Small nuclear power reactors—future or folly?

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Credit: AI-generated image (disclaimer)

Nuclear energy companies are proposing small nuclear reactors as a safer and cheaper source of electricity.

In June, Canadian Nuclear Laboratories put out a "call for a discussion around Small Modular Reactor (SMRs) in Canada," and the role the organization "can play in bringing this technology to market."

The news release asserts that SMRs are "a potential alternative to large-scale nuclear reactors," would be effective at "decreasing up-front capital costs through simpler, less complex plants" and are "inherently safe" designs. All of this warrants examination.

As a physicist who has researched and written about various policy issues related to nuclear energy and different nuclear reactor designs for nearly two decades, I believe that one should be skeptical of these claims.

SMRs produce small amounts of electricity compared to currently common nuclear power reactors. In Canada, the last set of reactors commissioned were the four at Darlington, east of Toronto, which entered service between 1990 and 1993. These are designed to feed 878 megawatts into the electric grid.

In contrast, the first two nuclear power reactors commissioned in Canada were the Nuclear Power Demonstration reactor at Rolphton, Ont., in 1962, and Douglas Point, Ont., in 1968. These fed 22 and 206 megawatts respectively to the grid.

In other words, reactors have increased in size and power-generating capacity over time. For perspective, normal summer-time peak demand for electricity in Ontario is estimated at over 22,000 megawatts .

Cost considerations key

The reason for the increase in reactor output is simple: Nuclear power has always been an expensive way to generate electricity. Historically, small reactors built in the United States all shut down early because they couldn't compete economically. One of the few ways that nuclear power plant operators could reduce costs was to capitalize on economies of scale —taking advantage of the fact that many of the expenses associated with constructing and operating a reactor do not change in proportion to the power generated.

Building a 800-megawatt reactor requires less than four times the quantity of concrete or steel as a 200-megawatt reactor, and does not need four times as many people to operate it. But it does generate four times as much electricity, and revenue.

Small modular reactors are even smaller. The NuScale reactor being developed by NuScale Power in the United States is to feed just 47.5 megawatts into the grid. This reduction is chiefly due to the main practical problem with nuclear power: reactors are expensive to build.

Consider the experience in Ontario: In 2008, the province's government asked reactor vendors to bid for the construction of two more reactors at the Darlington site. The bid from Atomic Energy of Canada Ltd. was reported to be $26 billion for two 1200-megawatt CANDU reactors —more than three times what the government had assumed. The province abandoned its plans.

Not surprisingly, with costs so high, few reactors are being built. The hope offered by the nuclear industry is that going back to building smaller reactors might allow more utilities to invest in them.

NuScale Power says a 12-unit version of its design that feeds 570 MW to the grid will cost "less than $3 billion." But because the reactor design is far from final, the figure is not reliable. There is a long and well-documented history of reactors being much more expensive than originally projected. This year, Westinghouse Electric Company—historically the largest builder of nuclear power plants in the world—filed for Chapter 11 bankruptcy protection in the United States precisely because of such cost overruns.

Cost overruns aside, smaller reactors might be cheaper but they also produce much less electricity and revenue. As a result, generating each unit of electricity will be more expensive.

Design aims to reduce costs

The second part of the SMR abbreviation, "Modular," is again an attempt to control costs. The reactor is to be mostly constructed within a factory with limited assembly of factory-fabricated "modules" at the site of the power plant itself. It may even be possible to completely build a SMR in a factory and ship it to the reactor site.

Modular construction has been increasingly incorporated into all nuclear reactor building, including large reactors. However, since some components of a large reactor are physically voluminous, they have to be assembled on site. Again, modularity is no panacea for cost increases, as Westinghouse found out in recent years.

Safety in scale?

SMR developers say the technology poses a lower risk of accidents, as Canadian Nuclear Laboratories suggests when it asserts "inherent safety" as a property of SMRs. Intuitively, smaller reactors realize safety benefits since a lower power reactor implies less radioactive material in the core, and therefore less energy potentially released in an accident.

The problem is that safety is only one priority for designers. They must also consider about other priorities, including cost reductions. These priorities drive reactor designs in different directions, making it practically impossible to optimize all of them simultaneously.

The main priority preventing safe deployment is economics. Most commercial proposals for SMRs involve cost-cutting measures, such as siting multiple reactors in close proximity. This increases the risk of accidents, or the impact of potential accidents on people nearby.

At Japan's Fukushima Daiichi plant, explosions at one reactor damaged the spent fuel pool in a co-located reactor. Radiation leaks from one unit made it difficult for emergency workers to approach the other units.

Looking ahead

The future for nuclear energy in Canada is not rosy. Canada's National Energy Board's latest Canada's Energy Future 2016 report that projects supply and demand to the year 2040 states: "No new nuclear units are anticipated to be built in any province during the projection period." It notes annual nuclear generation is forecast to decline nearly 12.5 per cent from 98 terawatt-hours in 2014 to 77 in 2040.

Promoters of SMRs argue that investing in small reactors will change this bleak picture. But technical and economic factors, as well as the experience of small nuclear reactors built in an earlier era, all suggest that this is a mislaid hope.

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