An Evaluation of the Proliferation Resistant Characteristics of Light Water Reactor Fuel with the Potential for Recycle in the United States

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EXECUTIVE SUMMARY

The Advanced Fuel Cycle Initiative within the Department of Energy has been formulated to perform research leading to advanced fuels and fuel cycles for advanced nuclear power systems. Some of this research is focused on Light Water Reactor (LWR) fuels with the potential for recycle. As part of this research, program management convened a committee of internationally recognized experts to evaluate the nonproliferation characteristics of this fuel. This nonproliferation review committee was chartered to report to the Advanced Nuclear Transmutation Technology Subcommittee of the Nuclear Energy Research Advisory Committee (NERAC).

The review committee concluded that:

- The research and development being conducted on advanced fuels in the AFCI program on the UREX process has the potential for a major nonproliferation advance and can raise the bar with respect to proliferation resistance,

- The time integrated proliferation resistance measure of a fuel cycle intended to transmute minor actinides, if properly designed, has the potential to be roughly equal to that of the Spent Fuel Standard; the Inert Matrix fuel cycle is particularly notable in this regard,

- Recycling higher actinides for additional intrinsic proliferation resistance and employing highly advanced or ideal safeguards features for additional extrinsic proliferation resistance has the potential to increase the proliferation resistance measure of the more vulnerable points in the fuel cycle to approximately that of the Spent Fuel Standard,

- It is inappropriate to focus all attention on the recycling step as the only point of vulnerability in the overall fuel cycle. The enrichment step is also a point of

nonproliferation concern, since a lack of sufficient safeguards at this step could allow the production of weapons-usable uranium, and

- Elements of highly advanced safeguards features and innovations are under consideration in the research and development being performed on the UREX process and actinide transmutation in the AFCI.

The review committee recommends that the AFCI conduct research along several lines in order to realize the goal of increasing proliferation resistance measures associated with recycle. They include:

- Continuing research and development leading to the use of neptunium as a doping agent to produce Pu-238 during irradiation in the reactor, thereby degrading the isotopic composition and deliverable-weapon usefulness of discharged plutonium, as a means to increase intrinsic proliferation resistance,

- Continuing research and development on other fuel systems with the capability to degrade the plutonium isotopic composition, such as Inert Matrix Fuel, thereby reducing the deliverable-weapon usefulness of the discharged plutonium, and so increasing intrinsic proliferation resistance,

- Continuing research and development leading to the use of advanced fuels containing higher actinides, such as Am-241, to increase the radiation barrier and thereby increase intrinsic proliferation resistance,

- Ensuring that advanced safeguards techniques, leading ultimately to Ideal Safeguards, are incorporated into all steps (including enrichment) in the design process in order to increase extrinsic proliferation resistance, and

- Ensuring that plutonium and neptunium streams are retained together in order to utilize the daughter product Pa-233 as a tracer in the safeguards system to increase extrinsic proliferation resistance.

If the research, design, and development being considered in AFCI should prove successful, the UREX process -- combined with advanced safeguards and fuel systems that employ material doping to provide radioactive tracers and degrade the plutonium isotopic composition, or degrade plutonium isotopic composition by the use of inert materials -- will have a high proliferation measure. It can potentially increase the proliferation resistance measure of a closed cycle to roughly that of the Spent Fuel Standard. Research and development on advanced fuel systems with intrinsic and extrinsic nonproliferation attributes as defined above should continue to be pursued in the AFCI.

The effect of plutonium isotopic composition on the usefulness of plutonium in a deliverable weapon was not considered in detail in this study, but will be evaluated in separate studies. Nonetheless, some fuel systems have the inherent capability to provide this attribute and so research and development on fuel systems with these characteristics is recommended.