12

Lessons of Fukushima: Nine reasons why

Peter Van Ness

Abstract

Following the disaster in Fukushima, we brought together a group of specialists to address the issue of nuclear power in East Asia, and held two international workshops to investigate the topic. This chapter is not a consensus report on our work, but rather a personal statement—one participant's point of view—on our collective deliberations about nuclear power. In my view, there are nine reasons why nuclear power is a bad choice for any country, unless they are already a nuclear weapons power or they aspire to become one. Even then, there are serious problems in a potential commitment. My nine reasons follow the nine-item agenda for the second workshop that we held at The Australian National University in 2014.

Introduction

The Global Nuclear Power Database: World Nuclear Power Reactor Construction, 1951–2017 (Schneider et al. 2017, also published by the *Bulletin of the Atomic Scientists* 2017*)*, analyses the construction to date of the world's 754 nuclear power reactors in 41 countries, of which 90 have been abandoned. This is the most comprehensive global analysis of nuclear power published to date.

The Database provides a global understanding of the history of nuclear power for all countries interested in building new reactors and power plants. Our investigation of the experience in East Asia, especially looking into the vastly different situations in China and Japan, complements the work of the database, and helps to clarify questions that should be asked by any country, such as Australia or the 10 members of the Association of Southeast Asian Nations (ASEAN), when each considers whether it should, or should not, opt for nuclear power.

As of 1 January 2017, the Database reported that 55 reactors around the world were under construction, of which at least 35 were behind schedule. Forty of the 55 reactors under construction were in nuclear weapons states, and 20 of these were in China. Westinghouse had built the most nuclear power reactors (90, and a further 12 had been abandoned), and it currently had four reactors under construction in the US, and four in China. However, in February 2017, Toshiba (which owns Westinghouse) announced that it was taking a US$6.3 billion loss, and that it would not seek new opportunities to export nuclear power reactors. General Electric, France, and Russia are other major builders in different parts of the world.

When we held an international workshop at The Australian National University in August 2014 on the topic 'Nuclear Power in East Asia: The Costs and Benefits', participants from the United States, Japan, Singapore, Taiwan, and Australia attended. The objective of the meeting was to provide an empirical assessment of a commitment to build nuclear power plants, and to get beyond the typical debates between proponents and opponents of nuclear power in which they talk past each other and often make unsupported claims.

We identified nine aspects of a potential nuclear power project, and invited qualified specialists to address those specifics, no matter whether in the past they had publicly opposed or supported nuclear power. The key specifics were the initial cost of construction; the requirements of professional staff to operate and to maintain the nuclear reactors; the establishment of an independent and transparent regulatory authority; liability in the event of accident; the cost and procedure of decommissioning, under normal circumstances and under crisis circumstances (for example, Chernobyl and Fukushima); the relationship of nuclear power generation to nuclear weapons; problems of nuclear waste disposal; the health implications of exposure to radiation; and nuclear power and climate change.

Twenty-five scholars participated in three days of meetings: natural scientists, social scientists, physicists, biologists, and historians. As convener of the workshop, I was delighted by the quality of the insights that emerged and the dispassionate tone of our discussions. By the end of the third day, I was surprised by what I had learned.

1. The initial cost of construction

Building a new nuclear power plant is expensive, and a proper costing of the construction of a nuclear power reactor is a complicated task. Comparisons with the costs of alternative energy producers, like coal, gas, or renewables (see Andrew Blakers' chapter) are difficult to make because of the unique features of nuclear power. For example, should estimates of the cost of decommissioning the plant be included, or the expected cost of the disposal of its high-level nuclear waste? And, if so, how should it be valued in light of the long timescale involved in the latter expenditure?

Concerns about safety have become paramount, especially after the disasters of Chernobyl and Fukushima. But how much safety is enough? Which safety features might be required to deal with possible dangers to the integrity of the plant, and how much might the additional cost add to construction expenditure?

Critics also note the extraordinarily long time horizon involved: the length of time taken to build a nuclear power plant, the duration of its operation, and the lifetime of potentially dangerous radiation emanating from the plant. These issues further complicate the assessment. Cost overruns and failure to complete on schedule have markedly increased the comparative cost of nuclear power. Recall the Database report that of the 55 nuclear power reactors currently under construction around the world, 35 are behind schedule.

