UNDERSTANDING THE DEVELOPMENT AND FUTURE OF NUCLEAR ENERGY IN CHINA

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INTRODUCTION

The Fukushima accident in 2011 altered the course of global nuclear development. After the accident, there was a huge public outcry on nuclear safety, which compelled governments to reconsider their national nuclear ambitions. However, while many countries either stopped, stalled or re-examined their civil nuclear aspirations, China continued to ramp up its civil nuclear capabilities. According to the International Energy Agency (IAEA), China has the biggest installed power capacity since 2012. In fact, its growth trajectory since then contributes to almost a quarter of the global nuclear capacity, having reached 2011 GWe in 2019.[1] For a country whose civil nuclear programme only really advanced in the previous decade, China has come a long way in a short span of time and has more ambitious plans in the offing. In 2000, China had only three commercial nuclear reactors. Today, it has 45 reactors with 12 more under construction.[2] China's nuclear ambitions go

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1. "Nuclear Power in China", World Nuclear.org, at https://www.world-nuclear.org/information-library/country-profiles/countries-a-f/china-nuclear-power.aspx, accessed on May 3, 2020.
2. George David Banks, "The Rise of China's Civil Nuclear Program and Its Impact on U.S. National Interests", ACCF Center for Policy Research, January 2017, at http://accf.org/wp-content/uploads/2017/03/ACCF_China_paper_03.pdf, accessed on May 7, 2020.

For a country whose civil nuclear programme only really advanced in the previous decade, China has come a long way in a short span of time and has more ambitious plans in the offing. In 2000, China had only three commercial nuclear reactors. Today, it has 45 reactors with 12 more under construction.

beyond just powering its own development as it is also focusing on exporting nuclear power technology to other countries through its Belt and Road Initiative (BRI).

In this context, the paper aims to study the growth of China's civil nuclear programme, foresee its future trajectory and assess the possible challenges in this course. It also aims to understand the implications of its civil nuclear projects on its foreign policy and tries to examine the consequences therein, especially in the context of the Belt and Road Initiative. The paper is divided into three parts. The first part examines the history and development of civil nuclear programme in China. It assesses the rationale behind China's decision to develop its civil nuclear programme and the factors that are motivating it to press on. The second part analyses the effect Fukushima had on China's civil nuclear industry and the policy responses to it. The third part examines China's ambitions with regard to its nuclear energy policies to assess its future trajectory, while also addressing the challenges that China faces in this regard.

HISTORY AND DEVELOPMENT OF CHINA'S CIVIL NUCLEAR ENERGY PROGRAMME

The market systems reform in China in the late 1970s was a key factor in transforming the country. Ending centuries of isolation, the economy opened up to pave the way for rapid economic development. As economic growth was contingent on ample access to electricity, the focus was to establish reliable power sources. As the country embarked on rapid industrial development in the 1980s, electricity demand in China increased at a monthly rate of 15 per cent.[3] To meet these demands, China rapidly built thermal power

3. Manpreet Sethi, "China's Nuclear Energy Scenario: Three Years after Fukushima", *Defence and Diplomacy Journal*, vol. 3, no. 4, 2014 (July-September), at http://capsindia.org/files/documents/Defence-Diplomacy-Jul-Sep-2014-inside.pdf, p. 77.

plants which provided electricity at low cost. However, this too led to several challenges. First, there emerged a problem of import dependency as the domestic coal reserves fell short of rising energy demands. Second, it also led to increasing CO_2 emissions, which not only impacted public health but also had serious economic repercussions. Considering the gravity of these challenges, China in the 1990s shifted its focus to explore cleaner and more reliable sources of energy. Thus, nuclear energy gained prominence along with other renewable forms of energy such as wind and solar power.

The first reactor came into commercial operation in 1994, after which plans were devised to build four more nuclear power plants. The idea was to have "moderate development of nuclear power" so that they could build technical expertise while limiting capital requirements.

While nuclear energy in China developed only by the end of the last century, plans to develop nuclear power for electricity generation date back to the 1950s. A reference to it can be found in the First Five-Year Plan of 1953. But, this did not gain momentum until the Chinese city of Shanghai witnessed a severe power supply crisis in the 1970s, which brought nuclear power back to the discussion table. However, it remained there owing to bureaucratic scuffles between different agencies. It was only in 1978 that China officially declared its plan to develop a civil nuclear programme.

