Advanced Reactors, Nuclear Security and Non-Proliferation Concerns

The nuclear industry is developing several promising new technologies to meet the demand for "green" energy, but some may do more damage to U.S. non-proliferation policy than they are worth. The question for the federal government should be which of the possible avenues maximizes safety and minimizes proliferation risk.

Supporters of advanced reactors often point to nuclear power's possible role in tackling climate change and the utility of setting non-proliferation, nuclear security and nuclear safety standards with importing countries. However, advanced reactors pose new risks all along the supply chain and may require the development of new safeguards techniques. Further, the development and planned export of certain technologies could break with long-standing non-proliferation policy.

To minimize risk, the federal government must carefully assess what programs to support to instill "proliferation resistance" and "safeguards and security by design" from the beginning, as it is much harder to add later. The goal should be to make it difficult to divert materials in the nuclear fuel cycle from power generation to nuclear weapons. After all, civil nuclear energy programs affect proliferation but are not the main driver.

While no state has ever built a bomb with material from a safeguarded nuclear facility, civil nuclear programs have been used as cover for technology acquisition or expertise development. Congress should be conscientious of the precedents that U.S. research, development and planned exports set.

Higher enriched uranium

Many new models will rely on high-assay low-enriched uranium (HALEU), or uranium enriched up to 20 percent in uranium-235. Standard fuel for conventional reactors is enriched up to five percent and HALEU can be more easily enriched to weapons-grade compared with standard LEU, although it would still require an enrichment facility. Enriching uranium to this level was explicitly forbidden under the 2015 Iran nuclear deal.

For now, only Russia and China have the infrastructure to produce HALEU. One U.S. company, Centrus Energy, is constructing a pilot HALEU cascade as part of the Department of Energy's (DOE) cost-share program, and DOE also down-blends its highly-enriched uranium to HALEU. HALEU is seen as advantageous to achieve smaller reactor designs that get more power per unit of volume. Since there are not many sources of HALEU for purchase, some countries may seek indigenous enrichment capabilities. Saudi Arabia has hinted at this need as part of its three-legged approach to develop at least two large conventional reactors, small reactors and the nuclear fuel cycle.

New fuels under development

It is important to look at these technologies separately and not to lump them all together. Most current and proposed reactors use fuel that is not weapons-usable. Also, plutonium in spent fuel could not be used for weapons without a reprocessing facility. As long as safeguards and verification measures remain robust, many designs are fairly proliferation resistant. For instance, sealed core reactors where the reactor is transported as a single unit means the country where it is operating does not need to have any knowledge of the nuclear fuel cycle at all.

Mixed-oxide (MOX) fuels and other plutonium fuels are different. A relatively small quantity of plutonium could be used for a rudimentary weapon. Any state could easily separate pure plutonium from fresh fuel and, according to Matthew Bunn, an expert in nuclear security at Harvard, even some terrorist groups could. Some, including TerraPower's proposed *Natrium* "fast reactor," will produce concentrated plutonium, which can be extracted and used as reactor fuel instead of mining and using more uranium. While TerraPower claims this

reactor will not use plutonium fuel, it is a proof of concept in the debate over a domestic closed-loop fuel cycle that could do serious damage to decades-long U.S. non-proliferation policy.

In order to test advanced fuels for fast-neutron reactors, the Versatile Test Reactor is under debate again as the House and the Senate zeroed out funding from the Biden administration's request for the reactor this summer. According to Frank von Hippel, a senior research physicist at Princeton's program on science and global security, the reactor's development would break with over 40-years of U.S. policy to "discourage countries from doing research and development with fast-neutron reactors and their associated separation, storage, transport and fabrication of plutonium."

Benefits of enrichment and reprocessing restraints

U.S. non-proliferation diplomacy with South Korea, Iran and the United Arab Emirates, for instance, took advantage of the fact that the United States does not enrich its own nuclear fuel and actually imports over 90 percent of it to undermine arguments that uranium enrichment technology and access to the full nuclear fuel cycle are necessary for energy security. This argument may be more difficult to make if the United States develops new fuels and returns to enriching uranium.

Further, for non-nuclear weapon states, obtaining a reprocessing facility to fuel fast-neutron reactors opens the door to pursuing the fissile material for a nuclear weapon. Pairing non-proliferation goals to nuclear commerce is a necessity because most nuclear technology is dual-use. It can be used for civilian or military purposes and as such, even research deserves careful consideration. For this reason, support for international nuclear inspectors and full-scope safeguards will remain vital to non-proliferation efforts and should be built into any new reactor designs and agreements for the transfer of nuclear energy technology.