energy Policy Act of 2005 and in DOE's justification of the need for the plant. For example, the act directs DOE's R&D to examine reactor designs that, among other things, are economically competitive with other electricity generation plants and that are more efficient and cost less than existing reactors.[19] The Independent Technology Review Group concluded that, in addition to cost and performance, the most important consideration for commercial viability would be to reduce the risk associated with deploying new technologies. The review group cautioned that attempting to achieve too many significant technological advances in the plant could result in it becoming an exercise in R&D that fails to achieve its overall objectives, including commercial viability. Another key factor likely to affect the plant's commercial viability is the time frame for its completion. For example, the commercial attractiveness could be affected by competition with other high-temperature gas-cooled reactors under development and potentially available sooner, such as one in South Africa, although these other reactor designs would also need to be licensed by NRC before being deployed in the United States.

[19]Section 641 of the act provides that the prototype plant should be based on R&D activities supported by the Generation IV Nuclear Energy Systems Initiative carried out under another provision of the act. In conducting the Generation IV initiative, the Secretary of DOE is directed by section 952(d) of the act to look at project designs that meet these criteria.

DOE acknowledges the risk of designing and building a plant that is not commercially viable and has taken initial steps to address this challenge. For example, DOE has established what it considers to be “aggressive but achievable” goals, such as producing hydrogen at a cost low enough to be competitive with gasoline, and other goals consistent with targets identified by the Independent Technology Review Group, which included industry representatives. Furthermore, DOE initiated two efforts in July 2006 to obtain input from industry, although these efforts are at an early stage and it is too early to determine their outcome. DOE is seeking industry input in two areas: (1) the design of the plant and (2) the business considerations of deploying the plant. With regard to the design of the plant, DOE announced its intent to fund multiple industry design teams to complete studies by May 2007. According to DOE officials, the industry design teams would develop preconceptual designs (and associated cost estimates) for every aspect of the plant, including the reactor and hydrogen production technology. DOE considers the studies to be an important first step that could help focus R&D for the Next Generation Nuclear Plant. With regard to the business considerations of deploying the plant, DOE began participating in meetings with representatives from reactor vendors, utilities, and potential end users in order to obtain their insight into the market conditions under which the plant would be commercially viable, such as the cost of electricity.

Until DOE develops a better understanding of the business requirements for the Next Generation Nuclear Plant, DOE’s R&D plans are supporting multiple design options. For example, DOE is conducting R&D to support two distinct designs of the very-high-temperature reactor—pebble bed and prismatic block—rather than focusing on one design that may ultimately be found to be less commercially attractive.[20] DOE officials told us the department’s role is to determine the technical limits of the plant, which industry can then use to propose specific designs considered to be commercially viable. Assuming that the R&D supports proceeding with the project, DOE intends to select from among designs proposed by industry. DOE officials said that the selection would be based on objective and transparent criteria, such as the ability of the proposed design to be

[20]The pebble bed design, which is the focus of R&D in South Africa and China, uses fuel particles formed into billiard-ball-size graphite spheres that slowly move through the reactor core in a continuous refueling process. In the prismatic block design, which is being advanced in France and Japan and by General Atomics in the United States, fuel particles are formed into cylindrical rods that are loaded into large graphite blocks making up the reactor core, which is periodically refueled in a batch process.

licensed by NRC—a key requirement for the commercial viability of deploying additional plants.

