**The Secretary of Energy**
**Washington, DC 20585**

April 6, 2006

The Honorable Pete Domenici
Chairman, Committee on Energy
and Natural Resources
United States Senate
Washington, D.C. 20510

Dear Mr. Chairman:

Section 643(c)(3)(E) of the Energy Policy Act of 2005 requires the Department of Energy to submit to Congress the report of a Nuclear Energy Advisory Committee on the Next Generation Nuclear Plant (NGNP) within 60 days of receipt. On February 22, 2006, the Nuclear Energy Advisory Committee approved the enclosed report *A Review of the NGNP Project: January 31, 2006.*

The Department currently is evaluating this report as part of its overall review of the current status of the NGNP Project.

If you have any questions, please contact me or Ms. Jill L. Sigal, Assistant Secretary for Congressional and Intergovernmental Affairs, at (202) 586-5450.

Sincerely,

Samuel W. Bodman

Enclosure

cc: The Honorable Jeff Bingaman
Ranking Minority Member

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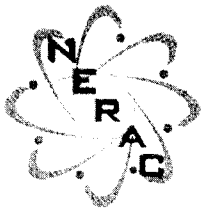
*Nuclear Energy Research*
*Advisory Committee*




March 7, 2006

Mr. R. Shane Johnson
Acting Director, Office of Nuclear Energy,
Science and Technology
U.S. Department of Energy
Washington, D.C. 20585

Dear Mr. Johnson:

It is my pleasure to submit to you the report, *A Review of the NGNP Project: February 22, 2006*, in response to section 643(c)(3)(C) of the Energy Policy Act of 2005. The full Nuclear Energy Research Advisory Committee (NERAC) adopted the report and endorsed its recommendations. These include:

- That the dual mission of electricity and hydrogen production be reconsidered and not accepted without further analysis;
- That DOE/NE staff, with the assistance of key industry representatives, should conduct economic and engineering trade studies that should be funded, initiated immediately, and completed as soon as possible;
- That DOE develop the NGNP as a reactor facility that can be upgraded as the technology advances; and
- That DOE/NE staff should update its R&D plans and develop options that can support a reactor deployment much before the 2017-2021 timeframe.

Section VIII of the report provides more detailed R&D suggestions.

NERAC notes that your office has already begun to address these recommendations and urges continued refinements and revisions. We look forward to working with you to build on that progress.

Sincerely,

William F. Martin
Chairman

Enclosure

# A REVIEW OF THE NGNP PROJECT

## EXECUTIVE SUMMARY

In 2002, the Department of Energy (DoE) Office of Nuclear Energy (NE) completed a technology roadmap project that provided an overall plan to the broad vision of enhancing the future role of nuclear energy systems in the U.S. and the world at large. The current NE plan puts a top priority on the successful development of a high-temperature fission reactor system, the Next Generation Nuclear Plant (NGNP), to meet these Gen-IV overall goals. In August 2005, the U.S. Congress passed and the President signed the Energy Policy Act of 2005. One of the key provisions of that legislative authorization was establishment of the NGNP project and the designation of an overall plan and timetable for its research, design, licensing, construction and operation by the end of FY 2021. One of the final directives of the EPACT was to require an initial review of the NGNP project and its associated R&D plan by the Nuclear Energy Research Advisory Committee (NERAC). In September 2005, the NERAC chair and co-chair charged the Gen-IV subcommittee of the full committee with the task of conducting this review. The subcommittee is composed of four members of NERAC along with two additional nuclear engineering experts from the industry, acting as unpaid consultants.

The complete charge to the NERAC subcommittee is given in Appendix A. This initial review focused on the existing NGNP program plan in light of the recommendations from an Independent Technical Review Group (ITRG) and addresses any ITRG recommendations not incorporated into NGNP plans.

The subcommittee focused on the first phase of the NGNP program; i.e., between 2005 and 2011. This first phase includes:

- Determination of whether the NGNP should produce electricity, hydrogen, or both;
- Selection and validation of a hydrogen generation technology;
- Conduct of R&D on associated technologies and components (energy conversion, nuclear fuel development, materials selection, reactor and plant systems development); and
- Initial design activities for the prototype nuclear power plant.

The subcommittee recommends a series of actions to make the NGNP program as effective as possible.

**Recommendation (1):** The current mission for the NGNP is to design and build a reactor that generates electricity and produces hydrogen. The subcommittee recommends that this dual mission be reconsidered and not be accepted without further analysis. The subcommittee further recommends that this analysis be done as outlined in the following discussion.

