CambysesAdvisors.Com -- Steven@CambysesAdvisors.Com -- +1 (818) 489-4228

Rolls Royce Rolls Out its SMR Design

Rolls Royce displayed a prototype of its Small Modular Reactor (SMR) at an energy exhibition held last week, making Rolls the latest entrant into a gradually strengthening market expected to reach approximately $7 Billion by 2030.

SMR Economics and Ecosystem

Small Modular Reactors (SMRs) are advanced nuclear reactors that usually have a power capacity between 100 MW(e) to 300 MW(e) per unit[1]. Their distinguishing features are

- Small: SMR reactors are physically small and occupy a far smaller footprint than standard commercial reactors. Rolls Royce's SMR is approximately 10 feet by 3 feet and can be assembled, along with its infrastructure, on less than 90,000 square feet (roughly, one and a half acres). Compare that to the now inactive San Onofre Nuclear site, 84 acres, 5.4 million square feet, and reactor containment domes approximately 160 feet tall and 300 feet in diameter.) The tradeoff, however, is output – Rolls' SMR design output approximates one third the power of a commercial reactor.

- Modular: SMR systems and components can be factory-assembled and transported to a location for installation. Thus, construction time and cost savings are significant. Rolls Royce cites these cost advantages but provides no estimate of their value.

  NuScale (NYSE: SMR), a nuclear company currently active in Oregon, Utah, and Poland, optimistically claims it can build SMRs for less than $3,000 per kilowatt (kW) and deliver power for $58/MW. Several critics challenge NuScale's estimates. the Institute for Energy Economics and Financial Analysis (IEEFA), citing the U.S. Department of Energy, estimates delivery costs nearly twice NuScale's estimates.[2]

- Reactors: Like conventional reactors, SMRs exploit (uranium, plutonium, or thorium based) nuclear fission to generate heat, which is then channeled to produce energy.

SMRs' primary distinctions (size and modularity) are most advantageous where power is needed on sites that are unsuitable or inaccessible to conventional nuclear sources (sites that are

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[1] Based on an International Atomic Energy Agency (IAEA) definition that may be outdated. Roll's Royce's prototype is slated to deliver ~430-470 MW. Other SMR systems promise (or deliver) similar power output.

[2] Even if NuScale's estimates are accurate, their delivery price exceeds zero-carbon solar and wind energy prices by a wide margin. Currently, Solar + storage prices are approximately $45/MW, Wind power approximately $30-$32. This price differential may limit SMRs to a niche power market: one in which site limitations or limited grid access obviates conventional clean power.

too small, too remote, too environmentally sensitive, too far off the grid, or to replace sources that are being decommissioned or are unreliable). For example, there is growing demand for SMRs to slot into brownfield sites in place of decommissioned coal-fired plants.

Those distinctions also imply, at least to some degree, transportability. Thus, SMRs (and their smaller cousin, micro-reactors) have been touted for roles in remote environmentally sensitive areas, energy-equity applications (delivering power to underserved areas), as backup power supplies, and replacement power generators for, e.g., applications fueled by diesel.

Rolls Royce touts its SMR for use in what is probably the ultimate such niche: powering moon colonies located near the Moon's southern poles. Microsoft (NASDAQ: MSFT) recently began to explore using SMRs and microreactors to power their (energy hungry) data centers.

Russia's Akademik Lomonosov reactor was (most likely) the first operational commercial SMR; May 2020. Lomonosov produces power from two 35 MW(e) SMRs.

The International Atomic Energy Agency (IAEA) identifies about 160 operational SMRs and 25 under construction. Operational SMRs typically produce between 100 MW and 300 MW. IAEA identifies more than eighty SMR designs under development in at least nineteen countries. The U.S. certified its first SMR design (NuScale) in Feb 2023.

Safety and Environmental Considerations

SMRs are generally considered safer than commercial reactors. Their size (small), low power output, reduced operating pressure, independence from external power sources, and simplicity contribute to this assessment. Those factors allow SMRs to employ passive safety measures (circulation, convection, gravity, self-pressurization) and reduce the systems' dependence on human intervention. This reduces or significantly lowers (but does not eliminate) the potential for accidental release of radioactivity to the environment.

