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Floating Nuclear Power Plants: The Future of Energy?

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Credit: Hansueli Krapf/Wikipedia [1]

By Tom Blees

The nuclear renaissance that captured the imagination of the press and public early in the 21st century's opening decade came crashing to a halt with the Fukushima tsunami in 2011. Yet climate change politics have continued to bring pressure to bear globally, demanding a dramatic increase in energy systems that don't emit greenhouse gases. Even many formerly anti-nuclear environmentalists have decided to take another look at nuclear power, having realized that so-called renewables (wind, solar, and hydro) simply can't produce the vast quantities of energy humanity demands.

Though the USA has only a couple nuclear power plants under construction, other countries are either ramping up their existing programs or embarking on their first nuclear power projects. So far the vast majority of the 54 reactors under construction as of 2018 are light-water reactors (LWR), various iterations of the same type of reactor that dominated the industry from its inception. Yet nuclear evolution hasn't stopped despite the lull in construction during the past few decades, and there are new reactor designs that will likely be built within the next ten years that represent substantial technology leaps beyond LWRs.

If nuclear power plants are to play a key role in addressing the climate change challenge, they are going to have to be able to be not only safe but economically competitive, and they must be able to be built a lot faster than current projects. Those characteristics have led many to promote so-called small modular reactors (SMR), with the idea that mass production will be possible. Among the most promising of the SMR concepts is the molten salt reactor (MSR, awkwardly the same acronym letters). The prototype of this reactor was built and operated at Oak Ridge National Laboratory in the early Sixties. At the time the project was shuttered, its creators had its scaled-up successor already on the drawing board, what was to be a 300-megawatt version.

As an international consultant on advanced nuclear power systems, I've watched the growing interest in MSRs during the past decade, but always was skeptical simply because of the materials challenges that they face. Whereas LWRs operate at about 350° C, MSRs would operate at about 700°. The molten salt containing the fuel elements (thorium, uranium, and/or plutonium) would imply a highly corrosive environment, and the embrittlement of the metals resulting from neutron bombardment would make things even more problematic.

Whenever I inquired from MSR promoters what they planned to build their reactors with, I was met with glib assurances that new alloys would make it work. At the same time, they were trying to create MSRs that would last 60-80 years or more, like LWRs. And none of the MSR promoters had any experience building nuclear reactors (or anything else, as far as I could tell).

Then a small startup came along that I believe will be the first company to bring a truly advanced non-LWR reactor to market, an MSR that solves the materials challenge. The company is called Thorcon [2]. It was started by two brothers, Jack and Dave Devanney, who started out in the shipping business. Jack taught marine engineering at MIT before building ships for the Navy, then commenced designing oil tankers. He designed what would be the largest ship in the world, then oversaw its construction in South Korea, home of the world's most sophisticated shipyards. The brothers were able to build it so fast and so cheap that they built three more. It got them to wondering if such high-tech shipyard technology could be used to build nuclear reactors.

Assembling a small group of engineers and physicists, the Thorcon team quickly realized that molten salt reactors would lend themselves to such shipyard construction. One of the salient features that would make it possible is that MSRs operate at atmospheric pressure, obviating the need for pressure vessels and other high-pressure components. Initially the concept involved building cylindrical reactor vessels in a shipyard, then transporting them by ship to power plant sites where silos would be dug near navigable waterways, with all the controls, generator, switchyard, and other power plant components ready to have the modules lifted into place with large cranes.

But then Thorcon came up with an even better idea: build the entire power plant on a ship. Building all the non-reactor infrastructure on shore could bring in complications like poor quality control, work stoppages, graft, NIMBY problems, etc. Building the whole power plant on a ship would avoid all such problems and make it possible to locate the power plants offshore. And if anybody knew how to build ships big enough it was Jack Devanney.

But how, you may ask, would the Thorcon MSR solve the materials challenges described above? Being accomplished industrialists who'd built big things (including other ships besides the four giants), the Devanneys calculated the costs and realized that they could build the reactors so cheaply that they could make them disposable after just four years of use. They knew that the materials would last at least four years because even with the alloys available in the Sixties the reactor at Oak Ridge had been run for four years. As for scaling it up, the Thorcon modules would produce 250 MW, slightly smaller than the design that the Oak Ridge team had already planned for their next prototype.

The inherent safety of MSRs has convinced many people to embrace the concept despite previous anti-nuclear leanings. The most problematic elements in nuclear accidents—iodine, cesium, and strontium—are chemically bound to the salt and would thus not be ejected in a potential accident. And since the salt solidifies at about 300°C, in the unlikely event that a terrorist or some such malevolent actor blew up a reactor with high explosives, the molten salt would almost immediately solidify and drop to earth as soon as it hit the air.

Aside from the technology, though, one of the most exciting aspects of building such power ships is that countries with the capability to build shipyards for their construction could essentially become utility companies. The ships could be floated to developing countries that often lack the capital for large construction projects, and they could simply plug a ship into their grid and buy electricity like any consumer. Even if the country owning the ships would sell the electricity at half the average price in Europe, a power ship would pay for itself in less than three years. Thus, countries highly dependent on oil and gas will be able to use their ample funds to build power ship fleets, and developing countries can quickly improve their standards of living with clean, affordable energy.

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