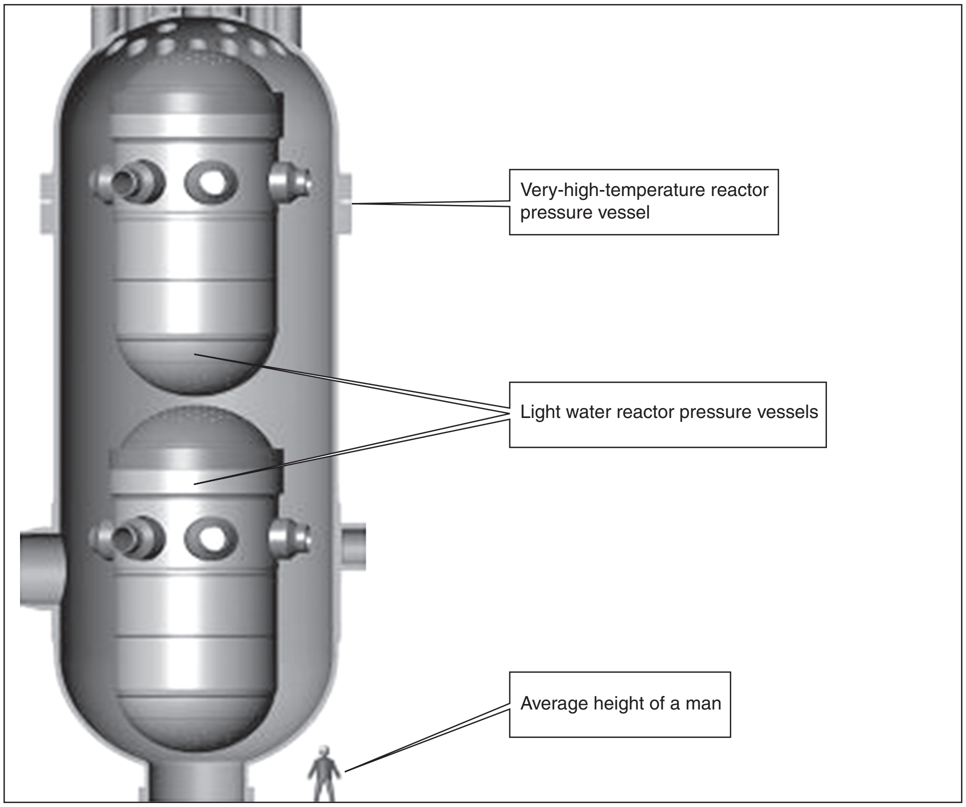
DOE Has Implemented Some Recommendations to Lessen the R&D Required for the Plant

Compared with other high-temperature gas-cooled reactors, including the two reactors operating in China and Japan, the Next Generation Nuclear Plant represents a technological advance with regard to size, operating temperature, fuel type, and the coupling of electricity generation and hydrogen production in one plant. These technological advancements require substantial R&D on virtually every major component of the plant. Examples of how the Next Generation Nuclear Plant advances existing technology include the following:

- DOE is conducting R&D on an advanced uranium fuel composition that could improve the safety and performance of the very-high-temperature reactor compared with the reactors in China and Japan and R&D efforts in France and South Africa. However, the performance of the advanced fuel composition is not proven and requires fundamental R&D.

- The thermal power of the very-high-temperature reactor design is expected to be up to 60 times greater than the reactors in China and Japan. The larger reactor creates significant challenges—for example, with regard to manufacturing the pressure vessel, which houses the reactor core. According to DOE officials, the pressure vessel would be more than twice as large as a light water reactor pressure vessel, and there is currently only one steel manufacturer, in Japan, that has the potential to scale up its production to produce such a vessel. (See fig. 4 for an illustration of the anticipated size of the very-high-temperature reactor pressure vessel.)

Figure 4: The Anticipated Size of the Next Generation Nuclear Plant Reactor Pressure Vessel Compared with Light Water Reactor Pressure Vessels Currently in Use



Source: DOE.

- The plant would extend the application of nuclear technology into a new area—the use of process heat from the reactor for the production of hydrogen or other applications, such as water desalination. Currently, no nuclear reactor is coupled with a hydrogen plant, although related R&D is being conducted overseas. The inclusion of hydrogen production requires R&D on the technology for transferring the heat from the reactor to the hydrogen plant and introduces considerations not present in other nuclear plants, such as how an equipment failure in the hydrogen plant could affect the operation and safety of the reactor.

- DOE aims to operate the reactor at a higher temperature than other gas-cooled reactors—up to 950 degrees Celsius—which increases the fuel and materials R&D needed for the plant and may require R&D on materials not previously used in nuclear plants. According to DOE officials, the gas-cooled test reactor in Japan has reached a comparable temperature, but just for short periods of time. The goal of operating at the higher temperature is to more efficiently use fuel, generate electricity, and produce hydrogen.