**Recommendation (2):** The DoE-NE staff should conduct, with the assistance of key industry representatives, economic and engineering trade studies that consider:

- The targets for hydrogen production for various scenarios over the next few decades;
- The DoE target for hydrogen production via nuclear power in this overall context;
- The likely hydrogen production and electricity production alternatives and how those alternatives would be factored into determining the proper mission for the NGNP.

The selection of the ultimate NGNP mission can drive the reactor design in different directions. The subcommittee recommends that these trade studies be funded, initiated immediately and completed as soon as possible.

**Recommendation (3):** The subcommittee recommends that the DoE develop the NGNP as a reactor facility that can be upgraded as the technology advances. Conceptually, the facility would be built using a smaller reactor, carefully choosing the scale to be the smallest reactor that could be reasonably extrapolated to support full size commercial applications, as a 'technology demonstrator'.

**Recommendation (4):** The DoE-NE staff should update its R&D plans and develop options that can support a reactor deployment much before the 2017-2021 timeframe. EPACT requires the overall cost of the NGNP project be shared with U.S. industry as well as members of the international community. The subcommittee believes that the chances of substantial industrial contributions and international collaborations to NGNP are greatly decreased with a completion target date of 2021. Further, these plans should adopt and enhance the ITRG perspective that to achieve a successful project even in the later time period, less aggressive project objectives must be adopted; e.g., for reactor outlet temperatures, fuel selection and performance.

The subcommittee notes that the DoE has already begun to address these recommendations and urges continued refinements and revisions. The subcommittee compares ITRG recommendations to current plans in Appendix B and provides more detailed R&D suggestions in Section VIII of the report.

# A REVIEW OF THE NGNP PROJECT: FEBRUARY 2006

M.Corradini*, H.Ray*, J.Rempe*, N.Todreas*
C.Boardman**, D.Chapin**
*Nuclear Energy Research Advisory Committee Members
** Nuclear Energy Research Advisory Committee Consultants

## I. Background

In 2002, the Department of Energy (DoE) Office of Nuclear Energy (NE) completed a technology roadmap project that provided an overall plan to the broad vision of enhancing the future role of nuclear energy systems in the U.S. and world at large. This Technology Roadmap [1] focused on the development of advanced nuclear systems, so-called Generation IV systems, which meet program goals of improved safety and economics, as well as enhanced sustainability and minimization of the risks from proliferation. This Gen-IV Technology Roadmap defined the lead reactor concepts and their associated fuel cycles to be pursued, as well as the R&D plan to develop the base technology for these reactor concepts and their complete fuel cycles.

The current NE plan put a top priority on the successful development of a high-temperature fission reactor system, the Next Generation Nuclear Plant (NGNP), to meet these Gen-IV overall goals. To that end, the NGNP was to be designed, built and operated by private industry, to produce energy products; i.e., hydrogen and/or electricity. The NGNP was a prototype nuclear power plant that is expected to be completed and begin operation before 2021. In the Expression-of-Interest document (EOI, Ref. 2) that DoE released in June 2004, a possible process was provided for eventual plant design, construction and operation of the NGNP

## II. Energy Policy Act of 2005

In August 2005, the United States Congress passed and the President signed the Energy Policy Act of 2005 [4]. One of the key provisions of that legislative authorization was the establishment of the NGNP project and the designation of an overall plan and timetable for its research, design, licensing, construction and operation by the end of FY 2021. Key aspects of the project include:

- NGNP is based on R&D activities supported by the Gen-IV Nuclear Energy initiative;
- NGNP shall be used to generate electricity, to produce hydrogen or (to do) both;
- NGNP will be managed by DoE Nuclear Energy Office along with the Gen-IV initiative;
- Idaho National Laboratory (INL) will be the lead national lab for the project;
- NGNP will be sited at the INL in Idaho;
- INL will organize a consortium of industrial partners for the cost-shared project;
- NGNP project will be conducted in two phases:
    - Phase I (2005 - 2011) is to select and validate hydrogen generation technology, carry out enabling R&D on associated technologies and components (energy conversion, nuclear fuel development, materials selection, reactor and plant), determine if it's appropriate to produce electricity, hydrogen or both and conduct initial design activities for the prototype nuclear power plant.
    - Phase II (2011-2021) is to continue first phase activities and to competitively develop a final detailed design, obtain an NRC license for construction and operation, and construct and start-up operations for the NGNP.
- NGNP project will maximize technical interchange and tech-transfer from other sources of relevant expertise – i.e., nuclear and chemical industries, international Gen-IV partners.