As the country embarked on a civil nuclear programme, it decided to begin by developing Pressurised Water Reactors through both foreign collaboration as well as development of indigenous ones.[4] The first reactor came into commercial operation in 1994, after which plans were devised to build four more nuclear power plants. The idea was to have "moderate development of nuclear power" so that they could build technical expertise while limiting capital requirements. China built four plants with designs

4. Philip Andrews-Speed and Sufang Zhang, *China as a Global Clean Energy Champion: Lifting the Veil* (Springer, January 2019), p. 111.

adopted from the USA, Canada, Russia and France, which helped them to test different designs and avert any common design problems.[5]

In the beginning of the new millennium, growing awareness of climate change led to elevating importance of clean energy sources in China's energy policies. In this regard, the 11th National Five-Year Plan (2006-2010) of China acknowledged the importance of clean energy generation by not only mandating the shutting down of old coal-fired power plants but also shifting its focus to cleaner forms of energy with lower carbon footprints.[6] Having virtually no carbon footprint, nuclear energy began to grow in prominence. This trend was reflected in China's *Medium to Long Term Plan for Nuclear Energy Development 2005-2020*, which envisioned achieving 45 GW in operation by the year 2020. China has been able to come very close to achieving this goal, currently having the capacity of 42.8 GW (as of March 2019).[7] This goal, however, has seen modifications over the years, most recently having envisioned 58 GW capacity by 2020, in addition to having 30 GW under construction. This was outlined in the *Energy Development Strategy Action Plan 2014-2020*.[8] In the last two decades, China has been able to develop its civil nuclear programme at an expeditious pace. Today, China has 45 operational nuclear power reactors and 12 more under construction, in addition to several others being planned.[9] China has also developed its own indigenous design for a Pressurised Water Reactor, in addition to expanding uranium exploration and has achieved full fuel cycle capability.[10]

5. Philip Andrews-Speed, "The Governance of Nuclear Power in China", *The Journal of World Energy Law & Business*, vol. 13, issue. 1, March 2020, pp. 23-46, at https://doi.org/10.1093/jwelb/jwaa004, accessed on May 15, 2020.
6. Manpreet Sethi, n. 3, p. 77.
7. "World Nuclear Power Reactors & Uranium Requirements", *World Nuclear Organisation*, May 2020, at https://www.world-nuclear.org/information-library/facts-and-figures/world-nuclear-power-reactors-and-uranium-requireme.aspx, accessed on May 10, 2020.
8. "Nuclear Power in China", n. 1.
9. Ibid.
10. Manpreet Sethi, n. 3, p. 86.

RATIONALE FOR DEVELOPING A CIVIL NUCLEAR PROGRAMME (1970s-PRESENT)

Several reasons led Beijing to develop its civil nuclear programme and focus on advancing it over the years:

To Mitigate Environmental and Public Health Concerns

China's rapid industrialisation led to high demand for power. To fuel its development, China's dependence on fossil fuels grew significantly. By 1990, the total energy consumption rate of coal in China grew to 76.2 per cent, as it became one of the world's largest producers and consumers of coal.[11] Initially, as the focus was solely on industrialisation and economic development, China did not pay much heed to environmental concerns. Instead, it viewed international concerns about its CO_2 emissions as a ploy by developed countries to hinder the progress of developing countries. However, by the beginning of the century, the effects of climate change became apparent, not only globally but also in China. The effects of increasing greenhouse gas emissions on Chinese public health and environment was dire. Having the largest carbon footprint amongst other sources of power, coal inevitably results in large death prints as well.[12] The excessive use of fossil fuels contributes significantly to air pollution. A study undertaken by the physicists at the University of California, Berkeley, revealed that around 1.6 million people die annually (which amounts to roughly 4,000 people every day) in China due to the deleterious impact of air pollution. The study attributes this problem to the extensive burning of coal.[13] This has economic repercussions as well, as it leads to loss of productivity and high amount of healthcare cost, among others. In fact, the World Bank estimates that the economic loss to China caused by air pollution is about 6.5 per cent

