Revisiting the Nuclear Option in the Philippines

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Abstract

Nuclear energy has been thrust into the spotlight by the administration of President Duterte. In order to allow the committee created by Executive Order 116 to craft a fair-minded national nuclear program, the issue of the Bataan Nuclear Power Plant (BNPP) has to be explained transparently. Meanwhile, the technical and scientific issues underlying nuclear energy are well known. However, its role in promoting a low-carbon society has to be re-evaluated because of the sharp decline in the cost of variable renewable energy (VRE). If nuclear energy will eventually be incorporated in the plans of the Department of Energy (DOE), building a new large reactor would be too expensive. There are two more feasible options: revive the BNPP and/or invest in small module reactors (SMRs). Even if the latter has not yet been mainstreamed in the global energy market, SMRs are already on the radar of DOE.

Keywords: nuclear energy, Bataan Nuclear Power Plant, white elephant, variable renewable energy

Introduction

Executive Order (EO) 116 directing a study on the possible design of a national nuclear program was signed by President Duterte on July 24, 2020. The Nuclear Energy Program Inter-Agency Committee (NEP-IAC) was subsequently formed with the Secretary of the Department of Energy (DOE) as chairperson. These actions complement the earlier establishment of the Philippine Nuclear Energy Program Implementing Organization (NEPIO) on 24 October 2016. The creation of the NEPIO was one of the major recommendations during a conference on the Prospects of Nuclear Power in the Asia Pacific region hosted by the Philippines in August 2016 under the auspices of the International Atomic Energy Agency (IAEA).

From a historical perspective, both the NEPIO and NEP-IAC appear to be yet another contentious issue raised by the current administration.[1] After all, nuclear energy in the Philippines is associated with the controversial Bataan Nuclear Power Plant (BNPP), considered by some as the epitome of a white elephant (Mendoza et al. 2018).

Nevertheless, nuclear power makes a significant contribution to global electricity generation, providing 10% of global electricity supply in 2019, almost a third of all low-carbon energy. As of December 2019, there were 443 nuclear power reactors in operation in 30 countries, with a combined capacity of 392.1 gigawatts (GW).[2] Nuclear power plays a much bigger role in advanced economies, where it makes up 18% of total generation. However, Germany notably passed legislation to decommission all of the country's nuclear reactors by 2022.

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[1] The current administration has been heavily criticized for its policy on extrajudicial killings and its support for the Anti-Terrorism Act of 2020 or Republic Act 11479. These events have drawn parallels to the Martial Law period, 1972–1981.

[2] https://www.iaea.org/newscenter/news/iaea-releases-2019-data-on-nuclear-power-plants-operating-experience (accessed 08 August 2020). It should be noted that Taipei,China is counted in the 30 countries.

This decision was swayed by the 2011 accident in Fukushima, Japan, which revived memories of the specter of the radioactive cloud that swept over Germany following the Chernobyl disaster in 1986.

Despite these prominent disasters, including the Three Mile Island accident in 1979, nuclear power generation remains generally safe and reliable.[3] The evidence over six decades shows that nuclear power is a secure means of generating electricity. The risk of accidents in nuclear power plants is low and declining. The consequences of an accident or terrorist attack are minimal compared with other commonly accepted risks. Radiological effects on people of any radioactive releases can be avoided.

This paper dissects the nuclear issue in the Philippines along two dimensions. First, the historical aspect is assessed by reviewing the controversy surrounding the BNPP. The decision to shut down the BNPP even before it produced a single watt of commercially accessible electricity may have been largely political. Second, the scientific, technical, and economic merits of nuclear energy are analyzed. This aspect becomes even more important in an era where variable renewable energy (VRE) has become mainstream.

The debate can highlight issues that should be considered by the NEP-IAC which is tasked to craft the national nuclear program in the Philippines. A major objective of this policy paper is to identify biases and even myths that surrounded the 1986 decision not to operate the BNPP. This can then set the stage for a more objective and fact-based discussion on the scientific, technological, and economic aspects of nuclear energy.

