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Comment on "Prevented Mortality and Greenhouse Gas Emissions from Historical and Projected Nuclear Power"

Pushker Kharecha and James Hansen have made a contribution in their article about the benefits of nuclear power.[1] However, issues of technology systems integration deserve added attention as well as addressing a few errors. Though there is some logic underpinning the notion that nuclear power can mitigate greenhouse gas emissions as a "stabilization wedge",[2] we argue that (a) its near-term potential is significantly limited compared to energy efficiency and renewable energy; (b) it displaces emissions and saves lives only at high cost and at the enhanced risk of nuclear weapons proliferation; (c) it is unsuitable for expanding access to modern energy services in developing countries; and (d) the authors' estimates of cancer risks from exposure to radiation are flawed.

First, nuclear power reactors are less effective at displacing greenhouse gas emissions than energy efficiency initiatives and renewable energy technologies. According to one early study, each dollar invested in energy efficiency displaces nearly 7 times as much carbon dioxide as a dollar invested in nuclear power.[3] McKinsey & Company's cost abatement curves have repeatedly affirmed this point, concluding that nuclear power is a significantly more expensive mitigation option than investments in efficiency, waste recycling, geothermal, and small hydroelectric dams, among others.[4]

Part of the explanation is that some countries enrich uranium with coal-fired power and have low reactor capacity factors, meaning the greenhouse gas emissions from their lifecycle can rival that of natural gas.[5] Another part of the explanation is that nuclear power plants have substantial opportunity costs—construction delays, cost overruns, and the like—that add to their carbon footprints—figures reflected in Table 1 below.[6] According to this table, on a lifecycle equivalent carbon dioxide basis wind energy is *twenty four* times as effective at displacing emissions per kWh and hydroelectricity is roughly *twice* as effective.

Second, even if nuclear energy could save lives, it does so at a substantially higher financial, environmental, and political cost than alternatives. As Table 1 also reveals, when recent marginal capital and levelized costs are factored in for the United States, wind energy is 96 times more effective at displacing carbon than nuclear power; other renewable sources range from about 20 times to twice as effective. Indeed, The U.S. Congressional Budget Office estimated nuclear power plant construction costs from 1966 to 1977, when most light water reactors in the U.S. were built, and found that the quoted cost for these 75 plants was \$89.1 billion, but the real cost was \$283.3 billion.[7] These cost overruns have every likelihood of affecting future plants.[8−11]

Nuclear power therefore needs significant subsidies in order to "compete" in the marketplace.[12] Douglas Koplow looked at five decades worth of subsidies data and concluded that "subsidies to the nuclear fuel cycle have often exceeded the value of the power produced. This means that buying power on the open market and giving it away for free would have been less costly than subsidizing the construction and operation of nuclear power plants".[13] Such reliance on subsidies caused Peter Bradford, a former regulator at the NRC, to observe that the best way to phase out nuclear energy would be to simply "do nothing".[14] New reactors today never prevail in competitive power procurement processes anywhere in the world.

Furthermore, these are only the direct financial costs of nuclear power—they do not include serious environmental degradation from uranium mining and milling,[15] nor do they factor in the water intensity of nuclear power and its inability to operate during water shortages and droughts.[16] In fact, according to the NRC's S3 table on impacts of the nuclear fuel cycle, by far the largest public exposure to radiation comes from the radon released by uranium mining and mill tailings.

The authors exclude macroeconomic property damage and evacuation costs from accidents such as Chernobyl and Fukushima.[17] Kharecha and Hansen ignore the serious issue of nuclear waste storage,[18] and that of nuclear proliferation.[19] To date, several countries have tried or succeeded in developing nuclear weapons under the guise of civilian nuclear weapons programs. If we doubled the number of nuclear reactors worldwide, many countries without weapons might obtain them. There is no such catastrophic risk associated with efficiency and renewables.

