No Need for DOE's Costly 'Versatile Test Reactor'

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In 1994, the Department of Energy (DOE) decided to shut down the Idaho National Laboratory's (INL's) liquid-sodium-cooled, fast-neutron Experimental Breeder Reactor II (EBR II) because it no longer had a mission. The US had ended its plutonium breeder reactor development program a decade earlier because of cost and proliferation concerns, the latter famously exemplified by India's use of its US-supported breeder program to acquire nuclear weapons.

France and the UK also canceled their breeder reactor programs in the 1990s, and Japan more recently. Their prototypes were crippled by sodium leaks. Sodium burns on contact with air or water, and the complexities of dealing with sodium coolants creates reliability problems. The median capacity factor of the 10 sodium-cooled prototypes that have been connected to the grid over the past 60 years has been about 10% versus the approximately 80% average for water-cooled nuclear power reactors.

Today, breeder development programs continue in three countries. Russia operates the BN-600 and BN-800. After 15 sodium fires during the BN-600's first 14 years of operation, the Russian reactors are operating relatively well. Both India and China have a prototype under construction.

None of these countries claims today, however, that sodium-cooled fast-neutron reactors operating on a closed fuel cycle are economically competitive with light-water reactors operating on a once-through fuel cycle. They argue, however, that breeders could be 100 times more uranium efficient and therefore could make nuclear power "sustainable" for millennia.

In the US, as memories of the proliferation, safety and economic debates over sodium-cooled reactors of the late 1970s and early 1980s have faded, advocates of these "advanced," "fourth-generation" reactors have begun finding an audience. In part, this is due to frustration in Congress over the lack of a deep underground repository for the spent fuel that has been accumulating at conventional nuclear power stations around the country.

US advocates of sodium-cooled reactors argue that the plutonium and uranium in spent fuel could be extracted in reprocessing plants and used to start fast-neutron reactors. They don't explain, however, that the radioactive waste from reprocessing needs a repository, too, or that reprocessing plants eventually become hugely costly radioactive cleanup sites.

In 2017, Sen. Mike Crapo of Idaho introduced the Nuclear Energy Innovation Capabilities Act that instructs the Secretary of Energy to "determine the mission need for a versatile reactor-based fast neutron source, which shall operate as a national user facility."

In February 2019, then-Energy Secretary Rick Perry announced the launching of the conceptual design stage for a Versatile Test Reactor (VTR) project at INL. The DOE estimated that the VTR would cost $3.9 billion-$6 billion and worried that the funding required could not be accommodated within the DOE's budget for nuclear energy research and development.

GE-Hitachi has a contract to do preliminary design work on the VTR, and it has partnered with Terrapower in an Expression of Interest for the construction contract. The reactor would be based on the design of GE's Prism reactor, which in turn is based on the design of the EBR II. For decades, GE has been promoting Prism to the US and UK governments as a way to irradiate their excess plutonium but has not found a buyer because of the small 311-MWe reactor's high price.

DOE's Office of Nuclear Energy, now headed by Rita Baranwal from INL, claimed in an October 2019 press release that "More than 50 US companies are currently working on new designs that will be smaller and more affordable to build and operate."

Among these companies are several that are interested in fast-neutron reactors. It is difficult to judge at this point whether any will come up with a design that can compete with renewable energy and with the existing fleet of light-water reactors whose capital costs have been paid off. It certainly appears premature,
however, for the government to invest several billion dollars in a material test reactor on the assumption that a major fast-neutron reactor industry will emerge. Last August, INL announced that Terrapower, which, thanks to Bill Gates, has the most substantial funding, signed a contract for fuel irradiation at INL's existing Advanced Test Reactor. The ATR is not a fast-neutron reactor but apparently adequate for some tests.

INL proposes that, to maximize the VTR's neutron flux, it be fueled by plutonium. The fuel "meat" is to be metal like that of the EBR II. Because metal fuel swells under irradiation, there is a gap between the meat and the cladding. The gap is filled with liquid sodium to conduct the heat to the cladding. Because sodium burns on contact with water, the fuel is not suitable for direct disposal in a repository and therefore must be reprocessed. INL developed its own pyroprocessing technology that has proved to be extremely costly and unreliable. Throughput has been less than one-tenth of what was projected and the cost per ton has been very high. The cost of pyroprocessing the equivalent of one year's throughput of VTR fuel was $100 million. INL claims that the technology is proliferation resistant but a 2009 review by experts from six national labs, including one from INL, found that claim to be exaggerated.

The VTR would therefore bring with it all the problems that made breeder reactors problematic. It would be fueled by plutonium and require reprocessing, creating a proliferation hazard if replicated in a non-weapon state. (INL is jointly developing pyroprocessing technology with the Korea Atomic Energy Research Institute.) It would be hugely costly and potentially offline most of the time because of problems with sodium leaks. Finally, claims that there would be a demand for its services appear very premature.