Comparisons of the costs of alternative energy sources are often made in terms of the so-called levelised cost of energy (LCOE), an economic procedure that attempts to take into account all of the relevant costs in the production of electricity, but in these calculations one should note what is included and excluded, and which values are used. Government subsidies, as described in Doug Koplow's chapter, and taxes also affect the comparisons.

2. Professional staff needed to operate and maintain the nuclear reactors

Almost never included adequately in a comparative costing of energy sources is the requirement for specially trained staff to build the reactors, to maintain them appropriately, and to assure the public that they can safely deliver the needed electricity. The nuclear physicists and engineers required are personnel with sustained academic and vocational training, which, in turn, means that a country making a commitment to nuclear power will have to make a substantial and continuing investment in its educational institutions to provide the technical specialists that are needed. Failure to continue to train and to support the technical staff required to run a nuclear power plant over the years can lead to serious management problems in the plant's operation. In an emergency, the need for appropriately trained staff is even greater.

3. Establishment of an independent and transparent regulatory authority

Among the problems here, the regulatory authority must have the required technical skills and understanding of the industry necessary in order to carry out its duties. However, given the security concerns about nuclear weapons, it is immensely difficult for the authority to operate transparently.

The problem of independence has also proven to be serious. In Japan, they speak of the 'nuclear village', which Jeff Kingston (2012: 1) has defined as: 'the institutional and individual pro-nuclear advocates who comprise the utilities, nuclear vendors, bureaucracy, Diet (Japan's parliament), financial sector, media and academia'. It became a closed shop of vested interests among the companies involved, the government, the press, and even some of the academic community in promoting the production of nuclear power, and when the Fukushima disaster occurred, those in charge were completely unprepared to respond or even to provide the public with reliable information. Japanese families affected by the disaster did not believe the information that the Tokyo Electric Power Company (TEPCO) or the government provided, and came to distrust what they were told about potential dangers to their health and their safety.

Mely Caballero-Anthony and Julius Cesar I. Trajano, in their chapter, address many of these issues from the perspective of ASEAN. One possibility in Southeast Asia is a regional regulatory authority, as Sulfikar Amir (2014) points out, because '[t]he logic is simple. If only one country in the region has a nuclear power plant, only that country will enjoy the benefits. But the geography of the region dictates that many nations will share the risks'. He notes that since ASEAN members are geographically located so close to one another, a nuclear accident in one country will mean that neighbouring countries may also suffer.

Typically, regulation in the nuclear power industry amounts to the industry regulating itself. Moreover, the accountability of the authority is further compromised by the degree of secrecy and security required because of the relationship between nuclear power production and the possibility of building nuclear weapons. In short, it has proven thus far almost impossible to construct an independent, transparent, and accountable nuclear power regulatory authority.

4. Liability in the event of accident

Liability has been a major concern for private investors in nuclear power because of the immense potential costs in the event of an accident. The final bill for the meltdowns in Chernobyl and Fukushima has not yet been calculated. Governments determined to build nuclear power plants with private capital have had to devise strategies to limit the liability of investors. As one workshop participant commented, '[t]he issue is that private vendors want to sell reactors and be indemnified in the event of an accident'.

In the United States, the Price–Anderson Nuclear Industries Indemnity Act, first passed in 1957, and renewed and extended by Congress through to December 2025, is designed to cap the liability of private investors in nuclear power by means of a combination of insurance held by a company in addition to a pooled amount of US$12 billion to compensate claimants in the event of a nuclear accident. The Act is reported to have worked effectively in the case of the Three Mile Island accident in 1979 in the United States (NAIC and Center for Insurance Policy and Research 2016), but such government insurance arrangements have been seriously tested by the more traumatic nuclear accidents in Chernobyl and Fukushima.

5. Decommissioning costs and procedures under normal circumstances, and under crisis circumstances (for example, Chernobyl and Fukushima)

There is much debate about what should be required for successful decommissioning of a nuclear power plant. Unlike a coal-fueled or petroleum-fueled facility, you cannot simply turn a switch and walk away when the plant is no longer needed. Kalman Robertson analyses in detail the problems involved.