Third, nuclear power as currently structured is nonviable for most emerging economies and developing countries. Small island developing states such as Fiji or the Maldives, and least developed countries such as Bhutan or Mali, have entire electricity sectors with only a few hundred million dollars of investment and small amounts of installed capacity. How are they to afford the billions needed for a commercial reactor? Moreover, corruption and challenges in securing nuclear power establishments in some nations radically elevate the risk of terrorists gaining access to nuclear materials. The best energy option for these countries is to expand access to improved cookstoves, microhydro dams, solar home systems, and microgrids [20] rather than nuclear technology. For instance, in India \$2 billion can be spent on a single new nuclear reactor, *or* it could provide 114 million households at the "bottom of the pyramid" with solar lanterns, cookstoves, and small hydropower systems.[21]

Fourthly, Kharecha and Hansen have chosen to go against the prevailing scientific consensus and chosen to use the lowest possible estimates of Chernobyl mortalities, unhinging their conclusions. For sure, there are uncertainties involved, but as the 2006 report of UNSCEAR concluded, "the inability to detect increases in risks at very low doses using epidemiological methods does not mean that the cancer risks are not elevated".[22] The U.S. National Research Council's Committee to Assess Health Risks from Exposure to Low Levels of Ionizing Radiation (BEIR Committee) went a step further.

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Table 1. Marginal Carbon/Cost Ratio for Selected Sources of Electricity[a]

source	carbon effectiveness (grams of CO_2/kWh): lifecycle equivalent carbon dioxide emissions	opportunity costs	risk of leakage, accident, and disruption	total	mean	cost effectiveness (US$): marginal capital cost (per installed kW)	mean levelized cost (cents/kWh)	carbon/cost ratio[b]
wind	2.8−7.4	0	0	2.8−7.4	5.1	$1,240−$2,600	5.6	31
concentrated solar power	8.5−11.3	0	0	8.5−11.3	9.9	$2,200−$4,800	14.7	146
hydroelectric	17−22	31−49	0	48−71	59.5	$800−$3,000	2.8	167
geothermal	15.1−55	1−6	0	16.1−61	38.6	$1,493−$3,300	6.4	247
solar PV	19−59	0	0	19−59	39	$4,700−$7,000	39.0	1521
nuclear	9−70	59−106	0 to 4.1	68−180	124	$3,600−$8,000	24.0	2976
clean coal with CCS	255−442	51−87	1.8 to 42	308−571	439	$1,900−$3,900	8.8	3863

[a]Source: Carbon effectiveness numbers come from ref 6. Cost effectiveness numbers come from ref 26. [b]Carbon/cost ratio refers to the mean lifecycle emissions multiplied by the mean levelized cost.

Because, "statistical limitations make it difficult to evaluate cancer risk in humans" at low-doses, they undertook a "comprehensive review of the biology data" which led them "to conclude that the risk would continue in a linear fashion at lower doses without a threshold and that the smallest dose has the potential to cause a small increase in risk to humans".[23]

The use of a linear no-threshold model would show much greater numbers for fatalities related to nuclear power. Just in the case of Chernobyl, using radiation dose estimates from UNSCEAR reports and the BEIR Committee, the Union of Concerned Scientists has estimated that the accident would result in 27,000 deaths (95% confidence figures of 12 000−57 000).[24] There would be corresponding increases in the estimates of fatal cancers from other elements of the nuclear fuel chain, making Kharecha and Hansen's estimates greatly biased in favor of nuclear energy.

In sum, Kharecha and Hansen's article is incomplete and misleading. Energy efficiency and renewable energy should be front and center in any campaign to address environmental pollution and climate change—they should not appear, as Kharecha and Hansen treat them, as an afterthought. If wind energy is truly 96 times as effective as nuclear power at mitigating greenhouse gas emissions, then it may have saved—and can save—96 times as many lives. Renewables and efficiency also get you faster climate protection as well as more carbon displaced per dollar expended.

The urgency of world hunger does not require us to fight it with caviar, no matter how nourishing fish eggs might be. In the end, buying the most expensive remedies first will only diminish what we can—and must—spend on more promising approaches.[25] Given the opportunity costs involved, nuclear power could reduce and retard the climate protection the authors so rightly seek.

Benjamin K. Sovacool[*,†]
Patrick Parenteau[†]
M. V. Ramana[‡]
Scott V. Valentine[§]
Mark Z. Jacobson[∥]
Mark A. Delucchi[⊥]
Mark Diesendorf[#]

[†]Vermont Law School, South Royalton, VT 05068
[‡]Princeton University, Princeton, N.J. 08544
[§]University of Tokyo, 7-3-1 Hongo, Tokyo
[∥]Stanford University, 450 Serra Mall Stanford, CA 94305−2004
[⊥]University of California Davis, 1 Shields Avenue, Davis, California 95616
[#]University of New South Wales, Sydney NSW 2052 Australia

AUTHOR INFORMATION

Corresponding Author

*E-mail: sovacool@vt.edu.

Notes

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