As recommended by the Independent Technology Review Group, DOE revised its R&D plans to lessen the technical challenge of designing and building the Next Generation Nuclear Plant. Most importantly, DOE reduced the planned operating temperature of the reactor from 1,000 degrees Celsius to no more than 950 degrees Celsius. According to Idaho National Laboratory officials, the small reduction is significant because it means that less R&D is required to develop advanced materials to build the reactor. In particular, it enables DOE to use existing metals rather than develop completely new classes of materials. Another example of a recommendation that DOE has implemented is to focus on an indirect power conversion cycle, which uses an intermediate heat exchanger to transfer the heat from the reactor to the electricity generation system. In contrast, a direct cycle, in which the same helium gas that cools the reactor flows directly to the system that generates electricity, would be more efficient but would require the development of new power conversion technology. An indirect cycle still requires R&D—specifically, on the intermediate heat exchanger—but relies on existing power conversion technology.

DOE, however, has not adopted other recommendations—in particular, to revise its R&D plan to focus on a uranium dioxide fuel kernel, which has been more widely used and researched than the advanced uranium oxycarbide fuel kernel DOE is currently researching.[21] The Independent Technology Review Group considered DOE's fuel R&D plan more ambitious than necessary and concluded that focusing on the more mature fuel technology would reduce the risk of not meeting the schedule for the plant. The Nuclear Energy Research Advisory Committee also suggested that refocusing the fuel R&D would allow DOE to accelerate its schedule. The recommendation to refocus the fuel R&D is significant because—as generally agreed by DOE, NRC, and industry officials—fuel R&D is one of the most important technical challenges to the plant. Not only must the fuel perform to design expectations, but it must also be licensed as safe by NRC. Nevertheless, DOE has continued to focus on the advanced uranium

[21]Whereas the more widely researched fuel kernel is composed of uranium dioxide, the advanced composition incorporates both uranium dioxide and uranium oxycarbide.

oxycarbide fuel because it has the potential for better performance. In addition, DOE officials said that the fuel R&D program is focused on the most significant challenge—the fuel coatings, which is independent of the fuel kernel composition. To respond to the Independent Technology Review Group's recommendation, DOE decided to test the performance of the two types of fuel kernels side-by-side as part of its fuel R&D plan.

The Nuclear Energy Research Advisory Committee also recommended that DOE re-evaluate the dual mission of demonstrating both electricity generation and hydrogen production.[22] Although the advisory committee did not recommend what the focus of the Next Generation Nuclear Plant should be—electricity generation or hydrogen production—it wrote that the dual mission would be much more challenging and require more funding than either mission alone. Instead, DOE's R&D is currently supporting both missions, and DOE officials said they consider the ability to produce hydrogen (or to use process heat for other applications) key to convincing industry to invest in the Next Generation Nuclear Plant rather than advanced light water reactors similar to the current generation of nuclear power plants operating in the United States. Furthermore, Idaho National Laboratory officials said that while the option of re-evaluating the dual mission remains open, including both missions would allow utilities that may invest in the plant greater flexibility in meeting the needs of the markets they serve.

DOE Has Not Implemented Recommendations to Accelerate Design and Completion of the Next Generation Nuclear Plant

A key recommendation of the Nuclear Energy Research Advisory Committee was to accelerate the project and deploy the plant much earlier than planned by DOE. The advisory committee based its recommendation on the assumption that participation in the project by industry and international partners would be greater if the project were accelerated because of a greater interest in near-term projects. Representatives of the Nuclear Energy Institute, which represents utilities that operate nuclear power plants, also told us that accelerating the project would increase the probability of successfully commercializing the plant. As one possible approach to acceleration, the advisory committee further recommended that DOE design the Next Generation Nuclear Plant to be a smaller reactor that could be upgraded and modified as technology advances. For

[22]The Energy Policy Act of 2005 directs that development of high-temperature hydrogen production technology be one of the major project elements and that the plant be used to generate electricity, to produce hydrogen, or to both generate electricity and produce hydrogen.

example, the initial fuel for the plant would be designed to be easily replaced with more advanced fuel. Under this approach, DOE would determine the plant size that could be scaled up to support full-size commercial application. DOE officials estimated that accelerating the project as recommended by the advisory committee would reduce the project's total cost by about 20 percent. However, DOE officials consider the schedule high risk and doubt that the degree of acceleration recommended could be achieved. Furthermore, according to DOE officials, a smaller reactor would require the same R&D as a larger reactor but would not support future NRC licensing of a full-scale plant, which is critical to the plant's commercial viability.