## III. NERAC Committee Charge

One of the final directives of the EPACT was to require an initial review of the NGNP project and its associated R&D plan by the Nuclear Energy Research Advisory Committee (NERAC). This review is to be completed and delivered to the DoE Secretary by February 2006 (see EPACT review subsection in Appendix A). This initial review is to be focused on the existing NGNP program plan in light of the recommendations of an interim review from an Independent Technical Review Group (ITRG) – "Design Features and Technology Uncertainties for the Next Generation Nuclear Plant" [3]. In addition, this initial review is to address any recommendations of the ITRG document not incorporated into the NGNP program plans.

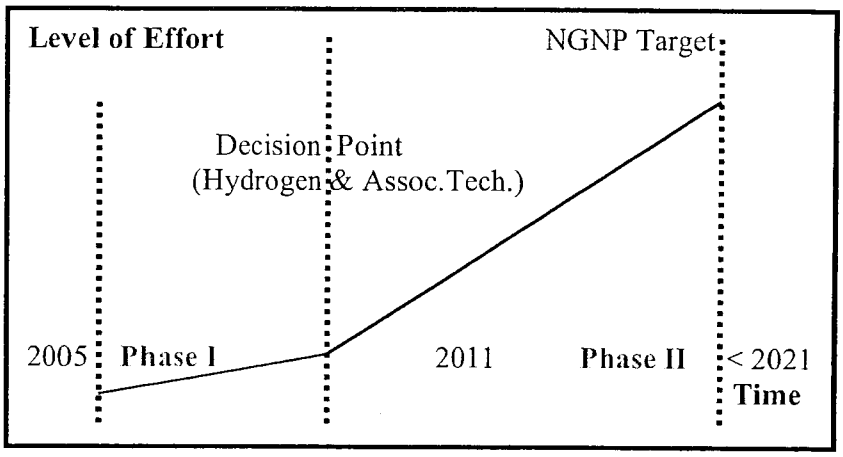
## IV. NERAC Committee Review Approach

In September 2005, the NERAC chair and co-chair charged the Gen-IV subcommittee of the full committee with the task of conducting this review. The subcommittee is composed of four members of NERAC along with two additional nuclear engineering experts from the industry, acting as unpaid consultants. The subcommittee held a series of teleconferences throughout the Fall of 2005. These teleconferences discussed the approach that would be followed for the review, identified the documents to be examined and provided an opportunity for preliminary discussions with the DoE NGNP staff. The ITRG report [3] was provided to the committee as well as all background documents for the current R&D underway prior to and during FY-2005. The subcommittee held a two-day meeting in November 2005 with the DoE staff to review the current program plan and associated R&D plan. A series of clarification questions were submitted to the staff to understand the current NGNP program more fully as well as to obtain additional background information.

Based on these activities, the subcommittee has decided to focus on the first phase of the NGNP program plan, which is planned to occur between 2005 and 2011. This first phase includes:

- Determination of whether the NGNP should produce electricity, hydrogen, or both,
- Selection and validation of a hydrogen generation technology,
- Conduct R&D on associated technologies and components (energy conversion, nuclear fuel development, materials selection, reactor and plant systems development), and
- Initial design activities for the prototype nuclear power plant.

The reason for this near-term focus is two-fold. First, the NGNP project, as specified in the EPACT, requires that the DoE focus on key technologies and their development in order to make informed and appropriate decisions by 2011; i.e., the mission of the NGNP prototype, the hydrogen generation technology and the associated energy conversion systems, nuclear fuel, materials, etc. It is the opinion of the subcommittee that this first phase embodies key decisions that will set the course of the whole NGNP project, and we need to focus our attention on DoE plans to handle these issues. That is, the detailed content of the second phase is dependent on the content of the first phase. Although it has broad commercial and regulatory implications, this latter phase is too vague at this early stage to support detailed review. Second, the subcommittee is aware of the budgetary pressure on discretionary spending. We have been told by DoE that funding plans will only support R&D in this first phase, and DoE will not be in a position to make significant advances in detailed Phase II design and licensing. This two-stage approach to the NGNP project is conceptually shown in the graphic below. Although we understand this logic, we revisit this two-stage approach and time schedule in a later section.