In short, the objective after decommissioning should be to return the plant site to a so-called 'greenfield' condition. Decommissioning is a lengthy and extremely technical procedure for dismantling a nuclear power plant, dealing with existing radiation, and preparing the site for alternative use. Nuclear power plants are typically under strict governmental regulation. Successful decommissioning would result in a condition that would no longer require regulatory oversight. But what happens if before decommissioning is completed, the company involved goes bankrupt, or the government with regulatory responsibilities changes?

Robertson notes that in the next 15 to 20 years, an unprecedentedly large number of reactors will have to be decommissioned as they reach their designed expiration date.

6. The relationship between nuclear power generation and nuclear weapons

Only one of this volume's case-countries, China (see the chapter by M. V. Ramana and Amy King), is a nuclear weapons power, while three others (Japan, South Korea, and Taiwan) have nuclear power plants but no nuclear weapons. For all three, however, the weapons option has been part of their nuclear history. Gloria Kuang-Jung Hsu describes this history in her chapter on Taiwan. Japan is a classic case of proliferation in a country that has nuclear power but no nuclear weapons. In the 1960s, Japan proclaimed its three non-nuclear principles—not to produce, possess, or permit the introduction of nuclear weapons—and later joined the Nuclear Non-Proliferation Treaty. But from its nuclear power industry, Japan has all that would be required to build nuclear weapons, along with enough plutonium for 1,000 nuclear warheads. Some analysts estimate that given a decision to build a nuclear weapons capability, Japan could achieve this within one year—a capacity that has been labelled as a de facto nuclear state, or 'having a bomb in the basement'.

Because of this possibility of employing nuclear physics to produce nuclear weapons, a country that builds nuclear power plants will inevitably require a degree of security that is not needed in the construction of other sources of energy (such as coal, gas, or renewables). In turn, this need for security has contributed to a serious problem of lack of transparency, and explains in part how accountability in the nuclear power industry has been so very difficult to establish and to maintain. Tatsujiro Suzuki, in his chapter, describes the extent of public distrust that developed in Japan, illustrated sharply in the Fukushima disaster.

From a broader national security perspective, the establishment of a nuclear power plant provides adversaries with a strategic opportunity to create a nuclear crisis in the country. The building of a nuclear power plant gives a country's adversaries a potential target for attack, either with an explosive device from a terrorist or an enemy country, or a cyber intervention to distort the management of a nuclear reactor in order to cause a nuclear meltdown. Such a cyber-attack, for example, might be designed to disguise the source of the attack, but nonetheless cause immense damage and disruption in the country, especially in heavily populated areas. Both Lauren Richardson, in her chapter on South Korea, and Tilman Ruff, in his analysis of health implications of radiation exposure, draw attention to the possibility of such attacks.

Another aspect of the relationship between nuclear power and nuclear weapons emerged in the British debate about whether or not to go ahead with construction of the Hinkley Point C nuclear power plant, potentially the biggest building project underway in the world. Following years of discussion and debate, British Prime Minister Theresa May confirmed in September 2016 that the UK would build the first new nuclear power plant in Britain in 20 years at Hinkley Point. Hinkley Point C nuclear power plant is to be built by Électricité de France S.A. (EDF), with Chinese investment and 33 per cent ownership of the proposed US$30 billion project, based on the European pressurised reactor (EPR) design. The UK has promised to pay twice the current market price for a unit of electricity produced by the project for 35 years. A key consideration for the Chinese was a promise that it might in the future build a second nuclear power plant, employing its own reactor design, in Essex.

The decision by May to go ahead with the Hinkley Point C project baffled critics because it made no sense from an economic, technological, environmental, or even national security point of view. The French company in charge, EDF, was in serious financial difficulties; the EPR nuclear technology was untested; the promised purchase price for the electricity to be produced was too high; the renewables alternative would be much better for the environment; and there was a national security concern about the deep Chinese investment involved, i.e. potentially having a major influence on the British national power grid.

