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A Systematic Approach for the Evaluation of Technology Opportunities to Enhance the Proliferation Resistance of Civilian Nuclear Energy Systems

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Abstract

Enhancing the proliferation resistance of nuclear energy systems and fuel cycles is an ambitious undertaking. Current systems, dominated by the light water reactor fuel cycle are quite proliferation resistant. However, continued accumulations of plutonium in spent fuel and accumulations of separated plutonium resulting from reprocessing are eroding the proliferation resistance of today's nuclear energy systems. Alternatives to address these issues invariably involve making trade-offs among different proliferation risks and advantages. For example, thorium cycles reduce the quantity and quality of plutonium in spent fuel, but do so at the expense of increased fresh fuel enrichment and/or production of separable U233. Evaluation of these tradeoffs is difficult, as there are serious and significant differences of opinion regarding the relative merits and significance of the various risks of and barriers to proliferation from commercial nuclear power fuel cycles.

The United States' Department of Energy Nuclear Energy Research Advisory Committee recently completed a study "Technological Opportunities To Increase The Proliferation Resistance Of Global Civilian Nuclear Power Systems (TOPS)." That effort included the development of a set of barriers to proliferation summarized in the report annex "Attributes of Proliferation Resistance for Civilian Nuclear Power Systems." This annex identified both intrinsic and extrinsic barriers to proliferation that technologies can directly impact. The intrinsic barriers are those features fundamental to the nuclear fuel cycle than deter or inhibit the use of materials, technologies or facilities for potential weapons purposes. The fact that LEU fuel is not an explosive fissionable material is an inherent barrier to proliferation. Extrinsic barriers depend on implementation details and compensate for weaknesses in the intrinsic barriers. Safeguards, material control and accountability are examples of these extrinsic barriers, often referred to as the institutional barriers. Since it is fundamentally impossible to construct a nuclear power system that is completely proliferation resistant, an effective combination of both intrinsic and extrinsic barriers is necessary to ensure an adequate level of proliferation resistance from any current or future nuclear energy system.

In this paper we will review the various barriers to proliferation as described by the TOPS work. We will outline an approach by which these barriers can be used to assist in

the evaluation of the relative proliferation resistance of various nuclear fuel cycles, technologies and alternatives.

We recognize that evaluation of proliferation resistance, and certainly the decisions regarding which technologies and/or fuel cycles should be developed cannot be made in isolation. Issues such as nuclear safety, economics, environment, waste disposal and energy security must also be taken into account. These issues impact a society's or a nation's perspectives on the relative importance of these issues and thus on the weights and significance of the various barriers and attributes described here.

A quantitative methodology, based on the TOPS "Barriers Approach" offers promise as an effective assessment tool by itself. However, its greater overall utility may well be found in as a vehicle for promoting dialogue about the effectiveness of various technology option for enhancing proliferation resistance, as well as contributing to the development of more detailed evaluation methods, such as phenomenological and risk-based methods.