Historical Animosity

On April 30, 1986, the administration of then President Corazon Aquino decided not to operate the BNPP. The official reasons revolved around fundamental questions concerning its soundness as well as the integrity of the process with which it was planned and implemented. In short, the BNPP officially became a white elephant. Mendoza et al. (2018) adopt the contemporary definition of white elephants as large-scale, socially unprofitable investment projects that have turned into heavy burdens for businesses and/or governments tasked with their maintenance. As a framework, the authors look at three alternative explanations of megaproject performance, namely, (1) strategic rent-seeking behavior, (2) misaligned and underdeveloped governance, and (3) diverse project cultures and rationalities. The authoritarian nature of the Marcos government contributed to making all these factors relevant in the case of the BNPP.

A September 1, 1986 article in *Fortune* magazine titled “The $2.2 Billion Nuclear Fiasco” (Dumaine 1986) details the evolution of the BNPP. Rent-seeking was manifest in the process. Initial discussions were between the Marcos government and General Electric and were characterized as professional. However, Westinghouse was able to get an inside track in the project and many sources claimed it was because President Marcos himself received bribes. Eventually, the cost ballooned from an initial price of US$650 million for two 620-megawatt (MW) reactors to US$2.2 billion for a single reactor.

Misaligned and underdeveloped governance usually pertains to internal project arrangements that are not robust enough to adequately manage shocks and uncertainties. In the case of the BNPP, weak governance promoted the rent-seeking behavior. Apart from overpricing, there were also possible construction defects. William Albert, an advisor from

[3] https://www.world-nuclear.org/information-library/safety-and-security/safety-of-plants/safety-of-nuclear-powerreactors.aspx#:~:text=The%20evidence%20over%20six%20decades,with%20other%20commonly%20accepted%20risks (accessed on 07 August 2020)

the IAEA was brought in by the new government of President Corazon Aquino to do inspections. Albert brought up issues of welding, base plates, pipe hangers, water valves, and transmission cables. He attributed all these shortcomings to quality control (Dumaine 1986).

Another issue was the location of the nuclear reactor, which is near a volcano and earthquake fault. More precisely, the "site for the plant is just five miles from a volcano and within 25 miles of three geologic faults" (Dumaine 1986, p.1). Despite the possible risks, the BNPP was still erected in its present site reflecting the "diverse project cultures and rationalities". Mendoza et al. cite a geological study by Professor Alfredo Mahar Lagmay and colleagues (2012) published by the *Geological Society of London* which provided evidence that the proximity of the BNPP to Mount Natib rendered its location geologically unsafe on account of volcanic hazards.

The Aquino administration doubled down on its decision to mothball the BNPP by filing a lawsuit against Westinghouse in 1988 in the United States District Court of New Jersey (Civil Action No. 88-5150 DRD). In the same year, Westinghouse filed an arbitration case with the International Chamber of Commerce (Arbitration Case No. 6401/BGD). In its lawsuit, the Philippine government alleged that Westinghouse bribed President Marcos and the BNPP was overpriced.

In May 1993, Westinghouse was acquitted by a US jury of bribing President Marcos to win the BNPP contract. The other legal case was settled in 1995. As part of the settlement, the Philippines received two units of 501-F Gas Turbines, 100 MW each, and US$40.3 million in cash. In exchange, the Philippine government agreed to drop all claims against Westinghouse and assume all remaining financial obligations related to the BNPP. It is quite interesting to note that when the Ramos administration took over the negotiation for a possible settlement in August 1992, the parameters included the possibility of reviving the BNPP. Administrative Order 4 listed the following areas for negotiation:[4]

a) Westinghouse shall make certain payments and provide certain discounts and credits to the Government in amounts at least equal to those stipulated in the Conditional Settlement Agreement of March 4, 1992;

b) Westinghouse will repair and upgrade the BNPP to bring up the plant to current standards of the US Nuclear Regulatory Commission, and at the same time establish the operations organization and provide for training and certification of plant operators;

c) Westinghouse will operate and maintain the BNPP for a period not exceeding thirty years; during which period, Westinghouse shall train Filipinos to take over BNPP operation, management, and engineering.

Mr. Corpuz revealed that there were confidential negotiations between Westinghouse and the Ramos government for a possible upgrade of the BNPP. The cost of the upgrade was based on the Seabrook Nuclear Plant, which was the latest one in the US at that time. The amount would then be compared with the cost of a new coal plant with a Fuel Gas Desulfurizer (FGD). The cost of the upgrade was lower, but when the decision was made, the cost of the FGD—which comprised 30% of the total cost—was not included in the comparison. As a result, the government did not pursue the upgrade. The design of the BNPP made its conversion to a coal plant difficult and as a result it remained mothballed.

