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By Robert Bryce

Nukes Get Small

Big nuclear power plants dominate the headlines and the debate. These projects, involving reactors that produce thousands of megawatts of electric power and requiring many billions of investment dollars, are hotly debated due to their huge costs and concerns about nuclear proliferation. Opponents also question their safety and point to the problem of long-term waste disposal.

But entrepreneurs are now developing small nuclear reactors that could ultimately become just as important as their bigger, more famous counterparts. These micro-nukes produce a small fraction of the power that their bigger cousins do, but they may have applications in far more locations, particularly in remote areas where electricity is prohibitively expensive. The small reactors may also be used for temporary power production, or at locations like military bases that need highly reliable electric power.

Small reactors could be extraordinarily useful in both the upstream and downstream sectors of the oil industry. In the upstream, a small reactor would be highly valuable for use in oil sands, heavy oil, or oil shale projects that consume huge quantities of natural gas to produce the steam needed to process the bitumen, heavy oil, or shale. The small reactor could also be used in refineries, which must burn natural gas or other hydrocarbons to produce steam for various processes. Further, the small reactors can be ganged, so they could be scaled up to provide power for small cities that don't need (or can't afford) a much larger reactor.

Several companies are vying to be the first to commercialize small reactors. Among the most promising competitors are two American companies: Hyperion Power Generation and NuScale Power Inc.

Hyperion, a Santa Fe-based company, is using technology developed and licensed by Los Alamos National Laboratory. Hyperion's plan is to commercialize the Los Alamos technology by selling reactors designed to produce 25 MW of electric power or 70 MW of thermal power. The reactor would be small – about the size of an average hot tub – and could thus be transported via tractor-trailer. A 25 MW reactor would provide enough electricity for about 20,000 homes.

Hyperion's design is similar to that of a Triga reactor, a design used for decades by scientific institutions and universities. (Triga stands for "training, research, isotopes, General Atomics.") The key advantage of the Triga design is its safety. As the temperature in the reactor core increases, the reactivity of the nuclear material decreases, making it unlikely (but not impossible) for the reactor to melt down. The original Triga reactor, built in the late 1950s, was designed by a team led by renowned physicist Freeman Dyson. Several dozen Triga reactors are now operating around the world.

Hyperion says that it wants to build "about 4,000" of its reactors within the first 10 years of production. The reactors will be self-contained, have no moving parts, and will be about 1.5 meters in diameter – small enough to fit inside the average hot tub. The units will be encased in concrete, buried underground, and must be refueled every five to seven years. According to C.E.O. John Deal, Hyperion will submit an application for a manufacturing license to the Nuclear Regulatory Commission in September 2009. But as with everything else in the nuclear power sector, the process is likely to be prolonged. According to documents posted on the N.R.C.'s Web site in February, the review of Hyperion's application for a manufacturing license could last until 2015. For his part, Deal says that timelines for approval are "all over the place until we actually submit" an application to the agency. Deal believes Hyperion could get a manufacturing license two to four years after it applies to the N.R.C.

In April, Hyperion received an undisclosed amount of venture funding from the Denver-based Altira Group, an energy technologies investment firm. Deal refused to discuss how much money Hyperion has raised, but he told me that the company will "get from zero to prototype for $100 million." The company, with fewer than 100 employees, aims to produce reactors that cost between $25 million and $32 million. Deal says the goal is to have those reactors able to produce electric power for less than $0.08 per kilowatt-hour "anywhere on the planet."

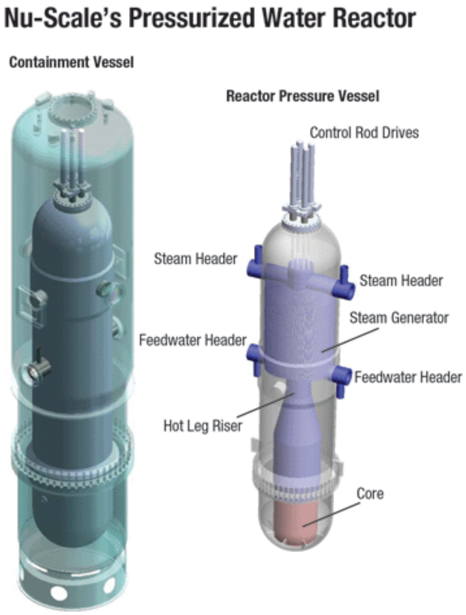
As with any nuclear power technology, a key issue is proliferation. Deal insists that Hyperion's design minimizes that concern. He said that the company's reactor uses uranium hydride as a fuel, which is not as problematic as the enriched uranium most reactors use. Deal says that the uranium hydride "is not appropriate for weaponization without massive refining and enrichment." He goes on, saying it "would be easier to just start with yellowcake."