Why did May decide to go ahead? A University of Sussex study tested a variety of possible explanations, and concluded that, despite the serious reservations, the British prime minister approved the project principally to sustain Britain's nuclear deterrent capability by keeping the nuclear power industry in the UK up to such a level as to support the construction of new nuclear-powered ballistic missile submarines intended to replace the existing Vanguard-class submarines (Cox, Johnstone, and Stirling 2016).

Although critics have raised concerns about Chinese investment in Hinkley Point C because of its potential influence over the UK power grid, a more serious national security concern is that China's participation in the development of the British nuclear power industry, which will be focused on producing the UK's new nuclear-powered ballistic missile submarines, could compromise Britain's Trident nuclear deterrent.

7. Nuclear waste disposal

One of the most serious problems confronting the production of nuclear power is how to dispose safely of high-level radioactive waste (HLW). As Ramana (2017: 415) has argued:

> Some of the radioactive elements produced during the operation of nuclear reactors have extremely long half-lives, and have to be isolated from human contact for hundreds of thousands of years … This requirement for stewardship is unprecedented in human history.

Currently, there is no operational site for the permanent storage of high-level nuclear waste anywhere in the world. Deep geological disposal has been proposed as the answer to this problem, and sites have been suggested in different countries, including Australia. Meanwhile, all countries that have working nuclear power plants have made temporary arrangements to store nuclear waste, some with tragic consequences, as outlined in Hsu's description of the situation on Orchid Island in Taiwan.

Yucca Mountain in the United States, a remote Nevada desert site in which the government has invested US$15 billion, was officially designated as a site in 2002, but its current status is uncertain, and there was a serious accident in 2014 at the Waste Isolation Pilot Plant (WIPP) in New Mexico (Alvarez 2014). Globally, the most promising project is a US$3.2 billion facility on Olkiluoto island in Finland (Gibney 2015), which is not yet operational.

8. Health implications of exposure to radiation

The chapters by Tim Mousseau and Anders Pape Møller, and Ruff, on the biological and human health implications of exposure to radiation, were written by some of our most experienced researchers. Mousseau had worked for 10 years on Chernobyl before beginning research about Fukushima after the disaster, and Ruff, a public health physician, has combined a lifetime of research, teaching, and activism focused on investigating the public health dimensions of nuclear technology. In my view, there are no better statements of the serious risk to human health and ecological viability involved in a decision to build a nuclear power plant, and their work should provide warnings to countries considering whether or not to invest in nuclear power.

9. Nuclear power and climate change

Christina Stuart, in her chapter on the exceptional situation in France where more than 70 per cent of the country's electricity is provided by nuclear power, notes that when the United Nations Framework Convention on Climate Change Conference of the Parties (COP) was held in Paris in December 2015 (COP21), and universal agreement on climate change among the 195 participating countries was achieved, a role for nuclear power was not directly addressed. Having observed the meetings, she reports that, surprisingly, nuclear was only indirectly discussed.

Yet some prominent climate scientists, like James Hansen et al. (2015), have made forceful arguments for nuclear power, and the Nuclear Energy Institute insists:

> There is widespread agreement that nuclear energy is part of the climate change solution. Mainstream analyses conducted by independent organizations have shown that reducing carbon emissions will require a diverse energy portfolio and that nuclear energy is the only low-carbon option to help meet forecasted global electricity demand (Nuclear Energy Institute n.d.).

Compared with the production of carbon dioxide by fossil fuels, there is no question that nuclear power is vastly superior with respect to concerns about climate change. The principal argument made by proponents is that nuclear power is the only low-carbon option that can provide so-called 'baseload' electric power. Blakers' chapter describes the current capacity of renewables to meet this demand, and Mark Diesendorf (2016) argues that not only are baseload power stations not needed, but also that renewable storage, such as the newly designed batteries and pumped hydro, as well as other technological innovations, can provide the flexibility needed to produce reliable electric power.

The victims of Chernobyl and Fukushima might add that the risks associated with nuclear power are simply too great to justify the nuclear option when other energy resources are available to respond to climate change concerns and to meet the requirements for the production of reliable electric power.