[4] https://www.chanrobles.com/administrativeorders/administrativeorderno4%201992.html#.Xy4lJCgzZPZ (accessed 08 August 2020)

Contrarian Views

Unbeknownst to many Filipinos, the BNPP was ready for operation at the time it was mothballed by the Aquino Government. An anecdote from Conrado D. del Rosario (1996, pages 4-5), president of the National Power Corporation (NPC) from May 1986 to November 1987, underscores this fact:

> "One of my first official actions was to appear in a Cabinet meeting where the nuclear plant was an item on the agenda. It had been one of the main political issues in the presidential snap elections of February 1986, and everyone was clear on where President Aquino stood on the matter. Before she appointed me, somebody close to the new administration asked if I would insist on operating the nuclear plant in case I became NPC president. In view of my involvement in the plant's inception, planning construction, supply negotiations, and financing, I was confident it was built according to the best engineering and nuclear standards in the world, and it should be operated … I came prepared with technical and financing data on the nuclear plant which, I thought, would give Cabinet members a more balanced perspective on the issue. The most important information of all was the fact that the plant was almost ready to operate anytime once the government gave its go signal…
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> "…They had apparently made up their minds about not operating the plant. It was useless and untimely for me to bat for its operation. I thought it is regrettable that the nuclear plant was not being judged for its technical merit. It seems to represent all the abuses that Marcos and his cronies stood for, and the decision not to operate it was a fallout of anti-Marcos sentiments. No technical argument could overturn that kind of bias."

This story was corroborated by Antonio T. Corpuz, who retired as Senior Vice President for Generation of NPC in 2003. Mr. Corpuz made the following assertions:[5]

- The Philippine government was ready and prepared to operate the BNPP after having undergone a series of systems tests;
- These consisted of Cold Functional tests and Hot Functional tests at which the power plant was synchronized to the Luzon Grid for less than a minute using pump heat;
- Fuel loading was the next step to complete the tests but the licensing proceedings with the Philippine Atomic Energy Commission, which was the regulator at that time, were discontinued when BNPP was mothballed;
- At that time NPC already had licensed nuclear power plant operators and all other disciplines had the requisite local and foreign trainings;
- The *Fortune* magazine article is not accurate. First, it should be clarified that the US$2.2 billion cost included interest charges that accrued even if construction was delayed for 18 months following the Three Mile Island accident in 1979. Meanwhile, design improvements that stemmed from this incident were incorporated in the BNPP and this cost an additional US$700 million.
- Second, the alleged defects were "punch list" items which NPC identified and were subject to compliance by Westinghouse. Said punch list items were not a detriment to operating the plant but could have been addressed during the warranty period; and

[5] Corpuz, A. T. Email interview by author. Quezon City, Philippines, August 6, 2020.

- The IAEA conducted two Operational Safety and Review inspections and did not report findings that the plant was not safe.

The current administration of the National Power Corporation made a presentation to the NEP-IAC in which it traced the history of the BNPP. The following timeline was presented (NPC, 2020):

- June, 1984: Uranium fuel delivered
- July, 1984: IAEA Operational Safety Review Team (OSART) I review: construction appraisal review
- February, 1985: IAEA OSART II review: operational readiness review
- June, 1985: Public hearings began for plant licensing

A country profile prepared by the IAEA dated July 2010 made reference to these events:[6] "In May 1984, the plant was fully completed and the hot functional tests of all systems were satisfactorily conducted. The 1985 IAEA OSART performed evaluation of the operational readiness of the plant and it reported that the plant could perform the core loading."

The implication is that the BNPP was technically sound and the decision to have it mothballed could only be justified scientifically by the risks posed by its location. A search of the literature on this topic led to a power point presentation prepared by Venida and Reyes (2011) who were staff of Department of Science and Technology-Philippine Nuclear Research Institute (PNRI) at that time. The power point refers to site studies in the following areas: hydrology, meteorology, geology, seismology, and lithology. The results all support the choice of location of the BNPP. However, there is no indication of the time when these studies were conducted.[7] The earliest formal study is attributed to Solidum (2009).

