Is Nuclear Power Our Energy Future — Or a Dinosaur in a Death Spiral?

Identical data yield drastically different conclusions about the role nuclear will play in meeting climate goals.

By David Levitan / Ensia *March 9, 2016*

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Nuclear power is dead. Long live nuclear power. Nuclear power is the only way forward. Nuclear power is a red herring. Nuclear power is too dangerous. Nuclear power is the safest power source around. Nuclear is nothing. Nuclear is everything.

It is now generally agreed that the world must rapidly reduce carbon emissions in order to fight off dangerous climate change, but the "how" of that process remains up for debate. And within that debate, nothing seems to produce such starkly opposing viewpoints as nuclear energy. Some experts and advocates argue that carbon-free nuclear power represents the only real hope of keeping the planet's temperature in check. Others claim that nuclear is risky, unnecessary and far too expensive to make a dent.

The same basic data set — nuclear plants currently in existence, those under construction, the status of new technologies, the history of costs and delays, and a few striking accidents — produces those totally contradictory opinions and predictions. Nuclear power is a Rorschach test: You see what you want to see — a rosy nuclear future or an old-world dinosaur in a slow death spiral — reflecting your own views on the energy present and future. In all likelihood, no one will be proven right or wrong for decades.

Today and Tomorrow

Nuclear power today accounts for around 10 percent of the total electricity generation around the world. This varies sharply by country — in the U.S. the rate is about 20 percent, in Russia and Germany it is a bit lower than that, while some other European countries get 40 and 50 percent from nuclear reactors. France has long led the way proportionally, at more than 75 percent (it has the second most total reactors, behind the U.S.). China, though building rapidly, drew less than 3 percent of its power from nuclear in 2014.

There are 442 reactors currently in operation globally, and the International Atomic Energy Agency says 66 are currently under construction. Twenty-four of those are in China; no other country is currently building more than eight.

That's the nuclear landscape now. The question is, how will it change in the coming years? And equally important, how shouldit change? The answers to both of these depend on whom you ask.

The International Energy Agency's World Energy Outlook 2014, which includes a close analysis of nuclear power, projects a 60 percent leap in global installed capacity by 2040, with almost half of that growth coming from China.

"I think we definitely need it in the battle against climate change. This is broadly recognized," says Jacopo Buongiorno, a professor of nuclear science and engineering at the Massachusetts Institute of Technology. "Because now there is such an overwhelming concern about climate change, it's like a tide that lifts all boats. Anything that is perceived as clean is going up. I think it is absolutely necessary."

That type of take on nuclear isn't particularly hard to find, but neither is this one: "I don't think nuclear power is a necessary component at all," says M. V. Ramana, a research scholar at Princeton's Nuclear Futures Lab. "Nuclear power as a share of electricity generation is only likely to decline in the foreseeable future. If we hold that up as a means of emission reductions, then we will not be successful with meeting any of the ambitious climate goals set" in the recent Paris agreement, in which 195 countries agreed to reduce emissions sharply.

In the run-up to that agreement, a group of the most prominent nuclear proponents — climate scientist James Hansen, Stanford's Ken Caldeira and others — wrote in the Guardian that "nuclear will make the difference between the world missing crucial climate targets or achieving them."

This was met with particularly harsh disdain from Naomi Oreskes, Harvard science historian and co-author of Merchants of Doubt, who wrote a response at the Guardian branding this "a new, strange form of denial."

The heart of Hansen's and Oreskes' disagreement regards the necessity for nuclear and the technical feasibility of scaling up renewables: Are other energy sources sufficient to wean us from fossil fuels? Or is the reliable, large-scale (a single new reactor can reach 1,600 megawatts capacity, three times the size of the world's largest solar plants) baseload power that nuclear provides a necessary component of the low-carbon future?

The anti-nuclear side of the argument focuses on several studies that have illustrated a renewables-only way to the goal, which could be cheaper and free of the risks associated with nuclear.Mark Jacobson, director of the Atmosphere/Energy Program at Stanford University, has published state-specific plans showing how 100-percent renewables penetration would be achievable. The National Renewable Energy Laboratory, part of the U.S. Department of Energy, published its "Renewable Electricity Futures Study" in 2012 and explained a clear path to 80 percent penetration in the U.S. Others have shown similar routes forward.