**Conceptual Diagram of the NGNP Project and the Current Two-Phase Approach**

There is an additional consideration. The ITRG interim review focused primarily on the Very-High Temperature Reactor (VHTR) as the main reactor concept that would satisfy the NGNP mission; i.e, a thermal-spectrum, gas-cooled reactor. This assumption was consistent with DoE plans at that time, and this will be same assumption that the subcommittee will operate under for the current review. However, the subcommittee notes that the EPACT enabling legislation does not restrict the technology to a thermal-spectrum gas-cooled VHTR design. This is beyond the scope of our review at this time, but needs to be kept in mind and properly considered as the DoE strategic plans unfold.

## V. NGNP Technology Mission

The EPACT requires that a range of technology missions be considered for the NGNP: to generate electricity, to generate hydrogen, or to do both. The original NGNP concept was based on the NGNP being a commercial scale demonstration plant for both hydrogen and electricity generation with the additional requirement that these capabilities be economically competitive. In our recent meeting with the DOE-NE Staff, they indicated that the working assumption for the NGNP remained the same; i.e., it still had a dual mission of electricity and hydrogen production.

The subcommittee recommends that the NGNP dual mission should be reconsidered and not be accepted without further analysis. There are several reasons for this conclusion:

- The cost and complexity of the facility will be strongly affected by the mission.
- The time that the facility needs to be deployed is strongly influenced by the mission.
- The hydrogen mission depends strongly on the parallel hydrogen production research program being carried out in the US National Hydrogen Initiative (NHI). The result of the NHI will likely set the key performance parameters for the NGNP, such as the process heat temperature requirements as well as the associated efficiencies.
- The synergy with ongoing activities, and therefore, potential cost share with others will depend on the mission. For example, the South Africans are planning to build an electricity-producer pebble-bed prototype that will startup in the 2011-2013 time frame.

Similarly the Japanese are operating the HTTR in Japan, a prismatic core reactor design, to study high temperature reactor operation and develop hydrogen production as well as other industrial applications. Properly choosing the NGNP mission is crucial to obtaining the cooperation, participation and financial contributions of these other programs, as well as potential U.S. industrial collaborators in an effective, cooperative way.

- The combined hydrogen and electricity mission is much more challenging than either single mission and will impose a greater burden on current and future funding resources.

Given that large-scale hydrogen production is a key DoE mission, for which the NGNP can have a significant role, the subcommittee recommends that the DoE-NE staff conduct, with the assistance of key industry representatives, economic and engineering trade studies that consider:

- The targets for hydrogen production for various scenarios over the next few decades;
- The DoE target for hydrogen production via nuclear power in this overall context;
- The likely hydrogen production and electricity production alternatives and how those alternatives would be factored into determining the proper mission for the NGNP.

Because the selection of the ultimate NGNP mission can drive the reactor design in substantially different directions, the subcommittee recommends that these trade studies be funded, initiated immediately and completed as soon as possible.

## VI. NGNP Mission Implications

The subcommittee understands that the two-stage schedule previously discussed is partly due to the practicalities of funding as well as the need to achieve R&D results that satisfy the original dual mission. However, we also note that EPACT requires the overall cost of the NGNP project be shared with U.S. industry as well as members of the international community.

With a scheduled completion of the project in 2021, the subcommittee believes that the chances of substantial industrial contributions are greatly decreased. From initial contacts with U.S. industry, it appears that the timeline for such a project to be attractive for their participation is in the range of 6-8 years, not double that time span. In addition, the R&D program would likely be more tightly coupled to the design and development phase with key industry participation.

To a lesser extent, the potential for international contributions may also be adversely affected by the current project timetable. Several other countries, such as Japan, France, South Africa, and China, have active programs for developing a gas-cooled reactor for energy and/or hydrogen production. If the NGNP in the U.S. follows the schedule outlined above, it is not likely to be attractive in garnering international support, because these international programs will likely be more timely than the 2021 goal.

Also, the longer the schedule, the greater the overall cost. Unless the schedule for the NGNP is compressed and accelerated, its cost and the financial burden to the U.S. may be increased disproportionately. DoE should reconsider the schedule for the NGNP to evaluate approaches that would allow it to simultaneously attract more non-US and industrial cost-sharing, while meeting the desire to minimize discretionary spending and obtain a high value result.