Meanwhile, Professor Carlo A. Arcilla, who is currently the Director of the PNRI, recently conducted similar site studies.[8] He is a co-author of the study titled "Is there a fault beneath the Bataan Nuclear Power Plant? A systematic study using electrical resistivity, seismic refraction and radon gas detection."[9] Based on the results of the various geological tests, he and his team concluded that there are no active faults that lie beneath the BNPP (Arcilla et al. 2017). Both Professor Lagmay and Professor Arcilla even acknowledge that the active fault map of the Philippines by PHIVOLCS does not list an active fault in the vicinity of the BNPP.

Its location near active faults was addressed by a structural design intended to withstand a 7.9 magnitude earthquake. In his interview, Professor Arcilla emphasized that the earthquake risk of BNPP was rated at 0.4 g, while that of the Fukushima nuclear plant was 0.14 g, i.e. BNPP's structure is 2.8 times stronger. The Fukushima plant withstood the magnitude 9.0–9.1 undersea megathrust earthquake that struck on March 11, 2011.

As to the volcanic hazard posed by Mt. Natib, Professor Arcilla offers a different perspective. He argues that the only reliable age dates by Carbon 14 testing put the age of the volcano at 27,000 and 60,000 years. This is older than the volcanoes in Laguna de Bay whose age is estimated at 25,000 years. He wryly concludes that if the reasoning for closing BNPP is

[6] https://www - pub.iaea.org/MTCD/publications/PDF/CNPP2010_CD/countryprofiles/Philippines/CNPP2010Philippines.htm (Accessed 08 September 2020).

[7] Effort was made to get in touch with the authors, who have retired from PNRI. Unfortunately, there was no response from the authors and current PNRI staff have no knowledge about the background studies.

[8] Arcilla, C. A. Zoom Interview by author. Quezon City, Philippines, July 30, 2020

[9] The study is discussed in this YouTube video: https://www.youtube.com/watch?v=Mz6qkiPDhWE (accessed 09 August 2020).

followed, then the cities of Manila and Angeles—because of the latter's proximity to Mt. Pinatubo—should have never been built. He suggests that the Philippine Institute of Volcanology and Seismology (PHIVOLCS) should be the final arbiter on this matter.

A possible reason why opponents of the BNPP have been pushing the issue of safety to the forefront is the high economic cost of mothballing the plant. A purely political decision could not justify the widespread consequences. The impact of the decision not to operate the BNPP was exacerbated by slow decision-making on new sources of power to compensate for the shortfall in supply. This resulted in a severe power crisis from 1989–1993. Alonzo and Guanzon (2018) refer to an Asian Development Bank study that estimated a 6% drop in gross domestic product (GDP) in 1989–1991 that could be attributed to the power crisis.

Table 1 presents GDP data from 1988–1993. If the foregone income is calculated based on ADB's estimate, then the equivalent amount is US$7.94 billion (6% of the combined GDP in 1989–1991). It should be noted, however, that the period of long daily power outages lasted until 1993. Based on the pattern of the GDP growth rate, 1990–1993 is the more relevant period in which output losses should be estimated. The economy decelerated quite significantly from the previous two years. A counterfactual growth trajectory is created, which is on the conservative side (Table 1). The cumulative change in GDP when comparing the actual growth rates with the higher counterfactual is US$12.96 billion. This does not even factor in the exorbitant rates consumers had to pay for electricity generated from onerous power agreements that were forged since 1993. The economic cost of not operating the BNPP is at least US$13 billion.

Scientific Debate

Clearly, the decision not to operate the BNPP was dominated by the following considerations:

- It was tainted by corruption, which is supported by the sharp increase in the construction cost;
- It was located near a volcano and earthquake faults (but not on one);
- The Chernobyl disaster on April 26, 1986 shook confidence in nuclear energy; and
- It was a campaign promise of President Aquino during the February 1986 snap election.

As lamented by Mr. del Rosario, "it is regrettable that the nuclear plant was not being judged for its technical merit." A crucial decision was not a product of rigorous scientific and technical analysis and debate.

The expensive lesson from the 1986 experience is that the current effort under EO 116 should be supported by science. The pros and cons of nuclear energy are well known in the literature. These are readily summarized:[10]

PROS

1. Low Cost of Operation

After the initial cost of construction, nuclear energy has the advantage of being one of the most cost-effective energy solutions available. The cost to produce electricity from nuclear energy is much lower than the cost to produce energy from gas, coal, or oil

[10] https://springpowerandgas.us/the-pros-cons-of-nuclear-energy-is-it-safe/ (accessed 09 August 2020)

unless those resources are located near the power plant they supply. Nuclear energy also has the added benefit of facing comparatively low risks for cost inflation—unlike traditional fossil fuels that regularly fluctuate in price.