11. "China Coal Consumption Cap Plan and Research Report: Recommendations for the 13th Five-Year Plan", *China Coal Cap Project*, October 2015, at https://d2ouvy59p0dg6k.cloudfront.net/downloads/china_coal_consumption_cap_plan_and_research_report__recommendations_for_the_13fyp.pdf, accessed on June 10, 2020.
12. 'Deathprints' refers to the number of deaths caused by a certain kind of energy technology.
13. "Air pollution in China is killing 4,000 people every day, a new study finds", *The Guardian*, August 14, 2015, at https://www.theguardian.com/world/2015/aug/14/air-pollution-in-china-is-killing-4000-people-every-day-a-new-study-finds, accessed on May 21, 220.

of its GDP.[14] Currently, China is the largest emitter of greenhouse gases in the world. Thus, as the problem of air pollution worsened, it became a strong impetus for the development of nuclear power in China. Having one of the smallest carbon footprints of just 15g of CO_2 emitted per kWh, in comparison to coal, which releases 900g of CO_2 per kWh, nuclear energy has appealed to Chinese technocrats and policymakers.[15] In addition, it is an important source to achieve the goals set by the Paris Agreement, which is an environmental accord that was adopted by 197 countries, to collectively combat global warming. The Paris Agreement set a target to ensure that global temperature rise should be controlled to below 2 degrees Celsius until the end of the century, while limiting the increase to less than 1.5 degrees Celsius. Numerous specialists around the world have explored ways to achieve this target. One important study which assessed the role of nuclear power in achieving this target in China, based on simulations, carbon emission funds and other factors, revealed that major changes would be required in China's energy policies and existing trends to achieve this. In pursuit of making these changes to energy policies, the study stated that nuclear power has high level expectations.[16]

To Fuel Economic Development

Since the opening of its economy, China has evolved from an agrarian economy to a global economic superpower in a matter of a few decades. China's economic development has resulted in a burgeoning consumption of energy. Along with the rise of its annual per capita GDP, the rate of energy consumption has also increased proportionately. For example, China's rise of annual per capita GDP was about US$ 100 in 1980 and increased to a whopping

14. Costs of Selected Policies to Address Air Pollution in China", *Rand Corporation,* at https://www.rand.org/content/dam/rand/pubs/research_reports/RR800/RR861/RAND_RR861.pdf, p. ix. Accessed on June 12, 2020.
15. James Conca, "How Deadly Is Your Kilowatt? We Rank the Killer Energy Sources", *Forbes,* June 10, 2012, at https://www.forbes.com/sites/jamesconca/2012/06/10/energys-deathprint-a-price-always-paid/#33ab4771709b, accessed on June 3, 2020.
16. Xin-Jian Xiao and Ke-Jun Jiang, "China's nuclear power under the global 1.5°C target: Preliminary feasibility study and prospects", *Advances in Climate Change Research,* vol. 9, issue 2, June 2018, p. 138.

US$ 7,000 in 2017. Correspondingly, the per capita energy consumption in the same time period also increased from 600 kg to 2,000 kg (of oil equivalent).[17] By extension, this has had a proportional increase in the electricity sector as well. For example, in 1990 China's electric power consumption rate was just about 1/5th that of the United States'. By 2013, China had become the world's largest consumer of electricity, with its energy use growing by 8.4 per cent in 2007, in comparison to the overall global electricity growth rate of 2.4 per cent.[18] This burgeoning energy demand is only expected to grow with the International Atomic Energy Agency (IAEA) predicting that the Chinese households will use almost twice the amount of energy by 2040.[19] One of the key factors that drive China's energy consumption is production expansion.[20] As it is crucial for the country's development, China is not willing to reduce its production expansion. As coal has proven to be detrimental in so many ways, nuclear power has emerged as a viable, alternate option to support its rapid development. These factors have elevated nuclear energy to play an important role in China's energy strategy.