Perhaps the most unusual small reactor design is the one being pursued by Japanese conglomerate Toshiba. For the past two years, it has been talking about its "4S" (super-safe, small, and simple) reactor (10 MW) that will be cooled by liquid sodium instead of water. The design is known as an L.M.R., short for Liquid Metal Cooled Reactor. Using sodium allows the reactor to run hotter and avoid using highly pressurized pipes. Toshiba, which owns Westinghouse, claims that the reactor could produce power for between $0.05 and $0.13 per kilowatt-hour, far cheaper than that from generators powered by diesel engines. The company garnered media attention in 2006 when it began discussing the possibility of locating a small reactor in Galena, Alaska. Toshiba has called its design a "nuclear battery" that could operate for up to 30 years without refueling. According to the Nuclear Energy Institute, Toshiba could apply to the N.R.C. for design certification as soon as next year. The agency says that the design approval for the 4S may not be complete until the end of 2013.

Oregon-based NuScale Power Inc. is developing a small reactor that will produce 150 MW of thermal energy and 45 MW of electricity. NuScale has received backing from a San Francisco-based venture capital firm, CMEA Ventures. NuScale claims that its reactor will give utilities and other power providers "a way to add and finance new generating capacity in a manner and on a time scale similar to gas turbines." The NuScale reactor is based on the "multi-application small light water reactor" designed largely by Oregon State University researchers, with funding from the

Department of Energy. The university also worked with the Idaho National Laboratory. As with the Hyperion design, the NuScale containment vessel could be fabricated by a number of medium-sized manufacturers here in the U.S. And given its relatively small size, it could be shipped by rail, truck, or barge.

Like many of the large reactors now in use, the Nu-Scale reactor is a pressurized water reactor, but its design is simpler. The water in the system is cooled by natural circulation, thus eliminating many pumps, pipes, and other machinery that could fail. C.E.O. Paul Lorenzini refused to discuss how much the NuScale reactor will cost, if and when it is approved for production. He believes NuScale has two advantages over Hyperion and Toshiba. "First, it is a light water reactor and, therefore, it relies on a vast body of existing" research and development, says Lorenzini. "Further, it can be certified using a regulatory framework for light water reactors that already exists."



Recent statements from the N.R.C. appear to support that conclusion. In a briefing released earlier this year, Brian Sheron, director of the Office of Nuclear Regulator Research at the N.R.C., said that the "N.R.C. skill set and tools are lacking for L.M.R. and hydride reactor." Sheron's briefing slides also discuss the L.M.R. design being put forward by Toshiba, saying that "with adequate resources and staff it will take at least five years to develop independent capabilities for L.M.R." The problem, of course, is that the N.R.C. is chronically understaffed. Thus, getting the resources and staffing needed to deal with the Toshiba design could take far longer than the five years cited by Sheron.

Going to smaller scale reactors has many advantages, says Rod Adams, who writes about the industry on the Atomic Insights blog. Adams foresees the reactors providing electricity in markets that "traditionally have been supplied by power plants fired with oil or natural gas. So they have a potential to show that there's an alternative that can displace oil in some markets."

That said, Adams believes that Hyperion and Nu-Scale are likely to wade through the N.R.C.'s approval process for many years. "Because they are small, they are going to have to get in line behind some bigger players. Those players, like GE, Westinghouse, and Areva, already have identified U.S. customers, and that's something that the N.R.C. uses to prioritize their resources," says Adams.

Furthermore, Adams agrees with Lorenzini that NuScale may have an advantage at the N.R.C. He believes that the agency "is more comfortable with, and may be more inclined to license, a light water reactor given that they already have the expertise" in that technology. NuScale will have its first pre-application meeting with the N.R.C. on July 24. The company plans to apply for plant certification in the first quarter of 2010. According to the N.R.C., the design approval process for NuScale could last until 2014 or so.

Regardless of which design ultimately wins approval from the N.R.C., it's obvious that the global electricity market will embrace the winning technology. One of the first customers may be the tar-sands producers in Canada. According to some estimates, producing a barrel of crude oil from the tar sands consumes about 1,400 cubic feet of natural gas. Given today's soaring gas prices, a small reactor would be an ideal fit for that application. Small reactors would also be welcomed in petrochemical complexes. Another smart fit for small reactors: desalination plants. As fresh-water resources become strained, numerous countries around the world are resorting to desalination, a process that requires huge amounts of electricity. According to Global Water Intelligence, global desalination capacity will double by 2015.

In addition to industrial uses, small reactors are a natural fit for numerous small or underdeveloped countries interested in generation plants that could provide electricity for about $0.10 per kWh. Some 2 billion people on the planet do not have access to electricity in their homes. And global electricity consumption is soaring. Between 1990 and 2006, electricity use jumped 60 percent. That's a faster growth rate than oil, gas, or coal saw during the same span. And with the possibility that governments will impose constraints or taxes on carbon emissions, nuclear power is one of the few sources that can provide significant increments of new low-, or no-carbon electricity.

Of course, the small reactors will face questions about proliferation and how they can be protected from malicious attack. And if hundreds or even thousands of the small reactors are deployed, the security challenges will be significant.

Despite the many questions about their future, potential gains in new electric capacity are tantalizing. Small reactors are "ideally suited to facilitating an international market for safe nuclear plants within countries that may lack sufficient expertise for their own independent design approvals," says Lorenzini, who believes there is a huge market that "is waiting for the first small nuclear plant to be licensed" by the N.R.C.

In another few years, we will know which company (if any) gets that license. And if they do, small reactors could get very big.