2. Reliable Source of Energy

While some energy sources are dependent upon weather conditions, like solar and wind power, nuclear energy has no such constraints. Nuclear power plants are essentially unaffected by external climatic factors and create predictable and steady energy output. A nuclear power plant in full-swing operation can produce energy non-stop for an entire year, which allows for a good return on investment because there is no delay in energy production.

3. Stable Base Load Energy

This is related to the feature of dispatchability: output can be dispatched to the system as and when required. For example, wind turbines generate significant amounts of power—when the wind blows. When the wind is blowing, nuclear plants can adjust energy output to be lower. Conversely, when the wind is not blowing and greater energy is needed, nuclear energy can be adjusted to compensate for the lack of wind- (or solar-) generated power.

4. Low Pollution Output

Abstracting from the issue of nuclear waste (see below), the overall output of pollution from a nuclear power plant is quite low compared with energy production from fossil fuels. The current consumption of nuclear energy already reduces over 555 million metric tons of emissions every year.

5. Sufficient Fuel Availability

Like fossil fuels, the uranium used to supply nuclear power plants is in limited supply. However, current uranium reserves are estimated to last another 80 years, whereas fossil fuels have a much more limited lifespan. Switching to uranium might give the Philippines the extra time it needs to find better and cleaner renewable energy resources. Meanwhile, some countries like India, China, and Russia are already working toward using the greener and more abundant thorium to power nuclear reactors. If scientists are able to turn nuclear fusion into a reality, theoretically, the world will never run out of electricity. Turning nuclear energy into sustainable energy requires the use of breeder reactors and nuclear fusion.

6. High Energy Density

Nuclear fission is nearly 8,000 times more efficient at producing energy than traditional fossil fuels. That is a considerable amount of energy density. Because nuclear energy is more efficient, it requires less fuel to power the plant and therefore creates less waste as well.

CONS

1. Expensive to Build

Despite being relatively inexpensive to operate, nuclear power plants are incredibly expensive to build—and the cost keeps rising. From 2002 to 2008, the estimated cost to build a nuclear plant grew from US$2– US$4 billion to US$9 billion, and power plants often surpass their cost estimates during construction. A more recent example is the 1.63 GW European Pressurized Reactor being built by Électricité de France in Flamanville. The cost of this Generation III project has ballooned to over US$ 12 billion (IEA 2019, p. 19). In addition to the expense of building a power plant, nuclear plants must also allocate funds to protect the waste they produce and keep it in cooled structures with security procedures in place. All of these costs make nuclear power quite expensive.

2. Accidents

One of the first things most people think of when they hear nuclear power plant is the disaster at the Chernobyl plant and, more recently, in Fukushima. The Fukushima power plant crisis in 2011 showed that no matter how safe nuclear power plants are designed to be, accidents can and do happen.

3. Produces Radioactive Waste

Although nuclear energy production does not create any emissions, it does produce radioactive waste that must be securely stored in order not to pollute the environment. In small quantities, radiation is not harmful—people are constantly exposed to small amounts of radioactivity from cosmic rays or radon in the air. However, radioactive waste from nuclear energy production is incredibly dangerous.

Storage of radioactive waste is a major challenge facing nuclear power plants. Because there is no way to destroy nuclear waste, the current solution is to seal it securely in containers and store it deep underground where it cannot contaminate the environment. As technology improves, there would be better ways of storing radioactive waste in the future.

4. Impact on the Environment

Nuclear power plants have a greater impact on the environment than just the waste they produce. The mining and enrichment of uranium are not environment-friendly processes. Open-pit mining for uranium is safe for miners but leaves behind radioactive particles, causes erosion, and even pollutes nearby sources of water. Underground mining is not much better and exposes miners to high amounts of radiation while producing radioactive waste rock during extraction and processing.

5. Security Threat

Nuclear power presents a unique threat to national security because it is powered by nuclear energy. Terrorists might target nuclear power plants with the intention of creating a disaster, and the uranium used to produce the power can be turned into nuclear weapons if they end up in the wrong hands. For these reasons, security surrounding nuclear materials and nuclear power plants is extremely important.