One approach the DoE could consider is to develop the NGNP as a reactor facility that can be upgraded as the technology advances. Conceptually, the facility would be built using a smaller

reactor, carefully choosing the scale to be the smallest reactor that could be reasonably extrapolated to support full size commercial applications; i.e., at least tens of megawatts as a 'technology demonstrator'. Further, the reactor would be designed as a test bed rather than a prototype reactor; i.e., it would support upgrades and modifications as the technology advances. This technique is often used in the petrochemical and process industries and has also been applied in the DoE fossil energy program in the R&D on gasifiers for clean coal technology. The nuclear plant has inherent design features, such as the easily replaceable fuel that would allow evolutionary changes over time. This approach, in combination with obtaining the industry and international support it would attract, could reduce the timetable as well as the overall cost. It could also accelerate the availability of the NGNP as a centerpiece for world-class nuclear technology centered in the U.S.

## VII. ITRG NGNP Recommendations

From the Fall of 2003 through the summer of 2004, a review panel of experts in nuclear fission technology, specifically gas-cooled nuclear reactor technology, conducted a comprehensive review of the NGNP program. This Independent Technology Review Group (ITRG) report was published in the summer of 2004 [3] and provided a series of recommendations to provide additional guidance for the NGNP reactor program; i.e., basic design assumptions, the R&D program as well as the commercial development and associated licensing and eventual commercial operation.

The major ITRG recommendations are outlined in Appendix B along with the current DoE response and R&D plans. It is important to note that because of the timing of this current NERAC review, shortly after the EPACT was enacted, the DoE had not completed a formal revised plan of the R&D program associated with the NGNP. Hence, the NERAC subcommittee met with cognizant personnel to understand current DoE plans and intent. In order to properly compare the ITRG recommendations with the current DoE NGNP program, this NERAC subcommittee reviewed the major ITRG recommendations with the DoE staff and summarized our observations and recommendations in Appendix B. There are additional detailed comments about the NGNP concept by the ITRG in its document that are still being evaluated by the DoE staff. These additional ITRG detailed comments are not addressed in this report.

There are also a number of substantive R&D issues that require more detailed discussion. For these R&D issues, a detailed discussion is provided below. The central theme is that the subcommittee recommends developing R&D plans that can support a reactor deployment much before the 2017-2021 timeframe. Further, these plans should adopt and enhance the ITRG perspective that to achieve a successful project even in the later time period, less aggressive project objectives must be adopted; e.g., for reactor outlet temperatures, fuel selection and performance. The subcommittee notes that the DoE has already begun to address these recommendations and urges continued refinements and revisions.

## VIII. NGNP Research and Development Program Plan

The DoE-NE staff developed an overall R&D program that will enable the full range of possible missions and gas reactor designs for the NGNP. Completion of activities specified in this R&D plan requires funding in the range of 100 million per year and nearly a decade to complete. Current funding for the entire Gen-IV program is in the range of 50 million dollars a year, and

the subcommittee believes that it is unlikely that US funding will increase substantially in the near future. Hence, the success of this project requires that a large portion of R&D funds come from industrial and international partners, in-kind and direct, both private and public. In addition to recommending that an early decision be made with respect to the NGNP's mission, the subcommittee recommends that the R&D program be reviewed and an integrated realistic plan be developed that is consistent with the selected mission, that is consistent with potential funding realities, and that can provide the required research results for a possible earlier deployment than the currently proposed 2017-2021 timeframe.

The multiple missions and designs currently considered by NGNP R&D has led to a very broad research program that may not even yield the required data for deploying an NGNP by 2021. Our committee believes that a careful review should be completed (with industry, regulatory, and international participation) after the mission is selected to confirm that NGNP research primarily supports the selected mission, has appropriate industry, regulatory, and international support, has considered the ITRG recommendations, and is consistent with EPACT.

The subcommittee offers a number of specific suggestions for the DoE-NE staff to consider that can provide more focus to the current R&D plan

1. Develop an integrated schedule of all planned activities, similar to the computer-based scheduling program currently used by DoE staff for the Nuclear Hydrogen program. This integrated schedule and associated work breakdown structure can be used to identify a baseline R&D plan for highest priority R&D activities (and assess the impact of alternative/additional R&D tasks). Such a schedule should facilitate the adjustments that will be needed to the NGNP R&D program after its mission is selected.