When it comes to any energy source, it is cost that sits at the root of the discussion. Nuclear proponents argue that there are impediments to having a grid entirely run on renewables. Buongiorno, for example, says that the intermittency of solar and wind can realistically only be addressed by adding large amounts of electricity storage (in the form of large batteries or other newer tech such as compressed air) to the grid, and that would change the ongoing "renewable prices are plummeting" narrative.

"When I hear people say 'Oh, the costs are coming down,' the costs for generation may be coming down, but if installing that capacity forces me to have energy storage, you have to add those costs," he says. Think of it like buying a car: The baseline price sounds okay, but it's all the options and add-ons that'll get you. Buongiorno says he expects the costs of nuclear construction will come down, and that when storage costs for renewables are factored in, nuclear — with its reliable, 24/7 output — starts to look much more attractive as an alternative.

Billions and Billions

When it comes to any energy source, it is cost that sits at the root of the discussion. Adding more nuclear to the grid could reduce some of the burden on renewables and storage, but the economics of nuclear itself could prove an insurmountable roadblock.

In general, the more experience accumulated with a given technology, the less it costs to build. This has been dramatically illustrated with the falling costs of wind and solar power. Nuclear, however has bucked the trend, instead demonstrating a sort of "negative learning curve" over time.

According to the Union of Concerned Scientists, the actual costs of 75 of the first nuclear reactors built in the U.S. ran over initial estimates by more than 200 percent. More recently, costs have continued to balloon. Again according to UCS, the price tag for a new nuclear power plant jumped from between US$2 billion and US$4 billion in 2002 all the way US$9 billion in 2008. Put another way, the price shot from below US$2,000 per kilowatt in the early 2000s up to as high as US$8,000 per kilowatt by 2008.

Steve Clemmer, the director of energy research and analysis at UCS, doesn't see this trend changing. "I'm not seeing much evidence that we'll see the types of cost reductions [proponents are] talking about. I'm very skeptical about it — great if it happens, but I'm not seeing it," he says.

Some projects in the U.S. seem to face delays and overruns at every turn. In September 2015, a South Carolina effort to build two new reactors at an existing plant was delayed for three years. In Georgia, a January 2015 filing by plant owner Southern Co. said that its additional two reactors would jump by US$700 million in cost and take an extra 18 months to build. These problems have a number of root causes, from licensing delays to simple construction errors, and no simple solution to the issue is likely to be found.

In Europe the situation is similar, with a couple of particularly egregious examples casting a pall over the industry. Construction began for a new reactor at the Finnish Olkiluoto 3 plant in 2005 but won't finish until 2018, nine years late and more than US$5 billion over budget. A reactor in France, where nuclear is the primary source of power, is six years behind schedule and more than twice as expensive as projected.

"The history of 60 years or more of reactor building offers no evidence that costs will come down," Ramana says. "As nuclear technology has matured costs have increased, and all the present indications are that this trend will continue."

Some experts, however, dispute the idea that the "negative learning curve" is intrinsic to the nuclear industry. In a recent paper Ted Nordhaus of the energy think tank The Breakthrough Institute pointed out that the history of nuclear plant construction costs varies dramatically by country. South Korea, for example, has demonstrated a fairly consistent drop in costs over time; it imported its first designs from foreign companies with more experience before homegrown designs took hold, and all the country's plants are built and owned by a single utility.Nordhaus wrote, "with the right policies and institutions, nuclear plants can be built quickly, safely, and cheaply."

Still, most countries have seen costs increase. As it stands, only China's non-free market may allow for a truly rapid build-out of nuclear plants; the country's current domination of the nuclear construction world reflects this idea, and the 2016 Five-Year Plan includes provisions to approve and build six to eight new plants each year.

Along with price hikes, the specter of major accidents hovers over every discussion of a nuclear scale-up. The industry, for its part, argues that the benefits of nuclear are worth the price tag. The Nuclear Energy Institute, whichrepresents plant owners, builders, designers, suppliers and related companies, notes that in the U.S. nuclear power generates as much as $50 billion each year from electricity sales and revenue, and provides around 100,000 jobs. The lack of carbon emissions, of course, only adds to the benefits.