Idaho National Laboratory officials also consider the schedule proposed by the advisory committee to be high risk, potentially resulting in the need to redo design or construction work. Nevertheless, the laboratory has proposed accelerating the schedule, but to a lesser extent than recommended by the advisory committee. According to laboratory officials, if DOE does not begin design sooner than currently planned, too much R&D and design work will be compressed into the shorter time frame after DOE begins design in fiscal year 2011, and the department will not be able to complete the plant by fiscal year 2021. Consequently, the laboratory has proposed beginning design earlier than planned by DOE, which would also reduce the scope of the R&D by focusing on fewer design alternatives. The laboratory's proposed schedule would result in completing the plant up to 3 years earlier than under DOE's schedule. While the laboratory's proposed schedule would slightly reduce the project's total cost estimate, it would require that DOE provide more funding in the near term. For example, in fiscal year 2007, Idaho National Laboratory estimates that R&D on the very-high-temperature reactor design would need to be increased from $23 million (the amount requested by DOE in its budget submission) to $100 million.

DOE officials said that the laboratory's proposed schedule is the best option for accelerating the plant and that they would consider it if there were adequate funding and sufficient demand among industry end users to complete the project sooner. In addition, DOE officials said that even if the schedule is not accelerated, increasing the funding for the project would enable additional R&D to be conducted to increase the likelihood that the plant is completed by fiscal year 2021. For example, DOE officials stated that its current R&D plans for the very-high-temperature reactor design could support doubling the department's fiscal year 2007 budget request of $23 million. However, DOE has limited funding for nuclear energy R&D and has given other projects, such as developing the capability to recycle fuel from existing nuclear power plants, priority over the Next Generation Nuclear Plant.

We consider it too soon for DOE to determine, based on its early R&D results and interactions with industry, whether DOE should accelerate or maintain its current schedule for design and completion of the Next Generation Nuclear Plant. DOE's problems with project management call into question the department's ability to successfully accelerate its schedule for the plant. The risk of similar problems in managing the Next Generation Nuclear Plant is complicated by the fact that the responsible office within DOE—the Office of Nuclear Energy—does not have previous experience in managing a design and construction project of this size.

Concluding Observations

DOE is making progress in implementing its plans for the Next Generation Nuclear Plant, including R&D and efforts to involve industry stakeholders. However, these efforts are at the beginning stages of a long project not scheduled to be completed until fiscal year 2021. Consequently, it is too soon to determine how successful DOE will be in designing a technically and commercially viable plant. Furthermore, in our view, it is too soon to support a decision to accelerate the project, as recommended by the department's Nuclear Energy Research Advisory Committee, to ensure that the plant will be attractive to industry participation and investment. Accelerating the project would require that DOE narrow the scope of its R&D and begin designing the plant before having initial research results on which to base its design decisions. This could result in having to redo work if future research results do not support DOE's design decisions. In addition, DOE has only recently begun to systematically involve industry in the project in order to obtain industry views on issues such as the design of a commercially viable plant and the market conditions under which a plant would be competitive with other options. Such input is critical to key decisions, such as whether DOE should design a less technologically advanced plant that is available sooner rather than a larger, more technologically advanced plant that requires more time to develop. Finally, DOE's history of problems managing large projects on budget and within schedule raises concerns about the department's ability to complete the Next Generation Nuclear Plant in the time frame set forth in the Energy Policy Act of 2005, and accelerating the schedule would only add to these concerns. Given these considerations, we do not support at this time the Nuclear Energy Research Advisory Committee's recommendation—which DOE has not implemented—to accelerate the schedule for the Next Generation Nuclear Plant. DOE will be in a better position to make any future decision to accelerate its schedule once it has obtained more research results and information from industry stakeholders about the design and market conditions needed for a commercially viable plant.