6. Limited Fuel Supply

There might be some important pros and cons of nuclear energy, but one of the most important considerations to keep in mind is that nuclear energy is dependent on uranium and thorium to produce energy. Unless nuclear fusion is created or better breeder reactors are built, mankind will eventually be unable to create energy with nuclear power plants. Ultimately, nuclear power is only a temporary solution with a very high price tag.

Nuclear Energy and VRE

How nuclear energy will fit in with the existing realities and the plans and policies of the DOE has to be assessed. The Renewable Energy Act of 2008, together with the Biofuels Act of 2006, was enacted to promote low-carbon energy and at the same time address the Philippines' continuous dependence on imported fossil fuels by promoting the exploration, development, and use of the country's renewable energy sources such as solar, wind, biomass, hydro, and geothermal. The National Renewable Energy Program (NREP) outlines the policy framework and sets out the indicative interim targets within the 2011–2030 timeframe to achieve the goals set forth in the Renewable Energy (RE) Act of 2008.

The DOE is mandated to implement the RE law and to perform the necessary actions for the execution of the policy mechanism set forth by NREP. Several policy mechanisms have been promoted to encourage the development of renewable energy in both on-grid and off-grid systems. Among them is the Renewable Portfolio Standard (RPS) which is a market-based policy that requires power distribution utilities, electric cooperatives, and retail electricity suppliers (RES) to source an agreed portion of their energy supply from eligible renewable energy (RE) facilities. The aim is to increase RE utilization by 35%.

Given the parameters of energy generation in the future, the possible role of nuclear power has to be explored. Both VRE and nuclear power are considered as important low-carbon sources of energy. The literature reveals tensions between advocates of each source in achieving the demands of a low-carbon society. There are several areas where the rivalry manifests.

Foremost is that it takes longer and much costlier to build a nuclear power plant. A summary measure for comparison is the levelized cost of electricity (LCOE), which is the average net present cost of electricity generation for a generating plant over its lifetime. The LCOE is calculated as the ratio between all the discounted costs over the lifetime of an electricity-generating plant divided by a discounted sum of the actual energy amounts delivered. Figure 1 shows the LCOE of various energy-generating technologies reported in November 2019. Nuclear is clearly more expensive than solar and wind.

However, the LCOE comparison does not take into account dispatchability. The main claim used to justify nuclear is that it is the only low-carbon power source that can supply reliable baseload electricity. VRE is not dispatchable. Utilizing electricity from solar and wind in a grid becomes problematic at high levels. In general, supply does not correspond with demand. Back-up generating capacity is required due to the intermittent nature of solar and wind. System costs escalate with an increasing share of VRE. Related to this is the high-capacity factor of nuclear energy (Table 2). The figures imply that nuclear power plants are producing maximum power more than 93% of the time during the year, which is higher than all other sources.

Some experts dispute this advantage of nuclear energy.[11] The article cited in Footnote 12 is titled "Dispelling the nuclear 'baseload' myth: nothing renewables can't do better!" The author argues that practical considerations and simulation studies show that the role of baseload power is overrated. Instead, the electricity system can adopt flexibility in its operation so that supply and demand can be matched instant by instant. The author also maintains that baseload supply can be substituted for energy imports from neighboring regions or countries. This debate can be taken into consideration by the NEP-IAC.

[11] For example, https://reneweconomy.com.au/dispelling-the-nuclear-baseload-myth-nothing-renewables-cant-do-better-94486/ (accessed 07 August 2020)

The last area for comparison is the impact of nuclear energy and VRE on the environment. The most interesting source for discussion is a TEDx talk by Michael Shellenberger and other material he authored.[12] Some of his key arguments are: Solar farms require hundreds of times more land, an order of magnitude more mining for materials, and create hundreds of times more waste than do nuclear plants; and wind farms kill hundreds of thousands of threatened and endangered birds, may make the hoary bat go extinct, and kill more people than nuclear plants. These are some of the factors that caused Mr. Shellenberger to shift his support from VRE to nuclear energy.

There is of course a middle ground. The title of an article captures this position: "Nuclear & Renewables, the Ultimate Power Couple? We Think So."[13] One problem of relying exclusively on VRE is that excess supply is created. By adding resources like nuclear that can generate power on command, much of the excess supply can be eliminated. Estimates show that when there is collaboration between nuclear and renewables, the cost of reaching a carbon-free grid could fall by as much as 62%.