Without question, SMRs require significantly less fissionable fuel and less frequent refueling than conventional commercial reactors. SMRs typically refuel every 3 to 7 years, with some designed for a 30-year refueling cycle. In contrast, conventional plants refuel every 1 and 2 years and require, on average, 27 tons of fissionable material during each cycle.[3] [*3]

Advocates cite this as evidence that SMRs are "cleaner" and reduce environmental impacts. As with many advertising generalizations, the full story is more complex than the advocates' position.[4] [*4]

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[3] The literature includes surprisingly few estimates of SMR refueling requirements. Design differences between various SMRs and the use of alternative fission sources by some SMRs make generic averages questionable. Some SMR designs employ plutonium, and at least one uses thorium isotope. In these designs, refueling produces less waste mass, but greater radiotoxicity than conventional reactors. Conventional reactors employ more uniform fuel sources.

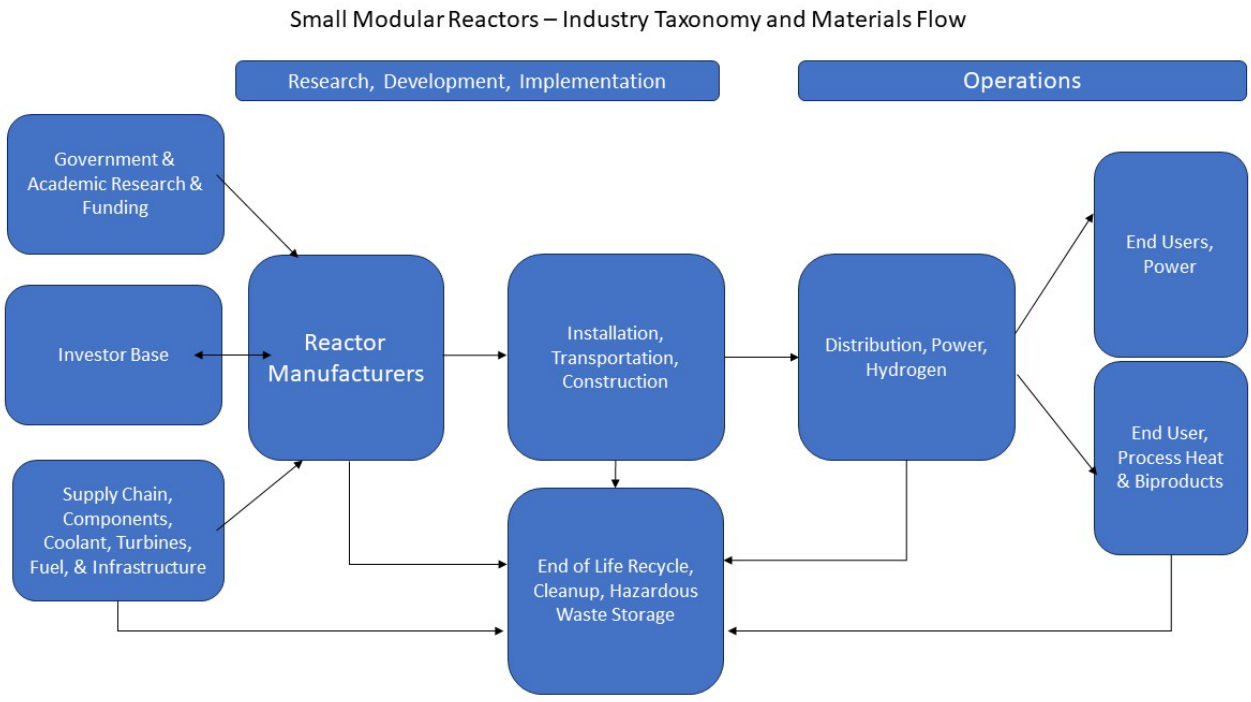
[4] c.f., Krall, L, et al; Nuclear waste from small modular reactors; Proceedings of the National Academy of Sciences, 05/2022

- An obvious logic flaw: SMRs output between 1/10th and 1/4th the output of conventional reactors. Therefore, replacement of conventional reactors with SMRs would generate between four and ten times the spent-fuel waste of individual SMRs. Possibly enough to equal or exceed conventional reactor waste.