Agency Comments and Our Evaluation

We provided a draft of this report to DOE and NRC for their review and comment. In oral comments, DOE stated that the report's description of the Next Generation Nuclear Plant project accurately summarizes the many interviews, presentations, and program documents DOE provided to us. DOE also provided technical comments, which we incorporated, as appropriate. In its written comments (see app. II), NRC commended GAO's effort to ensure that the report is accurate and constructive. We incorporated, as appropriate, NRC's clarifying comments regarding NRC licensing of the Next Generation Nuclear Plant.

We are sending copies of this report to interested congressional committees, the Secretary of Energy, the Chairman of the Nuclear Regulatory Commission, and other interested parties. We will also make copies available to others upon request. In addition, the report is available at no charge on the GAO Web site at http://www.gao.gov.

If you or your staff have any questions about this report, please contact me at (202) 512-3841 or wellsj@gao.gov. Contact points for our Offices of Congressional Relations and 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 III.

Sincerely yours,

Jim Wells

Jim Wells
Director, Natural Resources
and Environment

Appendix I: Scope and Methodology

To determine the Department of Energy's (DOE) progress in meeting its schedule for the Next Generation Nuclear Plant, we analyzed DOE's project plans, interviewed DOE and Idaho National Laboratory officials, and observed research and development (R&D) activities at Idaho National Laboratory, including experiments being conducted to test the performance of materials for use in the plant and to model the flow of helium gas in the reactor core. We reviewed project plans for the major R&D components of the project, including fuel, materials, and hydrogen production. We also reviewed the sections of the Energy Policy Act of 2005 requiring the establishment of the Next Generation Nuclear Plant as a DOE project and DOE's guidance on program and project management for the acquisition of capital assets (DOE order 413.3). We compared DOE's schedule for the Next Generation Nuclear Plant with the requirements set forth in the act and in DOE's order. Because of the project's long time frame, we focused on DOE's progress in meeting near-term milestones, specifically in completing the first phase of the project as defined in the act. At the time of our review, DOE had completed the first step in its project management process (approval of mission need), and we reviewed DOE's statement of mission need for the Next Generation Nuclear Plant, which documented this step.

Regarding the progress of DOE and the Nuclear Regulatory Commission (NRC) in developing a licensing strategy for the Next Generation Nuclear Plant, we reviewed the draft memorandum of understanding between DOE and NRC for establishing the guiding principles for interactions between the two agencies. In addition, we reviewed documentation relating to the approval of the draft memorandum of understanding by the NRC commissioners, including the written comments of each of the five commissioners. To gain a further understanding of NRC licensing of gas-cooled reactors, we reviewed NRC's advance notice of proposed rule making, issued May 2006, on a technology-neutral framework for reactor licensing; NRC's *Future Licensing and Inspection Readiness Assessment*, which was issued in October 2001 and evaluated, among other things, NRC skill gaps related to the licensing of gas-cooled reactors; and an April 2003 NRC research plan to support licensing of advanced reactors. Furthermore, we interviewed officials from DOE's Office of Nuclear Energy; NRC's Office of Nuclear Regulatory Research, which has responsibility for programs related to advanced reactor designs; and Idaho National Laboratory.

To examine DOE's approach to ensuring the commercial viability of the project, we analyzed the reports of two independent advisory groups that reviewed the project—a 2004 report of the Independent Technology

Review Group, which was coordinated by Idaho National Laboratory and composed of an international group experienced in the design, construction, and operation of nuclear systems; and a 2006 report of DOE's Nuclear Energy Research Advisory Committee, which provides independent advice to DOE on science and technical issues associated with the planning, management, and implementation of nuclear energy programs. We interviewed DOE and Idaho National Laboratory officials regarding the reports' recommendations, and we interviewed the chairmen of both advisory groups to gain further insight into the recommendations. (The chairman of the Independent Technology Review Group was working as a consultant for Idaho National Laboratory at the time we interviewed him.) In addition, we analyzed Idaho National Laboratory's March 2006 *Preliminary Project Management Plan* for the Next Generation Nuclear Plant. This plan discusses the risks associated with the project and presents three options for scheduling the R&D, design, construction, start-up, and testing of the plant. We interviewed representatives of two of the primary companies that have conducted R&D and designed high-temperature gas-cooled reactors (the South African Pebble Bed Modular Reactor company and General Atomics, based in San Diego, California). We also interviewed Nuclear Energy Institute officials; the president of the National Hydrogen Association; a representative of DOE's Argonne National Laboratory with experience in advanced reactor design and assessment of the safety of gas-cooled reactors; and nuclear energy and materials experts from the Union of Concerned Scientists, an independent nonprofit organization. Finally, we attended the American Nuclear Society's 2006 annual meeting, which included a number of sessions on nuclear fuels and materials R&D related to advanced nuclear energy systems, including the Next Generation Nuclear Plant; and we observed a meeting of industry, DOE, and Idaho National Laboratory officials regarding the structure of a public-private partnership to develop the plant.

