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Research Commentary

Non-Economic Matters Involved in Future Nuclear Deployment

John Deutch

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Introduction

In Dubai at the 2023 COP, thirty-three nations, including the United States, pledged to increase the deployment of nuclear power by a factor of three by 2050. There are approximately 440 nuclear reactors operating across the globe today, which imply approximately 1300 reactors in use by 2050. Many motivations lie behind this initiative: nations generally believe greater energy will be required to power a growing economy, that the global fuel mix will shift from fossil fuels to electricity; and the electricity footprint will expand as poorer nations gain access to electricity. Of course, the pace of the nuclear deployment will depend on the complex interactions of economic and market mechanisms. In recent years the pace of nuclear deployment has slowed in the United States and most OECD countries, but for the reasons mentioned above, a renaissance is expected.

The attention of the public and its leaders will understandably focus on economic and energy market conditions, international trade and diplomatic relations among nations. Nuclear energy like other global socio-economic topics such as health care or agriculture involve important subjects are only loosely linked to economic and market conditions but can become major determinants of the outcomes of public policy initiatives.

The purpose of this brief essay is to identify four areas that have such collateral effect on a nuclear energy economy with potentially decisive consequences:

1. nuclear accidents;
2. nuclear waste management;
3. fuel cycle technology; and
4. proliferation issues: enrichment (U_{235}) and reprocessing (Pu_{239}).

Therefore, those working on econometric modeling of nuclear power growth need to be cognizant of the influence of a broader range of issues.

Like many governmental initiatives, the factor of three increase in nuclear deployment is *aspirational* – it is a hope, not a goal supported by a program with explicit quantitative targets for output and cost expectations in future time periods.

* This paper is an outgrowth of an introductory talk given at the NEA-MIT Conference (June 11 -12, 2026) Financing the Nuclear Future: From Demonstration to Deployment.

Public leaders like to adopt *aspirational* goals because it signals to the public the direction, they believe the society *should* move, creates some excitement, and may stimulate early ventures and spending. But if aspiration goals do not result in expected results, they will lead to misguided investments and contribute to a loss in confidence the country's leadership. A recent example is President Biden's target of carbon free electricity for the United States by 2035.

1. Nuclear Accidents

Global nuclear reactor deployment is targeted to increase from 450 today to about 1200 in 2050. Since 1979, there have been three serious reactor accidents: at Three Mile Island in the U.S. (1979), at Chernobyl in Ukraine (1986), and Fukushima Daiichi in Japan (2011). These are the only three nuclear reactor core accidents that have occurred in 20,000 cumulative years of commercial nuclear operations.[1]

There is no reason that reactors cannot be built and operated without a risk of accident. The Institute of Nuclear Power Operations, (INPO), has been enormously successful in encouraging safe operations and hence a profitable increase of plant capacity factor. But experience with human activity suggests it is wise to anticipate and plan for accidents that result in explosions and release of radiation.[2] The U.S. Nuclear Regulatory Commission, (NRC) uses probabilistic risk assessment techniques to estimate how reactor accidents could occur.[3] The NRC frequency estimate for significant core damage accompanied by large release of radiation is 1 per 100,000 reactor years of operation.

It is not unreasonable to suppose if deployment of reactors triples by 2050, the probability of an accident will triple as well. Assuming an average 60-year operating life for each reactor and 1300 reactors deployed leads to an 80% chance of a serious accident for that cohort if the NRC's optimistic assumption of accident frequency holds.

There are two important reservations. First a significant fraction of the reactors operating in 2050 will be of an earlier vintage and likely pose a higher accident risk. More seriously, up to 2/3 of these reactors will be built in countries new to nuclear that will present greater accident risk. Economists and policy makers need to acknowledge these risks and determine what measures should be taken to mitigate risk and how to internalize the cost. Finally, as history shows, if there is a nuclear accident anywhere, it is likely that it will shut down nuclear power operations everywhere for some time.

