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Yes, nuclear can help answer the climate and energy security challenge

But doing so will require the industry to step up.

by Chad Cramer, Bill Lacivita, Daniel Pacthod, and Humayun Tai

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As the world moves toward decarbonization, there is no shortage of commitments to countering climate change. At COP27 in Egypt last November, an international agreement reinforced pledges to limit global temperature rises to no more than 1.5 degrees above preindustrial levels.[1] Countries with net-zero pledges now number 133.[2] In the United States, President Joe Biden has committed the country to cutting emissions in half by 2030 from 2005 levels.[3]

Of course, the path to net zero was never going to follow an unbroken line. Fossil fuels still account for about 80 percent of global energy consumption, and greenhouse-gas emissions hit a record last year.[4] War in Ukraine injected global economic volatility and energy market turmoil.

We believe that nuclear energy can be an important way to fill the gaps on the desired pathway to a secure, affordable, clean-energy future. Nuclear power produces zero emissions, is a well-established technology that, with the right approaches, can scale and complement power sources such as wind and solar, and can drive clean energy directly through critical sectors like transport and buildings. Not only does it have an important role to play in the energy transition, but its potential is achievable—if the industry can step up to meet this moment of need.

The energy transition's challenges

There is no doubt that decarbonization faces many obstacles. Financing and investment is a significant one—McKinsey research has shown that about $1 trillion a year in capital investment will be required for the United States to make the energy transition happen by 2050. That is about 4 percent of the United States' GDP on average.

Controlling greenhouse-gas emissions is another obstacle. Last year, emissions hit a record 36.8 billion tons.[5] Although the rollout of renewables has increased in recent years, it is uncertain whether they can grow fast enough to meet net-zero targets and the projected increasing electricity demand. And even in a high-renewables grid, the supply of energy will be inconsistent—reflecting the variability of renewable resources. Nonrenewables will be needed to fill that gap to secure a reliable source of energy.

Nuclear should be part of the energy transition

Nuclear power can play a significant role in the search for energy resilience. The power sector has to decarbonize—at present, it accounts for about 30 percent of global emissions, and electricity demand could triple by 2050, driven by increasing electrification and economic growth.

Unlike renewables that offer an intermittent energy supply, nuclear has already demonstrated that it can provide 24/7 reliable and flexible power, while using far less land than many renewables. A proven and safe technology, it provides 10 percent of global electricity generation and is the largest single source of zero-carbon power in the United States. It is also the only zero-carbon option that works for high-temperature industrial processes, such as steel or cement production. Nuclear is a key element in the Intergovernmental Panel on Climate Change's pathway to net zero.[6]

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[1] Sam Meredith, "Historic deal for poorer nations as COP climate summit agrees to 'loss and damage' fund," CNBC, November 20, 2022.
[2] Global net zero coverage database, Net Zero Tracker, May 18, 2023.
[3] "Fact sheet: President Biden sets 2030 greenhouse gas pollution reduction target aimed at creating good-paying union jobs and securing U.S. leadership on clean energy technologies," The White House, April 22, 2021.
[4] *BP statistical review of world energy*, BP, June 2022.
[5] "Global CO_2 emissions rose less than initially feared in 2022 as clean energy growth offset much of the impact of coal and oil use," IEA, March 2, 2022.
[6] *Comparing nuclear accident risks with those from other energy sources*, OECD, August 31, 2010; "What is U.S. electricity generation by energy source?," US Energy Information Administration, 2023; Jonathan Rauch, "The real obstacle to nuclear power," *Atlantic*, February 7, 2023; *Climate change 2022: Mitigation of climate change*, IPCC, 2023.

Nuclear technology is well established and available. As of May 2022, there were 439 nuclear reactors in operation in 30 countries, with the largest number of reactors—92—operating in the United States.[7] Utilities in North America have already made commitments to new nuclear—including Ontario Power Generation, Southern Company, and the Tennessee Valley Authority.

Against this backdrop, building more nuclear plants to provide reliable, always-on, zero-emissions power generation can seem like a simple decision. Yet in many important markets, including Europe, Japan, and the United States, public skepticism and hostility to doing so remains. The great majority of new nuclear construction is taking place in Asia, particularly in China, India, and Korea. Russia and Turkey are also building multiple plants.[8]

This won't provide enough zero-carbon energy, however. Using techno-economic grid modeling, which evaluates the optimal mix of zero-carbon technologies in a given geography, we estimate that at least 400 gigawatts (GW) of new nuclear capacity (and perhaps as much as 800 GW) could be needed to arrive at net zero by 2050. Current capacity is 413 GW. Only once in this century has as much as 11 GW been added in a year—about 20 percent of what the model projects is needed.

