How many countries are ready for nuclear-powered electricity?

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As demand for low-carbon electricity rises around the world, nuclear power offers a promising solution. But how many countries are good candidates for nuclear energy development?

A new study in the journal *Risk Analysis* suggests that countries representing more than 80 percent of potential growth in low-carbon electricity demand—in Asia, the Middle East, and North Africa—may lack the economic or institutional quality to deploy nuclear power to meet their energy needs. The authors suggest that if nuclear power is to safely expand its role in mitigating climate change, countries need to radically improve their ability to manage the technology.

"Efforts to enhance institutional quality in these countries must be redoubled and could well be one of the things on which the future of nuclear power as a low carbon energy solution hinges," says co-author Michael J. Ford, a nuclear energy and public policy expert with Argonne National Laboratory who conducted much of this study while at Carnegie Mellon University.

Ford and his colleague Ahmed Abdulla, an expert in energy system design at Carleton University in Ottawa, assessed the relative nuclear power readiness of 126 countries using Data Envelopment Analysis (DEA) to benchmark performance across nations.

While previous studies have evaluated the role that nuclear power could play in global decarbonization based on the low-carbon electricity needs of different countries, this research focused on developing a method to integrate economic risks and institutional risks into that evaluation.

The researchers analyzed 126 nations across a 15-year time period from 2001 to 2015, dividing them into three categories by grid size. Nations with bigger electric power systems—an installed generating capacity greater than 10 GWe— were analyzed for their capability of installing traditional "gigawatt scale" reactors. Nations with very small electric grids (less than 500 MWe) were assumed to be best served by "micro-reactors" (producing 20MWe or less), and those in between were nations best served by a Small Modular Reactor (SMR) with an output of 20

MWe to 300MWe. SMRs and micro-reactors are emerging advanced nuclear power technologies that offer a more affordable way for countries to enter the nuclear energy market.

Once risk is taken into account, the study suggests that the vast majority (80%) of nuclear power would be deployed in richer countries with better institutions. Meanwhile, the vast majority of future low-carbon energy need (>85%) is in poorer countries with relatively weaker institutions.

Despite the weaker performance of many nations with rapidly growing energy demand, the authors note that these nations may still have the potential to develop nuclear programs if supported in developing an improved governance structure.

Several growing Asian and Middle Eastern nations—Malaysia, Vietnam, Brunei, Oman, and Qatar—demonstrated above-median economic and institutional performance. These nations would be leading candidates for new nuclear development with SMRs and micro-reactors. Others, like Thailand and Saudi Arabia, are strong economically but weaker institutionally, requiring more attention in capacity building.

The authors argue that nuclear development programs must focus on reducing institutional risks, not just cost. "Nuclear power brings security concerns regarding proliferation and weapons development," says Ford. "This is why it's prudent to investigate institutional risk factors like corruption, regulatory quality, rule of law, and political stability—especially when we're talking about deploying nuclear power in new countries."

One way to increase nuclear energy capacity in higher risk nations is an arrangement known as build-own-operate (BOO). In this situation, a technology developer finances, builds, owns, and operates a power

plant—effectively transforming the electric utility from an infrastructure owner to a land provider or power purchaser.

Abdulla suggests that the impact of this study on climate change mitigation expands beyond nuclear to other investments in large energy infrastructure, such as carbon capture and sequestration and even the large renewable energy plants that we will need to build when we get serious about decarbonization.

"It is time to develop new, improved energy system models that consider things like institutional quality" he says. "This would change where and how much nuclear power to deploy. It could limit its role in certain places while encouraging deployment in others, but the overall result will be a society that steers its resources more efficiently toward a low-carbon future."

More information: Michael J. Ford et al, New Methods for Evaluating Energy Infrastructure Development Risks, *Risk Analysis* (2021). DOI: 10.1111/risa.13727

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