2. Conduct a series of structured workshops with industry, regulatory, laboratory, and international representatives to discuss the following:
   - Trade study results to select the NGNP's mission
   - Design optimization studies to meet the selected NGNP mission (e.g., plant power level, fuel configuration, fuel material, operating temperatures, structural materials)
   - R&D program elements (analysis codes and associated data needs, materials research, fuels development and certification). As noted below, steering committees may be required to ensure that appropriate parties provide continued input in some of these areas.
   - Appropriate cost sharing by NGNP stakeholders (industry, international, regulatory agencies, DOE)

3. Materials R&D: The subcommittee is aware that there is also research being conducted in-this area in the nuclear hydrogen program and recommends that the work for NGNP be better coordinated with that work to avoid overlap and assure the work is complementary. After trade studies are completed and an NGNP mission selected, the following items should be considered:
   - Focus on key material research needs. For example, if hydrogen production were selected as the key mission and an Intermediate Heat Exchanger (IHX) concept were included in the optimized design for that mission, the use of developmental materials should be limited to the IHX (and a systematic evaluation should be

conducted to identify an appropriate material for the IHX operating conditions and develop a "code case" for the identified material). To the extent possible, the remainder of the plant should rely on conventional, proven materials.
- Graphite certification activities, which are required irrespective of the NGNP mission and reactor design, should be reviewed and accelerated so that an appropriate material is certified within the required timeframe for deployment.

4. Design Methods
   - Using results from Item 2 workshops, identify analysis tools of interest and areas where data are needed for developing, verifying and validating these codes.
   - Develop a joint USNRC/industry/regulatory NGNP steering group to define required tests, needed facilities, and data to be collected (including parameter definition, accuracy, etc.). Determine data quality level and need for sequestering some data for use with "blind" predictions.
   - Define appropriate cost sharing required by industry, regulatory, DOE, and international organizations to complete such tests.

5. Plant Operations – The need to potentially couple two diverse processes (electric power generation and hydrogen production) complicates the dual mission and the differing dynamic responses of the reactor plant and the hydrogen production process or the electricity production process must be carefully assessed for the single mission project. Design and analytical studies need to be performed to investigate possible configurations and control schemes. The results of these studies will provide insights as to the reactor design conditions, provision of direct versus indirect process heat cycles, etc. (The subcommittee is aware that the there is also research in this area being performed under the nuclear hydrogen program, which is also managed by DOE-NE; the work for NGNP should be coordinated with that work to avoid overlap and assure the work is complementary.)

6. Safety and Licensing – A conversation should be begun with the NRC regarding the key aspects of safety and licensing that need to be addressed if the NGNP were deployed prior to the 2017-2021 timeframe. The subcommittee notes that the NRC staff has already begun a concerted effort for a "technology-neutral" licensing framework that the NGNP project can utilize as initial guidance (SECY-05-0130). However, this staff document has not yet been adopted by the NRC commission, but is under on-going discussion and review by the NRC staff and ACRS.

7. Fuels Development – The Subcommittee notes this is a complex subject area. The ITRG recommended that the NGNP fuel R&D program focus on $UO_2$, which has the largest experience base worldwide, instead of its current focus on UCO fuel, which is also TRISO fuel but with kernels that have a mixture of $UO_2$ and UC fuel particles. U.S. and international experts concur that UCO fuel has the potential to exhibit superior performance over the $UO_2$ kernel fuel. If UCO can be successfully developed and demonstrated, including developing and proving the needed manufacturing methods and parameters, it should allow higher burn-ups, operate at higher power densities, and release less fission products at higher accident temperatures. The use of UCO fuel is

particularly important to the eventual economic success of reactors with prismatic fuel, as compared to the pebble bed fuel, since the prismatic reactor pushes the fuel harder to avoid the undesirable complexity of the pebble bed reactor's refueling scheme. Nevertheless, UCO fuel would confer performance advantages on both reactors and if it worked would likely be adopted for both.

However, UCO fuel performance is not proven and requires fundamental research and development to establish that its properties are superior to $UO_2$. In addition, R&D is required to demonstrate that it is possible to manufacture fuel of the requisite quality, get it accepted by the regulator and then produce the large quantity of fuel needed to load the reactor. $UO_2$ fuel is much further along in this process. The international community, (France, South Africa, China, Japan) have focused on first demonstrating their ability to fabricate $UO_2$ and demonstrating that it meets the required performance. Once this is accomplished, they will consider going forward with UCO. In the near term, it appears they would be willing to cooperate with the US on work on $UO_2$, but are less enthused about UCO cooperation because obtaining a successful and proven capability in $UO_2$ for TRISO fuel is such a large undertaking (of the same order as the cost and of longer duration than building the capability to manufacture the reactor plant). Once $UO_2$ can be manufactured successfully and is proven to the regulators, the international community plans to adapt their approach to UCO, which can then be loaded into existing and future reactors as desired. That is, the international community de-couples the reactor design, construction, and operation processes from the need to successfully develop UCO.

