A Nonproliferation Research Strategy for Fusion and Fusion/Fission Hybrid Energy Systems

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Background

Renewed interest in nuclear power around the world has sparked further examination of nuclear proliferation concerns. This work should be supplemented with an examination of advanced technologies including fusion and fusion/fission hybrids. Although nonproliferation (NP) problems and solutions are not exclusively technical, proliferation resistant technologies and approaches can help mitigate risks. Initial work suggests that continued in-depth research on the nonproliferation implications of both fusion and fusion-fission hybrids would clarify the following:

- Existing and emerging vulnerabilities,
- Opportunities for greater intrinsic barriers to proliferation,
- Needs for greater extrinsic barriers to proliferation,
- Social, political, and economic factors in evaluating proliferation dynamics and risk, and
- Standards by which we should judge proliferation resistance and risk in the presence of tangible and intangible metrics.

Challenges to fusion and fusion/fission energy systems

Can fusion and fusion/fission energy systems be designed to exceed current proliferation resistance levels by a significant margin and also help with a number of essentially non-technical nonproliferation dynamics? Answering this question is complicated because different deployment concepts, missions, business models, or technologies appear to yield different contributions to or complications for nonproliferation. Only by examining concrete design concepts and their practical implementation options can we determine how fusion and hybrid energy approaches might compare with existing nuclear energy systems against existing nonproliferation standards and possible higher standards. In addition to exploring opportunities, potential pitfalls and dangerous paths should be highlighted.

Preliminary examination of Fusion and Fusion/Fission Hybrids such as the Laser Inertial Fusion Engine (LIFE) suggests the following:

- The level of proliferation resistance depends upon the general technical approach, details of design, the business/management plan, and the deployment strategy.
- Within fusion and fusion/fission hybrids, some longstanding nonproliferation challenges such as enrichment, reprocessing, transportation, and physical protection could be greatly eased even if not all proliferation concerns can be reduced to zero.
- Several interesting approaches could offer considerable nonproliferation advantages compared with other advanced or existing approaches to nuclear energy systems.
- Because new ground is being explored, expert review must include a broad range of expertise, particularly when factors such as emerging capabilities, domestic and international politics, and trade-offs against cost or non-discriminatory technology transfer play heavily on nonproliferation calculations.

- Integrating intrinsic and extrinsic barriers to proliferation into any fusion or hybrid program from the beginning, a step endorsed by the IAEA, and anticipating the environments in which they might be deployed could lead to a new "gold standard" for measures to help protect against nuclear weapons proliferation.

Framework for nonproliferation analysis:

Typically, analysis of proliferation vulnerabilities focuses on knowledge, resources, materials, process, policy, and motivation. Each nuclear energy system and its supporting infrastructure thus needs to be examined in terms of:

- Safeguarding of declared activities,
- Detection of covert activities,
- Security against theft and safety in the event of attack (insider/outsider threats)
- n^{th} country assistance to proliferation,
- Treaty breakout,
- Expansion of knowledge and the spread of technology and sensitive materials,
- Political, social, and economic NP dynamics, both domestic and international.

Systems to be examined:

The weight to be given to proliferation concerns differs with the approach, but also with the mission. An initial review suggests that several approaches should be examined up front for their nonproliferation contributions:

- A magnetic confinement fusion engine,
- A laser inertial confinement fusion engine,
- An integral fusion/fission engine, optimized for nonproliferation, burning natural/depleted uranium or thorium, with excursions looking at levels of actinide burn desired for the final waste product,
- A fusion/fission engine optimized to burn excess plutonium,
- A fusion/fission engine optimized for burning spent fuel
- A hybrid breeder producing plutonium for use in nuclear power plants, and
- Alternative fuel cycles such as thorium or TRUOX based cycles.

For comparative and heuristic purposes, these might be compared with alternative approaches such as:

- Light-water reactors (LWR)/Open fuel cycle,
- MOX fueled reactors
- Accelerator transmutation of waste,
- LWR plus Burners and Breeders
- Integral Fast Reactors,
- Pebble Bed Reactors

Illustrative future nuclear energy systems with fusion and/or hybrid components should be examined for potential synergy or conflict with non-fusion components that might co-exist and involve parallel infrastructures, and fuel cycles.

Priority Insights for Informed Assessments:

Whatever else emerges from a multidisciplinary examination of the nonproliferation implications of fusion and/or hybrid systems, informed assessments leading to more optimal research requires well grounded insights early on into the implications of fusion for:

- The spread of weapons useful knowledge and technology,
- Potential access to weapons related material such as Plutonium and Tritium, and
- Motivations to acquire nuclear weapons.

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