We performed our work from April to September 2006 in accordance with generally accepted government auditing standards.

Appendix II: Comments from the Nuclear Regulatory Commission

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

September 11, 2006

Mr. James E. Wells, Jr., Director
Natural Resources and Environment
U.S. Government Accountability Office
441 G Street, NW
Washington, D.C. 20548

Dear Mr. Wells:

On behalf of the U.S. Nuclear Regulatory Commission (NRC), I am responding to your letter dated August 23, 2006, requesting NRC review and comment on your draft report, "Nuclear Energy: Status of DOE's Effort to Develop the Next Generation Nuclear Plant" (GAO-06-1056). The Commission appreciates your providing the NRC an opportunity to review this draft report, the time and effort that you and your staff have invested in reviewing this important topic, and the care that you have taken to ensure that your report is accurate and constructive.

I would like to provide clarification regarding a few statements in the draft report. The statement on page 16 indicating that key licensing issues have not been resolved should be removed or revised because the U.S. Department of Energy and NRC have yet to identify any licensing issues. Regarding the last sentence of the first paragraph on page 17, I would note that the new technology-neutral framework would establish top-level safety requirements that, in theory, can be applied to non-light-water and light-water reactors alike. However, the top-level safety requirements need to be supplemented and/or supported by technology-specific regulatory guidance. Finally, in connection with the last sentence of the second paragraph on page 17, please note that the NRC plans to rely on expertise from various sources, including international research programs. The current report text omits this international connection.

Should you have any questions about these comments, please contact me at (301) 415-1700, Dr. Brian W. Sheron at (301) 415-6641 (or BWS@nrc.gov), or Ms. Melinda Malloy of my staff at (301) 415-1785 (or MXM@nrc.gov).

Sincerely,

Luis A. Reyes
Executive Director
for Operations

Appendix III: GAO Contact and Staff Acknowledgments

GAO Contact

Jim Wells, (202) 512-3841 or wellsj@gao.gov

Staff Acknowledgments

In addition to the contact named above, Raymond H. Smith Jr. (Assistant Director), Joseph H. Cook, Bart Fischer, and Fatima Ty made key contributions to this report. Also contributing to this report were John Delicath, Doreen Feldman, Mark Goldstein, Keith A. Rhodes, and Rebecca Shea.

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, GAO posts newly released reports, testimony, and correspondence on its Web site. To have GAO e-mail you a list of newly posted products every afternoon, go to www.gao.gov and select "Subscribe to Updates."

Order by Mail or Phone

The first copy of each printed report is free. Additional copies are $2 each. A check or money order should be made out to the Superintendent of Documents. GAO also accepts VISA and Mastercard. Orders for 100 or more copies mailed to a single address are discounted 25 percent. Orders should be sent to:

U.S. Government Accountability Office
441 G Street NW, Room LM
Washington, D.C. 20548

To order by Phone:	Voice:	(202) 512-6000
	TDD:	(202) 512-2537
	Fax:	(202) 512-6061

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

Gloria Jarmon, Managing Director, JarmonG@gao.gov (202) 512-4400
U.S. Government Accountability Office, 441 G Street NW, Room 7125
Washington, D.C. 20548

Public Affairs

Paul Anderson, Managing Director, AndersonP1@gao.gov (202) 512-4800
U.S. Government Accountability Office, 441 G Street NW, Room 7149
Washington, D.C. 20548

PRINTED ON RECYCLED PAPER