Can Small Modular Reactors and/or Advanced Nuclear Reactors Help Tackle Climate Change?

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Summary

It is clear we need to tackle climate change quickly and effectively. With energy policies, several ways exist to mitigate carbon emissions and we need to compare them as to how rapid, how realistic and how cost-effective they are. In a few countries, nuclear proponents are lobbying, increasingly frantically, for new types of nuclear reactors to be constructed. But these are not even at their design stages, and many scientific analyses reveal that they are slow to implement and are hopelessly costly both in terms of their construction costs and eventual would-be electricity prices. On the other hand, renewable energy and energy efficiency programmes are here and now, are inexpensive, can be implemented quickly and do not have the myriad of problems associated with nuclear projects. Investment in costly nuclear power programmes, which would take decades to implement, would effectively worsen climate change because each pound spent on nuclear would be buying less solution which won't save carbon until it's much too late. (1)

Introduction

The world's leading climate scientists on the UN's Intergovernmental Panel on Climate Change (IPCC) have warned that we have fewer than 10 years to make massive and unprecedented changes to global energy infrastructure in order to limit global warming to moderate levels. (2) Even the most optimistic projections don't foresee any new reactor designs coming on stream until the 2030s and 2040s, and it would be even later before significant amounts of electricity were produced.

For example, Dr Gregory Jaczko, former chairman of the U.S. Nuclear Regulatory Commission (2009–2012) says we should only support nuclear projects

"*if they can compete with renewables and storage on deployment cost and speed, public safety, waste disposal, operational flexibility and global security*. *There are none* [that can do that] *today*". (3)

What are SMRs and Advanced Nuclear Technologies?

Over the past few years, in a few countries with nuclear power programmes, (ie UK, Canada and the US), nuclear lobbyists have pressed for 'small' modular reactors' (SMRs), along with so-called "advanced" nuclear technologies (ANTs). These advocates allege that such nuclear projects could provide 'low carbon' energy solutions, although the large carbon arisings from uranium mining and milling and nuclear wastes are usually ignored in such claims.

It should be noted that many other countries (ie Germany, Austria and most EU countries including Ireland) have failed to support such claims. Indeed, the EU's taxonomy process, which is setting guidelines to apply to future EU support for energy projects, has pointedly refused to include nuclear projects as they are unsustainable both in environmental and economic terms.

Instead, independent commentators suggest that the nuclear industry and its protagonists are making these unsupported claims in order to stop the nuclear industry's actual (and apparently terminal) decline throughout the world, as many nuclear reactors are closing down at the ends of their lives.

SMRs and ANTs

The terminology used by nuclear supporters is unfortunately confusing. The UK government uses the term 'Advanced Nuclear Technologies' (ANTs) to cover two broad categories based on their technologies. First are reactors based on the same technology as existing reactors – ie Small Modular Reactors (SMRs).

Second are proposed Advanced Modular Reactors (AMRs) which have never operated successfully anywhere in the world.

- helium-cooled graphite-moderated high-temperature reactors (HTGR);
- sodium-cooled fast reactors (FBR);
- molten salt reactors;
- lead-cooled fast reactors. (4)

However other supporters lump the two categories under one heading of SMRs (5) or small, modular light-water reactors, and non-light-water "advanced" reactors.

The usually unstated reason for the nuclear industry's promotion of SMRs and AMRs is that existing large nuclear reactors are now uneconomic: some are even being shut because they are unprofitable to operate even after their capital costs have long been paid off. More important, new large reactors are exceedingly expensive to construct.

Therefore SMRs are being promoted as a solution to the high operating costs and to the difficulties of financing larger reactors. But the reason why existing reactors are large was precisely to derive economies of scale: why smaller reactors should be more economic is problematic. Nuclear proponents allege that assembly-line technology will be used in reactor construction but this has yet to be shown in practice anywhere in the world.

In addition, for a company to be confident enough to invest in a factory to manufacture reactors, it would need to ensure a market exists for them, and it would need to build a massive supply chain since none of it currently exists. Funding for that would presumably come from customer orders. But those customers are unlikely to appear until the designs and costs have been proven.