In the fall of 2005, the NGNP fuel R&D program indicated that for substantial additional funding, two million dollars per year for several years, $UO_2$ fuel kernels can be fabricated and introduced into the NGNP fuel irradiation test program. In order to expedite the R&D required for deploying a reactor prior to the currently planned 2017-2020 timeframe, the subcommittee recommends that the current fuel R&D program be re-evaluated after the mission and design of the NGNP has been selected. The subcommittee recommends that an integrated schedule and plan be developed with the objective of having adequate quantities of fuel to support NGNP operation prior to the 2017-2020 timeframe. This plan should account for the needed R&D to develop the fuel design, its manufacturing parameters and methods, irradiation testing and PIE to qualify the fuel and obtain regularity acceptance, and transfer the manufacturing capability to a commercial entity that is qualified to manufacture the fuel. The subcommittee anticipates that this plan will likely show that only $UO_2$ fuel is viable for fuel loading dates needed to support operation of the NGNP prior to 2020. However, if the planning study shows UCO is viable, this is an important result. If UCO is deemed to not be viable and if resources are available, the subcommittee recommends that basic R&D program on UCO fuel be considered for longer-term applications.

**References:**

1. "A Technology Roadmap for Generation IV Nuclear Energy Systems," Department of Energy, December 2002.

2. "Request for Information and Expression of Interest," Next Generation Nuclear Plant, Department of Energy, May 28, 2004.

3. "Design Features and Technology Uncertainties for the Next Generation Nuclear Plant-Independent Technology Review Group," INEEL/EXT-04-01816, September 2004.

4. Energy Policy Act of 2005, Subtitle C: Next Generation Nuclear Plant Project (S.641-645).

5. Dept. of Energy Generation IV presentations, July 19, 2004 and October 25, 2004.

6. Dept. of Energy Generation IV presentations, May 2, 2005 and November 15, 2005.

**Abbreviations and Nomenclature:**

DoE: Department of Energy

EPACT: Energy Policy Act (August 2005)

GIF: Generation-IV International Forum

IHX: Intermediate Heat Exchanger and loop used for hydrogen production

ITRG: Independent Technology Review Group

MSR: Molten-Salt cooled Reactor

NE: DoE Office of Nuclear Energy

NERAC: Nuclear Energy Research Advisory Committee

NGNP: Next-Generation Nuclear Plant

NHI: Nuclear Hydrogen Initiative

PIE: Post-irradiation examination

Trade-Study: Process for comparing alternative concepts and making logical design decisions.

TRISO: Fuel particle (~ 1mm sphere) with a triple layer of ceramic cladding around a fuel kernel

VHTR: Very-High Temperature gas-cooled Reactor

## APPENDIX A: EPACT CHARGE to NERAC for NGNP REVIEW

(3) REVIEW BY NUCLEAR ENERGY RESEARCH ADVISORY COMMITTEE-

(A) IN GENERAL - The Nuclear Energy Research Advisory Committee of the Department (referred to in this paragraph as the `NERAC') shall--

(i) review all program plans for the Project and all progress under the Project on an ongoing basis; and

(ii) ensure that important scientific, technical, safety, and program management issues receive attention in the Project and by the Secretary.

(B) ADDITIONAL EXPERTISE- The NERAC shall supplement the expertise of the NERAC or appoint subpanels to incorporate into the review by the NERAC the relevant sources of expertise described under paragraph (1).

(C) INITIAL REVIEW- Not later than 180 days after the date of enactment of this Act, the NERAC shall--

(i) review existing program plans for the Project in light of the recommendations of the document entitled `Design Features and Technology Uncertainties for the Next Generation Nuclear Plant,' dated June 30, 2004; and

(ii) address any recommendations of the document not incorporated in program plans for the Project.