In addition, recognising the need for cleaner sources, China has boosted its renewable energy capabilities. However, these renewable sources of energy, although very effective, have their own limitations. For one, these are intermittent sources of energy and energy storage technologies are not adequately advanced. Secondly, such plants have low capacity factors, high land requirements and non-availability as a baseload source of electricity. Nuclear energy, on the other hand, has a much higher capacity factor. Also, nuclear reactors require less maintenance, need refuelling only once in

17. Mark Hibbs, "Other Issues Critical to Chinese Decision-making", in *The Future of Nuclear Power in China*, Carnegie Endowment for International Peace, May 14, 2018, at https://carnegieendowment.org/2018/05/14/other-issues-critical-to-chinese-decisionmaking-pub-76316, accessed on June 2, 2020.
18. "Renewable Energy in China: A Necessity, Not an Alternative", Wharton University of Pennsylvania, April 20, 2009, at https://knowledge.wharton.upenn.edu/article/renewable-energy-in-china-a-necessity-not-an-alternative/
19. James Griffiths, "China's gambling on a nuclear future, but is it destined to lose?", *CNN Business*, September 14, 2019, at https://edition.cnn.com/2019/09/13/business/china-nuclear-climate-intl-hnk/index.html, accessed on May 29, 2020.
20. Feng Wang, Haitao Yin, and Shoude Li, "China's Renewable Energy Policy: Commitments And Challenges", *Energy Policy*, 38, 2010, at https://www.ourenergypolicy.org/wp-content/uploads/2014/07/China.pdf, accessed on May 19, 2020.

Increasing nuclear cooperation with other countries is not only expected to bring in more money to China but also to create energy dependency, achieve influence in these countries, and increase its say in issues of global nuclear governance. This appears to be China's version of the United States' "Atoms for Peace" programme of the 1950s.

two years and do not depend on natural or environmental variables. In addition, they can be built close to areas of demand. Recognising this and understanding the problem of uneven distribution of energy resources in China, the government has been boosting the nuclear energy projects along with their renewable energy projects. In industrial parts of China that require high amount of baseload energy, nuclear power projects are found more viable and efficient.[21]

To Further its Geo-economic Strategy

With the rapid development of its nuclear technology and nuclear programme, China has been using clean energy technology, specifically nuclear power, for strategic leverage. After a speech delivered by Liu Baohua, the Nuclear Energy Director of the China Atomic Energy Authority (CAEA), the Chinese media stated that nuclear energy is "an important cornerstone of strategic power, a vehicle for civilian-military integration, and a 'China card' to play in the country's international cooperation diplomacy."[22] In this regard, China's nuclear industry is now developing to be a part of the country's dirigiste business model. China is doing this by exporting civil nuclear technology and equipment to other countries through its Belt and Road Initiative. Increasing nuclear cooperation with other countries is not only expected to bring in more money to China but also to create energy dependency, achieve influence in these countries, and increase its say in issues of global nuclear governance. This appears to be China's version of the United States' "Atoms for Peace" programme of the 1950s. The Atoms for Peace programme was so influential that vendors of

21. Zhou Ping, "Nuclear Power Development in China", *Special Reports, IAEA Bulletin,* 1987, at https://www.iaea.org/sites/default/files/29204784346.pdf, accessed on May 3, 2020.
22. Mark Hibbs, n. 17.

the American nuclear industry sold reactors to more than 50 countries globally.[23] This not only boosted US ties with other countries but also paved the way for it to become a global leader in nuclear technology, which allowed the United States to influence the formation of global norms in the field of nuclear power.

China has signed several agreements (or is in the process of signing MoUs) with countries such as Argentina, Egypt, Kenya, Pakistan, Romania, Sudan, South Africa and Turkey, among others. They have even won stakes in the Hinkey Point C project in the United Kingdom. In a meeting of China's political advisory body, a senior nuclear industry official stated that China could build, at the least, thirty overseas nuclear reactors through its Belt and Road Project by 2030.[24] The nuclear technology deployment business is undergoing a systemised development, enabling Chinese vendors to set up supply chains and begin new projects in other countries. This is in distinct contrast to the US and European firms which once held prominence in nuclear exports but are now facing problems of financial challenges and technological stagnation.[25]

China is currently in the process of constructing its first floating nuclear power plant and has thirty more in the pipeline. It plans to deploy it in the South China Sea, where it would not only support its offshore oil and gas exploration but also provide power to its artificial, militarised islands and gain strategic advantage in the contested area.

