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Mobile Nuclear Microreactor Development: A Military-Civilian Symbiosis

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EXECUTIVE SUMMARY: The US Department of Defense has been working with American companies for the past year on a project to develop a prototype for a portable nuclear microreactor, a device intended for use by the US military in security scenarios around the world. The US Department of Energy is also involved in the project, with the aim of providing electricity to remote sites that are difficult to link to the grid. The project thus represents a symbiosis between military and civilian technological development.

A symbiotic relationship between military and civilian aspects of technological development gained momentum in the US after the end of WWII. This was particularly visible among applications in the communication, computing, and aerospace fields, but was also present in the field of nuclear technology. Some technology projects were presented as dual-use in order to justify the cost of their development.

One example of nuclear energy symbiosis was the development of nuclear power-generating reactors. By 1956, more than a decade after the destruction of the Japanese cities of Hiroshima and Nagasaki by nuclear bombs, only the UK's Calder Hall nuclear power plant, which had four reactors each producing 60 MW electricity (MWe), was in operation. However, as of December 2019, 443 nuclear power generators were operating worldwide, with a total output of 395 gigawatts electric (GWe)—an average output of nearly 900 MWe per reactor.

Nuclear propulsion development began in the US as early as the late 1940s, after the end of WWII and at the beginning of the Cold War. The goal was military-submarine propulsion, so the effort focused on developing small reactors.

The person who led the US Navy's nuclear submarine program was (Jewish) Admiral Hyman Rickover. The first US nuclear submarine to be constructed was the Nautilus, which was launched into the sea in 1955. Its installed reactor, S2W, was a pressurized water type of 10 MW output. It was manufactured by Westinghouse.

The USSR quickly followed suit, and in 1958 the first Soviet navy submarine was launched. In the years since, Moscow has used nuclear propulsion on aircraft carriers as well as on icebreakers.

(For both countries, aircraft were another story. Although during the Cold War both the US and the USSR initiated nuclear-powered bomber projects to strengthen nuclear deterrence, neither produced any nuclear-powered operational aircraft.)

Many other countries also began developing small (though not mobile) reactors for various purposes. In the 1970s, Canada made a few prototypes of its small SLOWPOKE (Safe Low Power K[c]ritical Experiment) reactor. Some were used for research, but the SLOWPOKE-3 model, with a 2 to 10 megawatt thermal output, was designed to heat cold areas.

Another small reactor, the CAREM-25 type, was developed in Argentina in the 1980s. Its first model of 27 MWe output was designed for both electricity generation and desalination.

Russia now operates several small reactors. The oldest is the 11 MWe EGP-6, which was established in Siberia and is expected to be shut down soon.

It is only in the past decade that the development of tiny reactors has come to the fore in the US and Western Europe. In recent years, there has been a worldwide trend to develop microreactors for power generation that will be transportable by road. The expected energy output of these reactors is on the order of a few MW to a few tens of MW.

The US Department of Defense intends to manufacture a prototype of an advanced mobile microreactor at the Idaho National Laboratory. Its purpose is to ensure future energy supplies for the US military. This microreactor is expected to be extremely rigid and high-security, highly efficient, and able to operate nonstop for about 10 years without the need for refueling. These characteristics will also make the reactor suitable for use in remote areas where it is difficult to supply electricity over the grid or where the cost of supply is high.

For the US military, the reactor is intended to be used during security events anywhere in the world where US forces have to deploy. It would enable them to reduce their dependence on local power grids that could be vulnerable to collapse during the crisis in question.

The reactor in which the DoD is interested would generate 1 to 10 MW of energy, enabling power for thousands of homes without the need for constant reactor maintenance. It could also be shut down or restarted instantly. According to the DoD, "A safe, small, mobile nuclear reactor would enable units to carry a nearly endless clean power supply, enabling expansion and sustainment of operations for extended periods of time anywhere on the planet."

The microreactor project, nicknamed Pele, began in January 2019 on the initiative of the Strategic Capabilities Office (SCO). The US Nuclear Regulatory Commission will oversee the project's safety and security. According to Jay Dryer, CEO of the SCO: "The US risks ceding nuclear energy technology leadership to Russia and China... By retaking technological leadership, the US will be able to supply the most innovative advanced nuclear energy technologies."

In the DoD's view, microreactor development is essential, as the US defense system now consumes about 30 terawatt-hours (TWh) of electricity a year and about ten million gallons of fuel a day—quantities that are expected to grow.

As reported in March, the DoD has approached three US companies for this project: BWX Technologies, Westinghouse Government Services, and X-Energy. After a two-year development period, one will be selected to build and demonstrate the prototype. They will be awarded between $13 million and $15 million. The microreactors the companies will offer to the DoD will differ from one another technologically in terms of reactor type, nuclear fuel type, and probably also expected power output.

In addition to the DOD and the SCO, the US Department of Energy as well as other government agencies will be involved in Project Pele.

Other nuclear energy organizations and systems in the US and abroad are motivated to make progress in the area of microreactor development. They are interested in providing energy to a broad range of consumers, especially in the residential domain, and particularly in remote areas. They hope not only to provide electricity but also to heat cold areas and produce drinking water.

Micro nuclear reactors are expected to have an advantage in terms of production modularity, which can guarantee high quality standards. In the civilian sector, they might also make the valuable contribution of lowering the price of electricity for consumers. This is because microreactors' costs of production and operation are expected to be low relative to the construction and operation of large nuclear power plants that produce hundreds of megawatts of electricity. Savings are also expected for consumers who are connected to the electricity grid.

Another major advantage to microreactors is that they are expected to be safer. If a malfunction occurs in a microreactor, the environmental radioactive pollution would be relatively low.

Unlike the microreactors described above, Lockheed Martin Corporation registered a patent in 2018 for a revolutionary design of a portable Compact Fusion Reactor small enough to be mounted on a truck. One version is designed to produce enough electricity to power a city of 100,000 people. If this reactor is successfully developed, the energy it produces will be clean, meaning it will be free of radioactive fission products. According to Lockheed's forecasts, the reactor development project should reach commercial production in the first half of this decade.

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