- Sustainable fission reactions are usually initiated by neutrons interacting with uranium (or plutonium, sometimes thorium). They result in one or more elements with lower atomic weights than uranium, heat, and additional neutrons. The additional neutrons are either absorbed by the fissionable material (thus sustaining the reaction) or escape to interact with their surroundings. Escaping neutrons induce radioactivity in the materials they impact (a process known as neutron activation). The neutrons' surroundings include reactor components, infrastructure, and containment vessels. Since SMRs are "small," their surface area to volume ratio is higher than conventional reactors: more neutrons impact the surface and the surface materials become radioactive (and structurally unsound) faster than those in conventional reactors. This nuclear waste must, eventually, be replaced and disposed of, similar to that of conventional reactors.

In our view, SMRs are not a solution to the nuclear industry's waste problem. SMRs are more accurately described as useful power options in specific applications for which conventional solutions are unsuitable.

Industry Taxonomy and Material Flow



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Investment in SMRs

Direct investment in the SMR ecology is difficult unless you are a Qualified Investor. Of the 21 companies in the arena, five are publicly traded. Of the rest, most are subsidiaries of larger ventures, or their shares are held by individual investors, private equity, venture firms, or investment funds. Performance and analysis covrag3 is very thin for even the public entrants.

Prominent or High-Profile companies in the SMR Arena:

BWRX and GE Hitachi Nuclear Energy {Subsidiary of GE (NYSE: GE), Hitachi (OTC:HTHIY), and First Nations Power Authority (Canada, NGO/NFP)}
Fifth largest in sector, GE Hitachi owns 100% of BWRX. BWRX has entered into an agreement to provide training and employment opportunities to qualified indigenous people in Canada.

General Atomics (Private: Blue Family sole shareholder since 1986)
Known primarily for its Uncrewed Aircraft Systems, tactical reconnaissance radars, and high-resolution surveillance systems (e.g., MQ-9 Reaper, Sky Guardian, and STOL drones), General Atomics' Electromagnetic Systems (GA-EMS) has been a cutting edge innovator in nuclear energy since its founding in 1955. In addition to SMR and conventional scale reactors, GA operates and maintains what is probably the world's oldest commercial Tokamak (fusion reactor).

Kairos Power (Private: Significant NRC funding)
Frequently mentioned "rising star" offering innovative SMR technologies and applications.

Moltex Energy (Private: Multiple funding sources including Canada and Ontario governments)
Builds an SMR that uses recycled waste from conventional reactors. Has energy storage capabilities and facilitates process heating for hydrogen production. Weird Fact: Moltex has held at least one GoFundMe round.

NuScale (NYSE: SMR)
The second largest SMR market share in 2022. NuScale. has undertaken several SMR projects in the US, Europe, South Africa, Asia, and Canada. The company has been criticized for overstating their capabilities. Short Seller, Iceberg, mounted a concerted short sell attack on NuScale's stock in November 2023. There is limited analyst coverage and data available -- much of it negative.

Rolls Royce SMR {Private: Rolls Royce (OTC: RYCEY), BNF (German Exchanges), Constellation (NASDAQ: CEG), and Qatar Investment Authority}
Developing SMRs for specific niche roles. Most recently, displayed its moon base power unit prototypes.

SNC Lavalin Group (OTC: SNCAF)
supports clients across the entire nuclear lifecycle from consultancy, EPCM services, field services, technology services, spare parts, reactor support and decommissioning and waste management.

Terrestrial Energy (Private: Undisclosed Investors)
Delivers "reliable, emission-free, and cost-competitive nuclear energy" with an advanced reactor, the Integral Molten Salt Reactor (IMSR). Has raised ~$95 million USD through thirteen funding rounds. Three undisclosed principals. Based in Canada

Terra Power (Private: Founded by Bill Gates and owned by Gates and Several Funds)
Prominent as much for who supports it as what it does. Developing SMRs to supply process heat and has plans for isotope harvesting from spent fuel for medical use in lifesaving cancer treatments.

Westinghouse Electric (Private, Brookfield Renewable Partners)
Westinghouse controls, by far, the largest share of the market. Westinghouse held the majority of the global SMR market in 2022. They are the original equipment manufacturer (OEM) and technology provider for ~50% of global commercial nuclear power market and provide maintenance and operations support to about two-thirds of the world's operating fleet.

X-Energy (Private: Kam Ghaffarian, with significant DOE Support)
SMR Developer, X-Energy is almost as notorious for what it didn't do as for what it does: X-Energy cancelled its lengthily negotiated SPAC IPO deal with Eres on 10/31/23.

Disclaimers

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