Other major obstacles remain. Some are technical, some are regulatory, and some are due to the resistance by local groups to having nuclear reactors in the midst of their communities. And the financing of such schemes would only be possible with significant subsidy from taxpayers.

In view of these manifest problems, some say that SMRs are little more than wishful thinking. For example, Professor MV Ramana – Simons Chair in Disarmament, Global and Human Security at the School of Public Policy and Global Affairs at the University of British Columbia - states:

"*SMR proponents argue that they can make up for the lost economies of scale by savings through mass manufacture in factories and resultant learning. But, to achieve such savings, these reactors have to be manufactured by the thousands, even under very optimistic assumptions about rates of learning*." (6)

And Dr Gregory Jaczko agrees. "*Only wide-scale adoption of the technology would deliver those benefits and there is no obvious market to support that today*."

UK Rolls Royce

In the UK, Rolls Royce is promoting a 450 megawatts (MW) reactor. But there is confusion about whether this is "small" or large and what is meant by this adjective in the name "small modular reactor". SMRs are generally expected to have a capacity of less than 300 MW compared with the 1,600 MW capacity of the reactors being built at Hinkley Point C in Somerset, England. Strangely, the reactor currently being promoted by Rolls Royce in the UK is larger than most of the UK's now closed Magnox reactors, and very similar in size to the UK's existing AGR reactors.

Rolls Royce claims its reactors could cost as little as £2bn each, and says its first SMR could be operating in the 2030s. (7) The company says it plans to build 16 SMRs in the UK by 2050. A consortium led by Rolls Royce says it has secured at least £210m needed to unlock a matching amount of taxpayer funding, so that it can submit its SMR design to the nuclear regulators for approval. (8) Rolls-Royce claims that its SMRs could generate power at a cost of £60/MWh (9). But several commentators say these estimates are implausible and far too small. In addition, Rolls Royce is demanding significant UK government funding to pursue its project and is threatening to abandon it if government largesse is not forthcoming. (10)

Dr. Gregory Jaczko says; "…*the nuclear industry always promises better, faster and cheaper yet it fails to deliver … Small modular designs are only promising to be cheaper than traditional reactors. Current estimates show they are more expensive than renewables, like wind and solar, even with storage and without subsidies. Small reactors have a long way to go to be competitive. Dramatic cost decreases for high-volume energy storage, which address the intermittency of some renewables, make the competitive case for any form of nuclear even tougher*."

Advanced Modular Reactors

The second category of Advanced Modular Reactors, ie non-light-water "advanced" reactors. are even more pie-in-the-sky than SMRs. AMRs are largely based on notoriously unsuccessful concepts from more than 50 years ago. They remain unproven today.

Unlike light-water reactors, these designs rely on materials other than water for cooling. Some developers contend that these reactors, still in the concept stage, will solve the problems that have plagued light-water reactors and be construction-ready by the end of this decade. (11) However, a Union of Concerned Scientists (UCS) analysis in the US suggests that this outcome may be just as likely as electricity being "too cheap to meter." Written by UCS physicist Dr Edwin Lyman, the 140-page report found that these designs are no better—and in some respects significantly worse—than the light-water reactors in operation today. (12)

Lyman took a close look at the three main designs here: sodium-cooled fast reactors, high-temperature gas-cooled reactors and molten salt–fuelled reactors. Many developers maintain, with little or no hard evidence, they will be cheaper, safer and more secure than currently operating reactors; will burn uranium fuel more efficiently, produce less radioactive waste, and reduce the risk of nuclear proliferation; and could be commercialized relatively soon.

Those claims do not hold up to even elementary levels of scrutiny. One of the sodium-cooled fast reactors, TerraPower's 345-megawatt Natrium, has received considerable media attention because it is supported by billionaire Bill Gates. But a massive problem associated with sodium-cooled reactors is the use of molten sodium itself. This burns fiercely when exposed to air and explodes when exposed to water. The disastrous experiences of the UK's Dounreay Fast Reactor and Japan's Monju reactor attest to the severe problems with liquid sodium. Lyman at UCS also believes the Natrium's design could experience uncontrollable power increases that would result in rapid core melting.

