
Project Title

A Practical Approach to Developing Floating Nuclear Power Plants in the United States

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Program: Reactor Development and Plant Optimization (Topic Area 1)

ABSTRACT:

The economic challenges facing the expansion of nuclear energy in the U.S. and globally are well known: large reactors are expensive, can take up to a decade to build, and require physical infrastructure (e.g., transmission lines) and institutional readiness that are not easily available, particularly in developing countries with limited financing or no previous nuclear experience. Floating Nuclear Power Plants (FNPP) using small reactors (<100 MWe), built efficiently in shipyards, towed to coastal sites, and perhaps leased to the host country, offer an interesting alternative, or at least a solution complementary to the traditional approach. Russia and China have relatively mature FNPP programs which target domestic and export markets. In recent decades U.S. FNPP initiatives have not risen above the level of press releases and exploratory work. As such, a change of pace on FNPPs is urgently needed, with fresh ideas that will help the US counter China's and Russia's dominance of this technology.

In current and past FNPP examples, the developers have designed new floating structures or ships that are customized for and integrated with specific reactors. This approach has two downsides: loss of versatility and high cost. Customizing the floating structure design entails high upfront development costs and makes it incompatible with a broader set of reactor designs. Such structures will easily add 100-200 million dollars in addition to the usual costs of the nuclear reactor and the balance of plant equipment. For reactors that generate between 5 MW (microreactors) and 77 MW_e (Nuscale-type reactor) of electricity, this expense translates to an increase of the levelized cost of electricity between 180 and 25 \$/MWh, respectively, assuming 6% discount rate, 90% capacity factor, and 30 years economic lifetime.

By contrast, in this project we seek to evaluate the techno-economic feasibility of conventional merchant ships hosting US-made microreactors within a self-contained enclosure, realizing a FNPP that should be both cost effective and versatile. This concept will enable versatile delivery of clean and reliable nuclear electricity, via submarine cable, to coastal, insular and offshore sites. The merits of the concept are (i) an expected low cost compared to the design and construction of dedicated platforms and barges, and (ii) added geopolitical value to the U.S. as it competes against China and Russia to serve the energy needs of developing countries.

The project comprises five tasks, including estimate of maximum number of microreactors that can fit within identified base ship types based on 3D layout (Task 1); engineering evaluation of weight distribution, static stability, mooring and dynamic response to sea states for the most promising configuration within each ship type (Task 2); model of operations determining the staff size and qualifications required to operate, maintain and refuel the FNPP (Task 3); an evaluation of the marine and nuclear regulatory challenges according to the model of operations (Task 4); and a cost and market analysis for the potential applications of the FNPP for a variety of port and coastal locations (Task 5).

The main outcomes expected from this project include (1) the conceptual design of a conventional merchant ship retrofitted with multiple microreactors to be used as a FNPP, and (2) an evaluation of the feasibility of said design including operations and maintenance (O&M), regulations, cost and potential markets. Deliverables will include annual and final reports to DOE detailing the project work, as well as journal and conference publications.