The Fukushima Shadow

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The accident at Fukushima Daiichi in Japan in 2011 led to a shutdown of all the plants in that country (with very limited reactor restarts coming only last year), and it has convinced Germany and Belgium to phase out the energy source entirely. Though those phase-outs will account for only a handful of total reactors, they put a damper on the idea of a revolutionary nuclear scale-up.

Many argue the fearful reactions and phase-outs are not entirely logical in the context of climate change. Fukushima clearly did result in a drop in global support for nuclear energy, but public opinion continues to vary sharply by country. In the U.S., a Gallup poll on nuclear favorability has shown a decline since Fukushima, but not a dramatic one. In 2015 public support for the use of nuclear energy hovered at 51 percent, down from a peak of 62 percent in 2010. The same poll, though, found that only 35 percent think the government should place "more emphasis" on nuclear; for comparison, 79 percent want more focus on solar power.

Cousins to the fear of a massive meltdown are both the worry over nuclear weapons proliferation and concerns over waste disposal. Spent nuclear fuel is currently stored on the site of nuclear plants in pools of water or sealed in dry cask storage, anddecades-old arguments over geologic repositories are unlikely to be resolved any time soon. With regard to weapons, nuclear plants produce plutonium during the course of their reactions, which can be made into bombs if enough is accumulated; terrorism and theft are thus constant worries. Both of these issues work to extend the shadow of risk stretching out behind nuclear power, and both lack immediate solutions.

Technological Breakthroughs?

Supporters of nuclear power hold out hope that new technologies will improve the economics and reduce the fear factor. There are ongoing efforts to develop small modular reactors, which produce about a third or less of a full-size reactor's output and can theoretically be built faster and cheaper. Allison Macfarlane, director of George Washington University's Center for International Science and Technology Policy and the former chairman of the U.S. Nuclear Regulatory Commission, notes that of the various companies working on these only one (NuScale Power) is currently expected to actually submit application materials to regulators in 2016 — a step that is still years removed from actual functioning reactors.

Other technological unicorns, though in many cases on the drawing board for decades, still remain off in the distance: different fuel sources such as thorium, molten salt-cooled reactors, even building plants on floating platforms like those used for oil drilling (a project that Buongiorno at MIT is heavily involved in) are all on the table. These have varying potential advantages: A floating plant could use seawater as a cheap and easy way to cool the reactor and would alleviate some of the safety fears by keeping the plant away from people and near a coolant should an accident occur; thorium could reduce waste and produce power more efficiently, though a U.K. government report in 2013 called the benefits "overstated" and experts have warned it could increase proliferation risks; and molten salts can operate at lower pressures than standard water-cooled reactors, offering some safety benefit.

Nuclear research and development, though, moves at a snail's pace, largely for safety reasons. If the goal is rapid emissions reduction, it is unclear if any of this new tech can play a role.

"I think we need to do some work on it, see if we can develop some new technologies, but they are not going to be a solution in the near term at all," Macfarlane says about the small modular reactors. "Some of these other things that just exist on paper right now? I think they're much further out."

Clemmer, of UCS, agrees that the next 15 years or so are unlikely to feature much of a nuclear revolution. He says the 2030 to 2050 period, though, will be a crucial time for nuclear, with many existing plants in the U.S. and elsewhere due to retire — the IEA projects almost 200 reactor retirements by 2040. In that time frame, perhaps some of the new technology could make it to market.

Changing Perspectives

In the coming years, it may come down to just how dramatic the effects of climate change become to force the Rorschach muddle to resolve into a clear image.

"As time goes on, and the impacts of climate change become more and more real — droughts and heat waves and sea-level rise and storm surge, coastal flooding issues, more powerful hurricanes and devastating storms and things like that are also a wake-up call to people," says Clemmer. "Hopefully at some point it will be enough of a wake-up call that we'll be demanding action to address climate change and reduce emissions. In that world, maybe there's more of a positive light that would be shed on nuclear."

Macfarlane also suggests that the changing perspectives on energy requirements could shift nuclear fortunes. "We go through these different transitions as a society," she says. In the past, these transitions have replaced wood with coal to help cities grow, and added oil to feed a boom in transportation.

"Nuclear never fulfilled one of those kinds of needs," she says. "We're going through another transition where we need to decarbonize our energy sources, and maybe it will fill more of a natural need now. We'll see.

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