The Way Forward

The goal of the NEP-IAC is to formulate a National Position on a Nuclear Energy Program. The groundwork was already begun through the conduct of energy planning studies on the 19 infrastructure issues of nuclear power development consistent with the IAEA's Milestone Approach. This is reported in the draft of Chapter IX of the Philippine Energy Plan 2018-2040 which is titled "Nuclear Power Program".[14]

This paper provides a framework for the NEP-IAC to craft a national nuclear program that is fair-minded and transparent. Biases have to be avoided, particularly those that emerged from the BNPP controversy. However, there are many factors to consider before nuclear energy can be incorporated in the national program of the DOE. The main obstacle is the cost involved. Investing in a modern Generation III reactor is simply too expensive to make private sector involvement profitable. Meanwhile, a PPP arrangement may not be feasible given limited government resources. If this would be one of the findings of the committee, then there are at least two possible options to cost-effectively incorporate nuclear energy in the Philippines. Both are not mutually exclusive.

The first is the revival of the BNPP. In 2009, Korea Electric Power conducted a feasibility study on the possible revival of the BNPP. The estimated cost at that time to make the BNPP operable was US1 billion. This is much lower than the option of building a new nuclear reactor. In May 2018, it was reported that Rosatom (the Russian state nuclear enterprise) revealed that its analysis of the BNPP showed that it was, in fact, not only possible but safe to refurbish and restart the plant. The assessment was conducted in August 2017. However, in April 2018, Russian Ambassador Igor Khovaev was reported as saying he believes the BNPP is beyond revival. The Philippine government can engage the

[12] "Why renewables can't save the planet" https://www.youtube.com/watch?v=N-yALPEpV4w (accessed 15 March 2019); and "The Real Reason They Hate Nuclear Is Because It Means We Don't Need Renewables" https://www.forbes.com/sites/michaelshellenberger/2019/02/14/the-real-reason-they-hate-nuclear-is-because-it-means-we-dont-need-renewables/#4f9e4d6128f7 (accessed 12 August 2020). The Forbes article refers to this site https://environmentalprogress.org/the-complete-case-for-nuclear/ for data that allows meaningful comparison.

[13] https://www.thirdway.org/blog/nuclear-renewables-the-ultimate-power-couple-we-think-so (accessed 09 August 2020).

[14] https://www.doe.gov.ph/sites/default/files/pdf/announcements/10_Nuclear%20Energy%20Program_19Aug2020.pdf (accessed 24 October 2020).

services of expert consultants to make an objective and unequivocal recommendation on this matter.

The other option is to look into small modular reactors (SMR) which is the emerging technology in nuclear energy. SMRs are defined as nuclear reactors with an electrical capacity of less than 300 MW per module. They could be installed as single modules distributed throughout the grid, which may be attractive in countries or regions with less developed networks, in remote regions, or as dedicated sources of electricity for industrial complexes. Estimates indicate that the LCOE of SMRs could be competitive with larger nuclear units and with other dispatchable generating technologies (IEA 2019).

SMRs have not yet been mainstreamed in the global energy market. However, they are already on the radar of the DOE.[15] Hence, this option can readily be considered by the NEP-IAC.

[15] https://business.inquirer.net/285959/ph-eyes-use-of-small-nuclear-reactors-for-power-generation (accessed 11 August 2020).

