NUCLEAR RESURGENCE

The energy security case for nuclear power is building

Ted Nordhaus and Juzel Lloyd

Recent months have marked a dramatic turnabout for the fate of nuclear energy across the developed world. As the Russian invasion of Ukraine turned post-pandemic energy shortages into a full-blown energy crisis, nuclear power plants slated for closure across Europe have been given an 11th hour reprieve. Japan has announced, after a decade of paralysis, that it plans to restart many of its reactors, which have sat idle since the nuclear accident at Fukushima Daiichi. France, which had launched plans to reduce its dependence on nuclear energy during President Macron's first term, reversed course and now plans to build six new reactors and a dozen more small modular reactors. The UK has launched an ambitious plan to build eight new reactors and 16 small modular reactors. Even anti-nuclear Germany has conceded to basic geopolitical energy realities and extended the life of the nation's last three operating nuclear power plants.

The turn back to nuclear energy has been a ray of hope in an otherwise dark geopolitical landscape. Despite significant progress on the cost and feasibility of renewable energy, the energy crisis reminds us just how dependent the world remains on fossil fuels. Europe, arguably the wealthiest and greenest precinct of the global economy, and a region that has invested trillions over the past two decades to transition its energy economy to wind and solar energy, has been forced to engage in a wild scramble to replace Russian oil and gas with alternative sources of fossil fuel, importing liquefied natural gas from the United States and other regions, fast-tracking new pipeline projects from North Africa, and firing up mothballed coal plants to keep the lights on and its factories humming.

The picture is darker still across emerging market and developing economies. Europe is buying its way out of energy poverty. Many other regions of the world do not have the resources to do so.

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Soaring energy prices have resulted in shortages, blackouts, and protests across the developing world and have pushed hundreds of millions back into extreme poverty. Meanwhile, the resulting spike in fertilizer prices has threatened harvests and raised the specter that famine, largely banished from even the poorest regions of the world in recent decades, might be back for an encore.

The limits of renewable energy

Taken together, these developments suggest two interlinked conclusions. First, the world remains far too dependent on fossil fuels. Progress to reduce dependence on them and cut carbon emissions is real. But that progress has been limited to rising shares of renewable energy in the power sector, which accounts for only about 20 percent of energy use and emissions globally, along with incremental improvements to energy efficiency across the rest of the global energy economy, which remains powered almost entirely by fossil fuels.

Second, wind and solar energy alone will not be sufficient to break that dependence. Even in the power sectors of the wealthiest countries in the world, no economy has succeeded in getting much more than about a third of its electricity from wind and solar combined. Even the exception proves the rule. Green icon Denmark generates about 50 percent of its electricity from wind. But it is fully integrated into the much larger Scandinavian grid, which includes Sweden, Norway, and Finland and is dominated by hydroelectric power and nuclear energy. Denmark's vaunted wind energy accounts for only about 4 percent of total electricity generation annually across the Scandinavian grid.

Nuclear energy represents a potential solution to both problems, providing a firm source of electricity that can complement the variable sources of renewable energy on electrical grids, as it does in Scandinavia. It also features the ability to produce carbon-free heat as well as power for a range of industrial and other energy-intensive activities—from refining and fertilizer manufacturing to steel and hydrogen production—that are difficult to fully electrify.

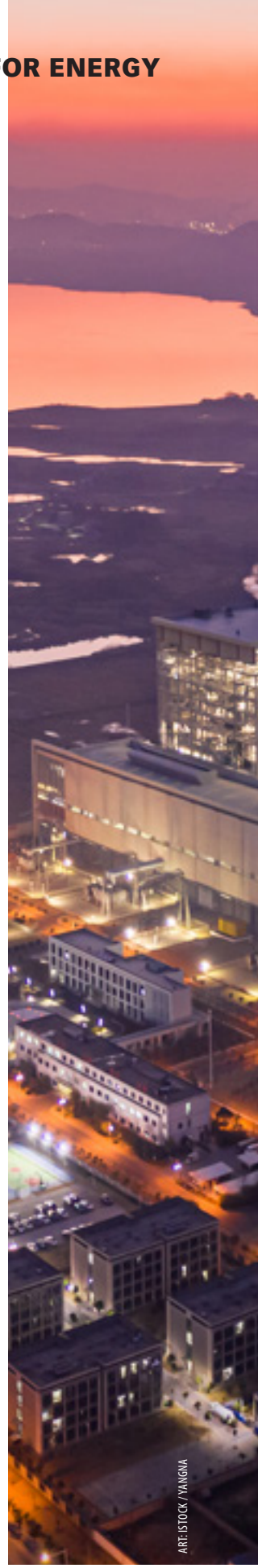
To be relevant beyond generating electricity in the power sectors of technologically advanced economies, however, nuclear technology will need to change. Under the right economic and institutional circumstances, the large light-water reactor technology that has dominated the sector historically can be remarkably effective at replacing fossil fuels on electricity grids. France gets 75 percent of its electricity from nuclear energy, while Sweden and several other advanced economies get about 50 percent.

But large light-water reactors are complex technologies, requiring highly trained personnel to maintain and operate them. They have a large amount of fissile material in their core and so depend on a multiplicity of active safety systems to ensure safe operations. These, in turn, require sophisticated regulatory capabilities to ensure that the plants are operated safely. Large light-water reactors also need to be refueled regularly, every 18 months or so. This makes it more difficult practically to decouple reactor operations in any given locale from the nuclear fuel cycle, which raises a range of nuclear proliferation concerns.