In addition, China is currently in the process of constructing its first floating nuclear power plant and has thirty more in the pipeline.[26] It plans to

23. Ibid.
24. "China could build 30 'Belt and Road' nuclear reactors by 2030: official", Reuters, June 20, 2019, at https://www.reuters.com/article/us-china-nuclearpower/china-could-build-30-belt-and-road-nuclear-reactors-by-2030-official-idUSKCN1TL0HZ, accessed on June 6, 2020.
25. Manpreet Sethi, "The Asian Nuclear Power Landscape: A Contemporary Examination", in *Security in Times of Uncertainty. Asian Strategic Review* 2017 (Pentagon Press, New Delhi: 2018), at https://idsa.in/system/files/book/book_ASR2017.pdf
26. Viet Phuong Nguyen, "China's Planned Floating Nuclear Power Facilities in South China Sea: Technical and Political Challenges", Belfercenter.org, November 21, 2018, at https://www.belfercenter.org/publication/chinas-planned-floating-nuclear-power-facilities-south-china-sea-technical-and, accessed on June 10, 2020.

deploy it in the South China Sea, where it would not only support its offshore oil and gas exploration but also provide power to its artificial, militarised islands and gain strategic advantage in the contested area.

Evidently, nuclear energy plays a very important role for China with not just economic, but also military and strategic implications. This is why there has been an increased focus on it since the end of the last decade, with China having decided by 2010 to "actively promote nuclear power."[27] With focus on developing its nuclear power capabilities, the beginning of this decade marked China accounting for approximately forty per cent of the reactor construction globally.[28] However, the unfortunate Fukushima accident impacted nuclear programmes around the world, it also threw a spanner in China's ambitious nuclear plans.

THE ACCIDENT AT FUKUSHIMA AND IMPACT ON CHINA'S NUCLEAR ENERGY PROGRAMME

The Fukushima accident in one of the world's most technologically advanced and experienced nuclear power generating countries raised apprehensions among other countries about their own vulnerability to such accidents. While several countries such as Belgium, Germany and Switzerland decided to do away with nuclear power altogether after the 3/11 accident, China's reaction, however, was more balanced and calculated.

POLICY RESPONSES BY CHINA POST FUKUSHIMA

Temporary Suspension of Nuclear Power

Immediately after the accident, the State Council in China temporarily suspended the approval of new nuclear power projects in order to warrant higher safety standards. It also mandated thorough and scrupulous inspection of its existing nuclear facilities to make sure they met the necessary safety requirements.

27. Ibid., p. 134.
28. Jane Nakano, "The United States and China: Making Nuclear Energy Safer", Brookings.edu, June 2013, at https://www.brookings.edu/wp-content/uploads/2014/01/USChina-Making-Nuclear-Energy-Safer_JNakano.pdf

Increased Emphasis on Safety

The Fukushima accident alarmed the Chinese authorities who had significantly accelerated their nuclear power development. The national policy on nuclear energy thus shifted from "moderate development" of nuclear power to "steady development with safety".[29] Just five days after the unfortunate accident, China's State Council declared that "… We will temporarily suspend approval for nuclear power projects, including those that have already begun preliminary work, before nuclear safety regulations are approved … Safety is our top priority in developing nuclear power plants ...".[30] Since then, the Chinese authorities made several promises to ensure safety and presented several new measures to take this ahead. In May 2012, a new safety plan for nuclear power was introduced and in October 2012, the government released a White Paper on energy policies. This document paid added emphasis on high safety standards for nuclear power reactors. Among the many initiatives, two important decisions were taken. The first was to restrict the construction of reactors in inland areas. This was done for safety reasons since reactors in inland areas would not have enough access to water supply in case of a serious accident. The other important decision was to adopt "third-generation" designs for future reactor construction. This was significant because although third-generation power designs have enhanced safety standards, they also cost more and take more time to construct.[31] In addition, new safety regulations were passed. This included the 2020 Vision for Nuclear Safety and Radioactive Pollution Prevention, which placed increased safety standards and stricter inspections. The Nuclear Safety Act was also passed which would ensure higher levels of nuclear safety. The Environmental Protection Department of China also issued new protocols that specified restrictions on site conditions for new power plants. These new regulations took into consideration factors such