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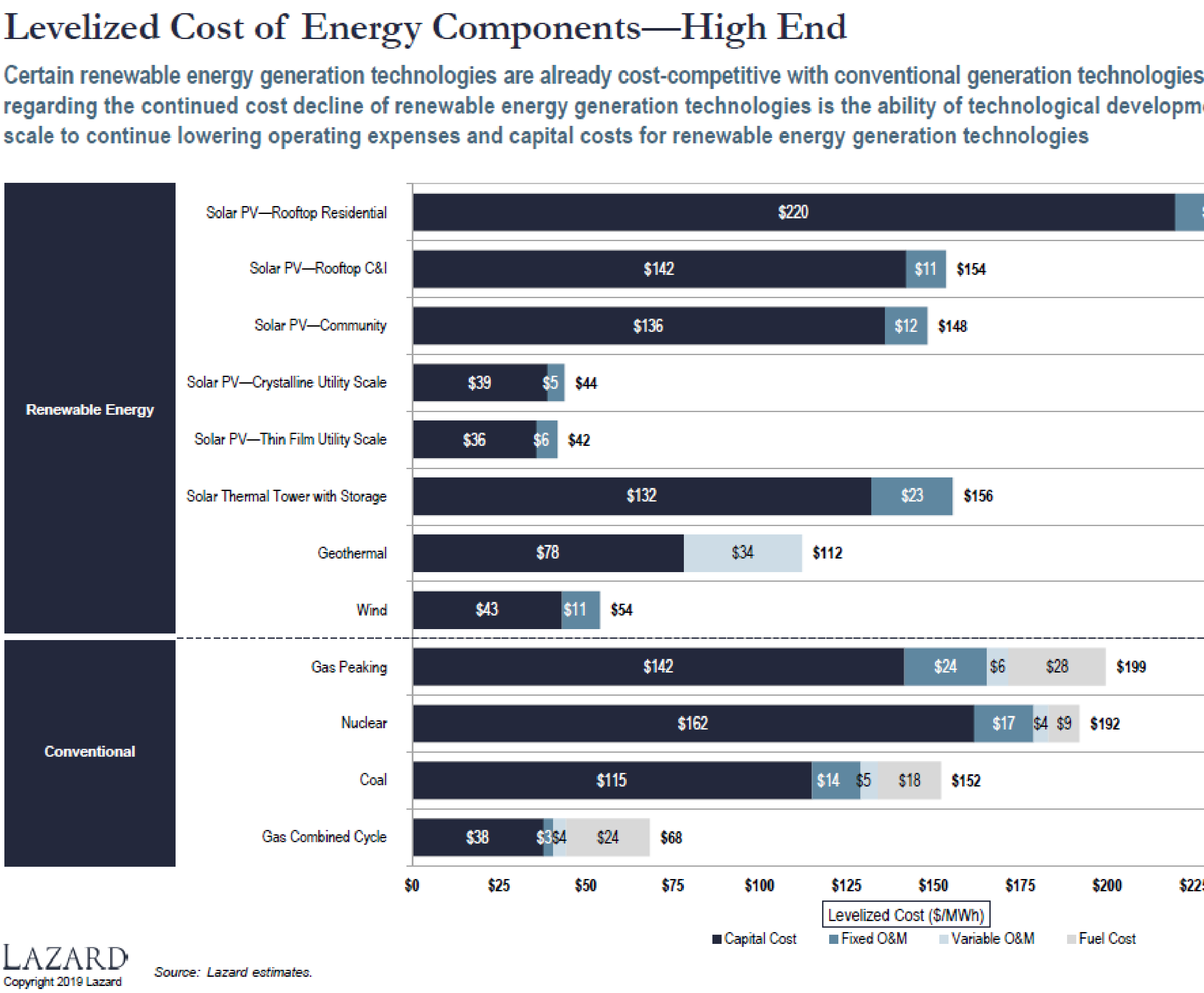
Table 1: GDP and GDP Growth Rate, 1988–1993						
	GDP growth rate	GDP in constant prices (million pesos, base year 2018)	Counterfactual GDP growth rate	Counterfactual GDP in constant prices	Actual GDP in USD (million)	Counterfactual GDP in USD
1988	6.8	4,813,453.58				
1989	6.2	5,112,143.35	6.2	5,112,143.35	42,575.18	42,575.18
1990	3.0	5,267,397.42	5.0	5,367,750.52	44,311.59	45,155.81
1991	-0.6	5,236,934.24	3.0	5,528,783.04	45,417.56	47,948.63
1992	0.3	5,254,614.29	3.0	5,694,646.53	52,976.34	57,412.69
1993	2.1	5,365,818.07	4.0	5,922,432.39	54,368.08	60,007.87
Source of basic data: World Bank database, https://data.worldbank.org/country/PH (accessed 01 August 2020)						

Table 2: Capacity Factors of Energy Generation Technologies	
Source	**Capacity Factor (%)**
Nuclear	93.5
Natural gas	56.8
Coal	47.5
Hydropower	39.1
Wind	34.8
Solar	24.5
Source: https://www.energy.gov/ne/articles/nuclear-power-most-reliable-energy-source-and-its-not-even-close (accessed 11 August 2020)	

Figure 1: Comparing LCOE of Various Energy Generation Technologies



Source: https://www.lazard.com/media/451086/lazards-levelized-cost-of-energy-version-130-vf.pdf (accessed 11 August 2020)