2. Nuclear Waste Management

All nuclear systems produce high level radioactive wastes. In addition to current commercial nuclear generation, the U.S. has accumulate high level wastes from national defense activities such as nuclear submarines and nuclear weapons production. It is massive disgrace that the United States has not found a solution for long-term waste disposal or the location for a permanent underground disposal facility. The federal government is responsible for accepting spent nuclear fuel, (SNF), from operating commercial nuclear reactors. A fee of 1 mil per kWe-hr generated by commercial utilities was required to be paid into a fund (until 2014 when the fee was indefinitely suspended because the government was not accepting SNF).

For the present, commercial reactors deposit their initially removed hot SNF in liquid pools to cool in then in dry cask storage on the reactor site. There is no location for away from reactor, (AFR), long term storage of SNF. Over decades many candidate permanent underground storage sites have been evaluated. In 1989 Yucca Mountain in Nevada was designated by Congress as a location for a deep underground terminal repository after fierce opposition from state residents. After $15 billion was spent on scientific characterization of the site, in 2010 DOE withdrew its license application

1 https://world-nuclear.org/information-library/safety-and-security/safety-of-plants/safety-of-nuclear-power-reactors

2 https://en.wikipedia.org/wiki/Nuclear_and_radiation_accidents_and_incidents

3 https://www.nrc.gov/about-nrc/regulatory/risk-informed/pra

and the NRC indefinitely suspended its licensing process. This action fulfilled Barack Obama's campaign promise to Nevadans, in 2009 to abandon Yucca Mountain as a site for a geological repository for disposal of nuclear waste.

In 2021 the DOE formed a Blue-Ribbon Commission on America's Nuclear Future (BRC), co-chaired by Gen. Brent Scowcroft and former Rep. Lee Hamilton, the commission to develop the Obama administration's new national strategy for managing spent nuclear fuel and high-level radioactive waste. This elegant study, which covered all aspects of nuclear waste management, including importantly creating ARS for SNF was presented to Congress, which has taken no action on the recommendations. Economists and policy makers must bear in mind that growing nuclear deployment means of long-term waste disposal. Without progress on ultimate disposal of high-level nuclear waste, the outstanding liability continues to increase.

3. Fuel Cycle Technology

Since the end of World War II, the United States has been the world leader in advancing nuclear reactor technology. There currently is an optimistic expectation that the reactor technology will make a transition from GEN III reactor technology that relies on low enriched ~ 3% U_{235} reactor fuel, to GEN IV reactor technology that relies on highly enriched HYLEU U_{235} fuel. GEN IV reactors open the possibility of smaller reactors that produce electricity more cheaply because they can be manufactured.

Groups studying possible future trajectories of nuclear power deployment need to aware of the possible variation in GEN III/GEN IV reactor composition and its consequences for electricity cost and fleet composition.

4. Proliferation Issues

The major danger of nuclear power is that the radioactive fuel, U235 and Pu237, in kilo quantities, can be fabricated into nuclear weapons. In 1953 the Eisenhower administration adopted a policy, *Atoms for Peace*,[4] that gives countries access to U.S. nuclear assistance and nuclear materials provided they pledge not to build enrichment or reprocessing facilities ("the gold standard" of the cooperation agreements) and abide by other nonproliferation measures.[5]

Reprocessing and enrichment are a proliferation risk because of the possibility of diverting bomb usable material U_{235} from centrifuges and Pu_{237} separated from spent fuel to weapons manufacture. There are considerable cost gaps between once-through enriched reactor fuel, reprocessed mixed-oxide fuel, and fuel from breeder reactors. As global nuclear power deployment increases the demand and price of natural uranium rises. Econometric analysis can track these increasing cost trends but have no tools to estimate the cost of measures to offset the increased proliferation risk.

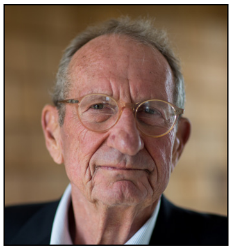
Conclusion

Researchers and policy makers should not be surprised that strong linkage exists between the various aspects of complex political, economic, and technological challenges. Nuclear energy is a vivid example as this essay shows. Ignoring the complications eventually will result in extremely costly consequences.