Light-water reactors operating at lower temperatures cannot meet heat requirements for many important industrial uses and so are limited to use primarily in the electricity sector. And even in that sector, they have limited ability to ramp up and down and so are not optimized for grids that have significant amounts of variable wind and solar generation as well.

Refining nuclear

For these reasons, the nuclear sector will need to evolve in important ways if it is going to play a major role in addressing energy security and climate challenges in many parts of the world and beyond the power sector. Several new advanced reactor technologies are under development that are better suited to industrial uses and are being targeted to replace existing coal-fired energy production. China has connected its first high-temperature gas reactor to the grid, and it envisions that it will ultimately be a drop-in replacement for existing coal-fired power plants and will be used for other industrial purposes, such as hydrogen and chemical production. The United States has committed to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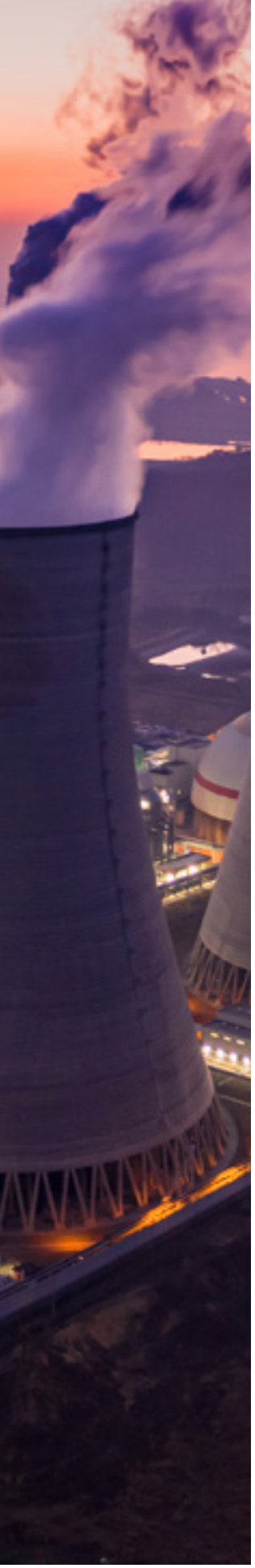

building two advanced demonstration reactors this decade. One by X-energy will be designed to provide industrial heat and power; one by TerraPower is planned as a coal plant replacement and will feature an integrated molten salt energy storage system that will optimize it to back up variable wind and solar electricity generation.

Similarly, smaller and less complicated advanced reactors—more suitable to the energy development needs of countries without the technical know-how and institutional capabilities to maintain, operate, and regulate large conventional reactors—are currently in the development pipeline. New advanced technologies such as Oklo's Aurora reactor are applying for licenses in the United States and Canada. These very small reactors are sealed and don't require regular refueling, making them well suited for applications in which the entire reactor can be plugged into a grid or dropped into a remote off-grid location. These reactors can operate for years without refueling and can eventually be replaced by a new unit and sent back to a factory for refueling and refurbishment.

Innovation of this sort will be necessary if nuclear is going to play a significant role in many developing economies, and beyond the power sector, and extends well beyond the technologies themselves. New business models; new and more flexible regulatory, licensing, and export rules; and a revised global nonproliferation framework will be needed to fully realize the potential of these new technologies to provide low-carbon heat and power consistent with displacing fossil energy at global scale.

So too will be significant reconsideration of the long-running festival of hypocrisy that is climate development financing. While rich countries scramble to monopolize global fossil fuel resources in response to the energy crisis, the European Union, the Biden administration in the US, and the global climate movement have put pressure on the poorest nations in the world. With a fraction of the wealth, infrastructure, and technological capabilities, they are expected to achieve what the richest countries in the world cannot—power their economies without significant additional fossil fuel development—because of blanket bans on fossil fuel development financing in the name of mitigating climate change.

Because most development banks exclude nuclear and hydropower, largely because of environmental objections from donor nations, climate development financing today in effect limits the poorest countries' development aspirations to the use of renewable energy. And while wind and solar energy have begun to gain a foothold in many poor countries, it is still very small and will do little to help these countries build passable roads, manufacture steel or fertilizer, or build modern housing and infrastructure in rapidly growing cities.

Powering Africa

If there is any place in the world that should be able to pursue an all-of-the-above energy agenda, it is sub-Saharan Africa, which uses about the same amount of electricity as Spain despite having 18 times its population. More than 600 million lack access to electricity, clean cooking fuels, and modern transportation. The entire continent has only two factories capable of producing ammonia, the critical precursor of synthetic fertilizers, and lack of access to affordable fertilizers punishes small farmers, whose yields are five times lower than US or European farmers'.

Nuclear energy, like wind and solar, is not a panacea and can't solve all these problems. And new nuclear technologies designed and scaled to Africa's needs are at least a decade away.

But numerous African nations, including Ghana, Kenya, Namibia, Nigeria, South Africa, Sudan, Tanzania, Uganda, and Zambia, have in recent years expressed significant interest in developing new nuclear plants. And any long-term pathway toward a prosperous and modern African future is likely to need them. Africa's population is expected to double by 2050, making it one of the most populous regions in the world.

No less than in the richest countries, fossil fuels across Africa and much of the rest of the developing world are likely to remain a fact of life for many decades to come. Accelerating a transition away from them globally will require putting new low-carbon options on the table, not taking them away. Nuclear energy is without question one of those options. As the rich world reconsiders the value of the atom, a reconsideration of its potential to address the global development challenge, as well as the global climate challenge, is long overdue. FD

TED NORDHAUS is founder and executive director of the Breakthrough Institute, where **JUZEL LLOYD** is a climate and energy analyst.