In an open letter to Bill Gates, Arnie Gundersen, former nuclear operator and now Chief Engineer of Fairewinds Energy Education says he fears

"*you have made an enormous mistake by proposing to build a sodium-cooled Small Modular Reactor (SMR) in Wyoming … your atomic power company Natrium (the Latin word for sodium), is following in the footsteps of a seventy-year-long record of sodium-cooled nuclear technological failures. Your plan to recycle those failures and resurrect liquid sodium again will siphon valuable public funds and research from inexpensive and proven renewable energy alternatives. Moreover, spending public funds on Natrium will make the global climate crisis worse, not better!"* (13)

Dr Edwin Lyman concludes:

"*Unfortunately, proponents of these non-light-water reactor designs are hyping them as a climate solution and downplaying their safety risks*. *Given that it should take at least two decades to commercialize any new nuclear reactor technology if done properly, the non-light-water concepts we reviewed do not offer a near-term solution and could only offer a long-term one if their safety and security risks are adequately addressed*." Any federal appropriations for research, development and deployment of these reactor designs, he says, "*should be guided by a realistic assessment of the likely societal benefits that would result from investing billions of taxpayer dollars, not based on wishful thinking*."

Dr. Gregory Jaczko has added that even if these risks of electricity from small and advanced reactors were addressed, proliferation concerns and waste management problems would still be hurdles.

Thorium

Thorium has been mooted as a fuel in thorium reactors for many decades, but their past records (in the US and USSR) have been dismal. In addition, spent thorium fuel is a proliferation hazard. Strictly speaking, thorium fuel does not exist, since thorium-232 is not fissile, but it is fertile. When blended with fissile plutonium-239, both are used to fuel a nuclear reactor. Plutonium keeps the chain reaction going, and while that is happening, thorium-232 absorbs neutrons and is changed into uranium-233 which is fissile.(14) This is a severe proliferation hazard as isotopically pure uranium 233 is suitable for making nuclear weapons. Therefore spent thorium fuel would be a tempting target for theft by terrorists. (15)

Robert Alvarez, former senior policy adviser to the secretary and deputy assistant secretary for national security and the environment of the US Department of Energy, says the United States tried to develop thorium as an energy source for some 50 years with no success. Sadly it is still struggling to deal with the legacy of those attempts. In addition to the $ billions it spent fruitlessly to develop thorium fuels, the US government will have to spend billions more, at numerous federal nuclear sites, to deal with the wastes produced by those efforts. (16)

Conclusions

Even in the extremely unlikely event that some of the claims of Advanced Nuclear Reactor proponents proved to be correct, building a sufficient number of these reactors to make any impact on carbon emissions would take far too long. We simply do not have the time to do this.

In the meantime, expending time, money and efforts on these unproven reactor dreams is a dangerous distraction from implementing more effective climate mitigation programmes. Renewable energy exists and is cheap and becoming cheaper, and needs little or no public subsidy - a big contrast with new nuclear. Many energy efficiency schemes can actually be implemented at negative net cost.

Many studies now show that it is perfectly feasible to run energy systems using 100% renewable energy in many countries and regions. See the abstracts of 56 peer-reviewed published articles from 18 independent research groups (with 109 authors) worldwide supporting the result that energy for electricity, transportation, building heating/cooling, and/or industry can be supplied reliably with 100% or near-100% renewable energy at difference locations worldwide. (17)

Many nuclear advocates call for a ‘balanced energy policy’ and promote the idea that ‘we need every energy technology’ in order to successfully tackle climate change. Of course, implicit here is the need for some nuclear capacity.

But these calls suggest we have infinite amounts of money to spend on energy projects. We do not: resources are scarce and we need to make choices.

Because climate change is a serious and urgent problem then we must spend our limited resources as effectively as possible on projects which can deliver carbon reductions as quickly as possible. Investment in untried, untimely and expensive nuclear power would, in effect, worsen climate change because each pound spent on nuclear is buying less solution than it would do if we were to spend it on energy efficiency and renewables. (18)

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