4 https://en.wikipedia.org/wiki/Atoms_for_Peace

5 https://www.state.gov/bureau-of-international-security-and-nonproliferation/releases/2025/01/123-agreements

About the Author



John Deutch is an emeritus Institute Professor at the Massachusetts Institute of Technology. Mr. Deutch has been a member of the MIT faculty since 1970, and has served as Chairman of the Department of Chemistry, Dean of Science and Provost. Mr. Deutch has published over 140 technical publications in physical chemistry, as well as numerous publications on technology, energy, international security, and public policy issues.

John Deutch has served in significant government and academic posts throughout his career. In May 1995, he was sworn in as Director of Central Intelligence following a unanimous vote in the Senate, and served as DCI until December 1996. In this position, he was head of the Intelligence Community (all foreign intelligence agencies of the United States) and directed the Central Intelligence Agency. From March 1994 to May 1995, he served as the Deputy Secretary of Defense. From March 1993 to March 1994, Dr. Deutch served as Under Secretary of Defense for Acquisitions and Technology.

From 1977 to 1980, John Deutch served in a number of positions for the U.S. Department of Energy: as Director of Energy Research, Acting Assistant Secretary for Energy Technology, and Undersecretary of the Department.

In addition John Deutch has served on many commissions during several presidential administrations. He has served on the President's Nuclear Safety Oversight Committee (1980–81); the President's Commission on Strategic Forces (1983); the White House Science Council (1985–89); the President's Committee of Advisors on Science and Technology (1997–2001), the President's Intelligence Advisory Board (1990–93); the President' Commission on Aviation Safety and Security (1996); the Commission on Reducing and Protecting Government Secrecy (1996); and as Chairman of the Commission to Assess the Organization of the Federal Government to Combat the Proliferation of Weapons of Mass Destruction (1998–99).

John Deutch has received fellowships and honors from the American Academy of Arts and Sciences (1978) and Alfred P. Sloan Foundation (Research Fellow 1967–69), and John Simon Guggenheim Foundation (Memorial Fellow 1974– 1975). Public Service Medals have been awarded him from the Department of Energy (1980), the Department of State (1980), the Department of Defense (1994 and 1995), the Department of the Army (1995), the Department of the Navy (1995), the Department of the Air Force (1995), the Coast Guard (1995), the Central Intelligence Distinguished Intelligence Medal (1996) and the Intelligence Community Distinguished Intelligence Medal (1996). He received the Greater Boston Federal Executive Board's Speaker Thomas P. O'Neill Award for exemplary public service in 2002, the Aspen Strategy Group Leadership Award in 2004, and he was elected to the American Philosophical Society in 2007. He delivered the 2010 Godkin Lectures on the Essentials of Free Government and the Duties of the Citizen. He was a member of the National Petroleum Council (2008–2018) and chair of the Secretary of Energy Advisory Board (2012–2017).

John Deutch earned a B.A. in history and economics from Amherst College, and both the B.S. in chemical engineering and Ph.D. in physical chemistry from M.I.T. He holds honorary degrees from Amherst College, University of Lowell, and Northeastern University. He has served as director for the following publicly held companies: American Natural Resources, Citigroup, CMS Energy, Cummins Engine, Perkin-Elmer, Raytheon, SAIC, Schlumberger and Cheniere Energy. He is a trustee of Center of American Progress, Resources for the Future, the Massachusetts General Hospital Physician Organization, the Museum of Fine Arts, Boston, and the Skolkovo Institute. He has served on the board of the Urban Institute and the Council on Foreign Relations.

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Contact.

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MIT Center for Energy and
Environmental Policy Research
Massachusetts Institute of Technology
77 Massachusetts Avenue, E19-411
Cambridge, MA 02139-4307
USA

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