29. Viet Phuong Nguyen, n. 26, p. 121.
30. M. V. Ramana and Amy King, "A New Normal? The Changing Future of Nuclear Energy in China", from *Learning from Fukushima: Nuclear power in East Asia* (Canberra: ANU Press, 2017), at https://press-files.anu.edu.au/downloads/press/n3873/pdf/ch04.pdf, accessed on June 13, 2020.
31. Ibid.

as geology and earthquakes while choosing potential sites for new power plants. New bodies were instituted to ensure high safety standards. This included the National Nuclear Safety Administration, China Earthquake Administration, etc. A report by the IAEA revealed that all Chinese nuclear plants were even supplied with new power supplies and water pumps as a precautionary step against flooding and loss of power, as a lesson from Fukushima. Along with this, new emergency response procedures were also created.

EFFECT OF FUKUSHIMA ON CHINA'S NUCLEAR ENERGY PROGRAMME

Slowing Down of Nuclear Growth

The Fukushima accident slowed the pace of China's development in the civil nuclear field. During the time of the Fukushima accident, China was said to have been considering almost 100 new nuclear projects that would be lined up in the coming two decades. However, the safety inspections and assessments delayed the timeline set up for the projects significantly. As approvals were held up for new nuclear power projects, it resulted in a slowdown of the civil nuclear programme. Although the government allowed the construction of coastal plants towards the end of 2012, it also revised its previously set target to achieve 80 GWe by 2020 to 58 GWe.[32]

Continued Support for Nuclear Power

Although the Fukushima accident slowed the pace of development of civil nuclear energy, Chinese officials made it clear that the Fukushima accident would not alter the course of their nuclear energy strategy.[33] Tian Shujia, the Director of two nuclear safety centres of the Ministry of Environmental Protection, said that "There is a guarantee for the safety of China's nuclear power facilities and (China) will not abandon (its nuclear power plants) for

32. Ibid.
33. Dr. Hooman Peimani, "Nuclear Energy in Asia: A Post-Fukushima Perspective", *Journal of Energy Security*, May 31, 2011, at http://sites.asiasociety.org/asia21summit/wp-content/uploads/2010/11/Nuclear-Energy-in-Asia.pdf, accessed on June 15, 2020.

fear of slight risks".[34] China reiterated its ambitious plans for the development of its civil nuclear programme by announcing at the end of 2011 itself that China would make nuclear energy the base of its power-generation system in the next "10 to 20 years", having planned to add almost 300 GWe of nuclear capacity in that time period.[35] China's continued support to civil nuclear power was also evidenced in the White Paper on Energy Policy released in October 2012, which reiterated the role of nuclear energy in China's plans to boost greener sources of power in its primary energy mix. The White Paper even made references to "invest more in nuclear power technological innovations, promote application of advanced technology, improve the equipment level, and attach great importance to personnel training."[36]

Erosion of Public Trust

One of the biggest outcomes of the Fukushima accident was the erosion of public trust in nuclear technology. Concerns over nuclear safety created paranoia among Chinese citizens. It was reported that in the immediate aftermath of the Fukushima accident, panicked citizens hoarded bags of iodised salt in the erroneous belief that it would protect them from radiation.[37]

Public support to nuclear power also declined significantly after the accident. This is evident from comparing the results of polls taken before and after the accident of people living near the Tianwan nuclear power plant in Lianyungang. The first poll was conducted in August 2008 and the second in March-April 2011. Response to the statement, "Nuclear power should be used in our country", got 68 per cent agreement in the first round of polls, but declined to 32 per cent in the second one. Similarly, the concurrence to the idea, "We should quickly increase the number of nuclear power stations in China" saw a steady decline from 40 per cent to 17 per cent! The number

34. Ibid.
35. Lt. Gen. Prakash Katosh, "Nuclear Energy—The Politics of It", *Indian Defence Review,* April 13, 2015, at http://www.indiandefencereview.com/news/nuclear-energy-the-politics-of-it/, accessed on June 2, 2020.
36. Ming Yang and Xin Yu, "Energy Efficiency: Benefits for Environment and Society" (Springer, 2015), p. 152.
37. James Griffiths, n. 19.