Conclusion

The lessons of Fukushima, learned in our years of investigation since the disaster in Tohoku in March 2011, are based first and foremost on the conclusion that the fundamental costs of nuclear power are incalculable. They cannot at present be measured either in financial terms or in terms of compromised public health and lives lost. One reason is that estimates of the cost of a truly successful decommissioning of a nuclear power reactor still vary widely, while the expected cost of decommissioning of reactors in crisis, such as at Chernobyl and Fukushima Daiichi, continue to escalate.

The problem of estimating the cost of processing high-level nuclear waste is even more difficult because, at present, there is no available permanent site for HLW anywhere in the world. And, in terms of public health, Ruff has spelled out in meticulous detail the implications of exposure to radiation, and Mousseau and Møller have demonstrated the adverse effects of radiation on the broader ecology.

As we studied each of the nine aspects listed above, questions were raised that could not be adequately answered by the proponents of nuclear power. However, if a country is already a nuclear weapons power, like China or the United Kingdom, or aspires to become one, then the calculations change fundamentally. It is not, then, a matter of finding the best way to produce reliable electricity for the cheapest price, but rather involves questions of national security. Countries that decide to build nuclear weapons must maintain a nuclear industry, no matter what the cost. For them, the problems raised in our study become secondary. They must decide what price they are prepared to pay for 'national security'.

References

Alvarez, Robert, 2014. The WIPP problem, and what it means for defense nuclear waste disposal. *Bulletin of the Atomic Scientists,* 23 March. thebulletin.org/wipp-problem-and-what-it-means-defense-nuclear-waste-disposal7002 (accessed 14 March 2017).

Amir, Sulfikar, 2014. The transnational dimensions of nuclear risk. *Bulletin of the Atomic Scientists*, 25 April. thebulletin.org/needed-ability-manage-nuclear-power/transnational-dimensions-nuclear-risk (accessed 14 March 2017).

Bulletin of the Atomic Scientists, 2017. Global nuclear power database: World nuclear power reactor construction, 1951–2017. thebulletin.org/global-nuclear-power-database (accessed 14 March 2017).

Cox, Emily, Phil Johnstone, and Andy Stirling, 2016. Understanding the intensity of UK policy commitments to nuclear power. Science Policy Research Unit Working Paper Series SWP 2016-l6. Brighton: University of Sussex, September.

Diesendorf, Mark, 2016. Dispelling the nuclear 'baseload' myth: Nothing renewables can't do better! *Ecologist,* 18 March. reneweconomy.com.au/dispelling-the-nuclear-baseload-myth-nothing-renewables-cant-do-better-94486/ (accessed 14 March 2017).

Gibney, Elizabeth, 2015. Why Finland now leads the world in nuclear waste storage. *Nature*, 2 December. doi.org/10.1038/nature.2015.18903

Hansen, James, Kerry Emanuel, Ken Caldeira, and Tom Wigley, 2015. Nuclear power paves the only viable path forward on climate change. *Guardian*, 4 December.

Kingston, Jeff, 2012. Japan's nuclear village. *Asia-Pacific Journal: Japan Focus* 10(37)(1) 9 September: 1–22.

NAIC (National Association of Insurance Commissioners) and Center for Insurance Policy and Research, 2016. Nuclear Liability Insurance (Price–Anderson Act). 8 December. www.naic.org/cipr_topics/topic_nuclear_liability_insurance.htm (accessed 14 March 2017).

Nuclear Energy Institute, n.d. Climate change. www.nei.org/Why-Nuclear-Energy/Clean-Air-Energy/Climate-Change (accessed 14 March 2017).

Ramana, M. V., 2017. An enduring problem: Radioactive waste from nuclear energy. *Proceedings of the IEEE* 105(3): 415–18. doi.org/10.1109/JPROC.2017.2661518

Schneider, Mycle, and Antony Froggatt, with Julie Hazemann, Tadahiro Katsuta, M. V. Ramana, Juan C. Rodriguez, and Andreas Rüdinger, 2017. *The World Nuclear Industry Status Report 2017*. Paris: Mycle Schneider Consulting Project.