(D) FIRST PROJECT PHASE REVIEW- On a determination by the Secretary that the appropriate activities under the first project phase under subsection (b)(1) are nearly complete, the Secretary shall request the NERAC to conduct a comprehensive review of the Project and to report to the Secretary the recommendation of the NERAC concerning whether the Project is ready to proceed to the second project phase under subsection (b)(2).

(E) TRANSMITTAL OF REPORTS TO CONGRESS- Not later than 60 days after receiving any report from the NERAC related to the Project, the Secretary shall submit to the appropriate committees of the Senate and the House of Representatives a copy of the report, along with any additional views of the Secretary that the Secretary may consider appropriate.

## APPENDIX B: ITRG REPORT: MAJOR OBSERVATIONS and RECOMMENDATIONS

| ITRG Recommendation | DoE Action | NERAC Comment |
|---|---|---|
| **A)** ITRG recommendations were based on a NGNP schedule for initial operation in 2017 | EPACT legislation provided a schedule with two phases; i.e., 2005-2011 - R&D and 2011-2021 - construction and licensing | DoE should re-examine and modify its detailed R&D program plan to meet the target timetable for technology selections |
| **B)** For the two VHTR reactor concepts, neither is more likely to be successful for the NGNP | DoE has modified its R&D plan to provide a more balanced effort for prismatic & pebble VHTR | No specific comments here. |
| **C)** It is impractical for a molten-salt-cooled reactor development effort to be successful for NGNP | DoE has adjusted its R&D program with only small MSR exploratory feasibility studies | There has been an appropriate alignment between DoE plans and ITRG recommendations |
| **D)** Use of molten-salt in a heat transfer loop in the NGNP may be a desirable design concept | DoE has adjusted its R&D program and has started a design activity in this technical area | There has been an appropriate alignment between DoE plans and ITRG recommendations |
| **E)** Consider alternatives for licensing and purchase of viable technology from offshore vendor. | This alternative is not consistent with EPACT 2005 and DoE plan | No specific comments here |
| **F)** NGNP fuel development should focus on processes that have most successful worldwide experience base (e.g. $UO_2$ kernel) | DoE agrees that worldwide fuel experience base be considered, but technically disagrees with ITRG focus only on $UO_2$ kernel | NERAC subcommittee examined this item in detail (F and G), and recommends that the fuel R&D program be reconsidered (VIII.7) |
| **G)** NGNP fuel development plan should incorporate $UO_2$ & UCO kernels in R&D to determine the influence of fuel manufacturing processes on fuel quality | DoE agrees and has incorporated this approach in AGR in-pile tests with $UO_2$ & UCO kernels; it has modifications planned for 2011 technology selection goals | NERAC subcommittee recommends that the fuel R&D program reconsider how AGR in-pile tests can be optimized for 2011 technology selection target |
| **H)** Fuel development R&D plan should be consistent with overall NGNP R&D plan and schedule | EPACT 2005 has provided an overall NGNP schedule and DoE is aligning its R&D schedule to it | The overall R&D plan needs to be aligned with the NGNP reassessed mission and associated schedule |
| **I)** ITRG views need to achieve a high outlet temperature in NGNP be justified, and suggested a reactor outlet value of 900-950C | DoE agrees and aims to set NGNP reactor outlet temperature by hydrogen production needs and the material capabilities | DoE approach is consistent with ITRG recommendation; NERAC recommends as wide a range as possible given tech. constraints |
| **J)** An indirect cycle power conversion concept fulfills the high-level functional objectives | DoE agrees this minimizes risk; this approach is needed for hydrogen production, but may be premature for electricity now. | DoE plan is generally consistent with ITRG recommendation, but subcommittee recommends the NGNP mission be reassessed |
| **K)** The development of a high-temperature hydrogen production capability should be accelerated | DoE agrees and notes that there has been greater R&D activity in FY-05 and will be in FY-06 | NERAC is pleased with the R&D plan and research activity for hydrogen production |
| **L)** Resource intensive R&D can benefit from direct international and industrial participation | The GIF provides international input to NGNP and DoE plan is developing to involve industry | NERAC subcommittee has some detailed suggestions for industrial input (Section VIII.) |
| **M)** ITRG noted that design uncertainties (IHX, RPV) be addressed focused R&D | DoE has identified these and other items for R&D plan for revision to meet 2011 target | No specific comments here |
| **N)** ITRG concern: Electricity, Hydrogen or a dual mission | EPACT 2005 has given guidance on this issue | NERAC subcommittee considers this a key decision (Section VI.) |