Although public perception represents one barrier to new nuclear plant construction, we believe that the onus of meeting this moment of need in the energy transition falls on the industry itself. With a history of exceeding budgets and timelines, rising to the climate challenge now will require the nuclear industry to become faster, more agile, more innovative, and more competitive in business. The key set of challenges for the industry to overcome includes the following:

— complexity and variation in reactor designs, such that every plant is a "first of its kind," with little repetition of standard designs to capture project-over-project improvements

— limited industrial base for materials, systems, and components, as well as a need for specialized manufacturing processes and rare materials

— scarcity of both skilled-craft and salaried workers who have the required expertise, compounded by an aging labor force of experienced nuclear professionals

— limits on the ability to execute construction efficiently and effectively, without rework, to ensure on-time and on-budget delivery that meets stringent quality standards

— partnerships and construction contracts that do not reflect the extent of the project risks inherent to the complexity of the technology

— complex and changing regulatory requirements for plant construction that are not consistent among governments

An action plan

We believe several actions will prove critical for the nuclear industry to meet the challenge of this moment. They include the following actions.

Aggressively reallocate public and private capital to the nuclear sector. The net-zero transition represents the biggest reallocation of capital ever. Nuclear should receive its appropriate share across all sources, including private equity, debt, and institutional investors, while also boldly pursuing public–private partnerships to reduce risk. Financing will be critical in kick-starting the industry; we estimate that capital costs could be roughly $500 billion per year to support the development of new technologies, scaling of the industrial base, and construction of new reactors. Regardless of investment sources, managing cost risks will be imperative—potentially requiring policy support to backstop financial risk as the industry scales up.

[7] "Number of operable nuclear power reactors worldwide as of May 2022, by country," Statista, May 2022.
[8] "Plans for new reactors worldwide," World Nuclear Association, May 2023.

Innovate faster to keep pace with other technologies seeking to meet the need. Over the past decade, there have been dozens of new entrants into an emerging nuclear "start-up" market. These are focused on innovating both traditional light-water reactor designs as part of Gen-III+ technologies and bringing new, and sometimes first-of-its-kind, Gen-IV designs into the mix. A great opportunity exists for the industry to accelerate these new designs by bringing to bear lessons learned from other start-ups and possibly the public–private defense sector, university system, and broader North American start-up ecosystem.

Close the labor gap across manufacturing, construction, and operations. Currently, the nuclear industry in the United States and Canada provides approximately 130,000 direct jobs and another 470,000 indirect jobs. Our analysis suggests that this workforce alone would need to grow to more than one million people—and to more than five million globally—for the industry to increase capacity to 50 GW per year. Industry and governments could coordinate on capability-building programs that include recruitment, training, apprenticeship, and placement, such as EDF Energy's efforts to train welders in anticipation of a new nuclear power station in the United Kingdom.[9]

Create an industrial base that will strengthen country competitiveness in the energy transition. Quickly scaling up could produce supply chain bottlenecks. Bottlenecks could affect, for example, heavy forgings for reactor pressure vessels, instrumentation, and control systems, as well as specialized valves for critical control systems. More new-build programs supported by governments could boost investor confidence in building out supply chains for these components. Industry players could establish centers of excellence to develop manufacturing processes and help qualify more components suppliers to meet performance and quality standards.

Streamline and speed up the global licensing processes. Industry leaders, regulators, and policymakers could use an industry consortium to define global licensing requirements and work with governments to plan scaling up. In the natural gas industry, for example, the International Group of Liquefied Natural Gas Importers (GIIGNL) defines common technical standards for liquefied natural gas across the globe and works with governments to see those standards codified.

Become best in class at executing megaprojects. Applying best practices to large-scale investment projects can reduce the likelihood of cost and schedule overruns. In our experience, proven strategies and management tactics for successful megaprojects in other industries apply in the nuclear context in areas including site productivity; schedule optimization; cost control; commissioning and operational readiness; quality, project control, and risk management; and project organization and governance. Lessons from other industries will be invaluable if nuclear is to succeed.

Nuclear power can play a significant role in fulfilling the world's climate change promises. But this can only happen if the industry meets the challenge of expanding efficiently and cost-effectively.

Chad Cramer is an associate partner in McKinsey's Columbus, Ohio, office; **Bill Lacivita** is a partner in the Atlanta office; and **Daniel Pacthod** and **Humayun Tai** are senior partners in the New York office.

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[9] "Energy Minister opens new training centre to support Hinkley Point C," EDF, April 28, 2022.