Not only has China achieved reasonable amount of experience in civil nuclear power generation, but has also made headway in indigenous nuclear technology and designs. In addition, considering the urgency to tackle the challenging problem of climate change, China appears to stay committed to nuclear power to deal with this crisis.

of people who opposed nuclear power increased from 13 per cent to 54 per cent.[38] These anti-nuclear sentiments translated into widespread protests across the country. In fact, the following year, China's plans to build a uranium processing plant in Guangdong province were also called off due to increasing protests

ASSESSING FUTURE TRAJECTORY OF NUCLEAR ENERGY IN CHINA

The future of nuclear energy in China, just as it would be in every nation, is determined by several domestic as well as international factors. This section assesses these factors and attempts to analyse the future trajectory of nuclear energy in China, while discussing the challenges that it faces in this endeavour.

ASSESSING THE CURRENT TRENDS IN CHINA'S CIVIL NUCLEAR PROGRAMME

Optimistic Nuclear Future

Considering the strides China has been making in the field of civil nuclear energy in the past two decades, China's future in this regard appears to be optimistic. Not only has China achieved reasonable amount of experience in civil nuclear power generation, but has also made headway in indigenous nuclear technology and designs. In addition, considering the urgency to tackle the challenging problem of climate change, China appears to stay committed to nuclear power to deal with this crisis. Projections made by official agencies also appear to be sanguine. The National Development and Reform Commission

38. Ramana and King, n. 30.

of China aspires to achieve the target of 200 GWe of nuclear generating capacity by 2035.[39] In order to achieve these targets, several educational establishments too have been instituted which would help in setting a basis for training of nuclear specialists. The Chinese government has also announced plans to develop nuclear power industrial parks which would not only provide training but also enable the development of its nuclear supply chain.

China has also gone on a uranium buying spree to support its domestic as well as international nuclear ambitions. It has been buying huge amounts of uranium from countries such as Australia, Kazakhstan and Namibia and is also exploring the markets of Canada, Mongolia and Niger.

In fact, China has also gone on a uranium buying spree to support its domestic as well as international nuclear ambitions. It has been buying huge amounts of uranium from countries such as Australia, Kazakhstan and Namibia and is also exploring the markets of Canada, Mongolia and Niger. This is because when China first began to develop its nuclear power programme, its domestic uranium production was enough to meet the demands. However, as China embarked on an extremely ambitious course of development, its domestic production was insufficient. It is estimated that China may require as much as 12,300-16,200 metric tonnes of uranium in 2030.[40] China plans to procure uranium from the following sources to meet its increasing demands: From its domestic reserves, overseas resources from its foreign investments, etc., and purchases from open markets.[41] In expectation of its future uranium requirements China has already begun hoarding uranium from these sources. In fact, in 2015 China's inventory had 85,000 metric tonnes of uranium, which is equivalent to 140 per cent of total annual global uranium demand. This implies that China was buying almost a quarter of the available uranium in the global market.[42]

39. "China's nuclear power output jumps 18% year on year", *World Nuclear News*, February 24, 2020, at https://www.world-nuclear-news.org/Articles/Chinas-nuclear-generating-capacity-continued-to-gr, accessed on May 17, 2020.
40. Mark Hibbs, n. 17.
41. Ibid.
42. Mark Hibbs, n. 17.

The Chinese government is also providing immense support for innovation and technology development. This is evidenced by the number of floating nuclear power plants that China is building to safeguard its interests and provide energy to remote areas. In addition, China is also looking to export this technology to other countries such as Bangladesh which has a small territory with a large and dense population. It is also making strides in the development of indigenous nuclear reactor designs, the Hualong One being a key example of this, having earned the nickname "China's business card", considering its efficacy.[43]

Slow Domestic Growth Rate

As discussed earlier, China has reduced the goal it had set in 2009 to achieve, 70 GW of energy by 2020 to 58 GW by 2020 in 2016. This happened for several reasons. First, the Chinese authorities had mandated more stringent safety clearances after the Fukushima accident. These new rules allow only third-generation nuclear technology designs which take longer to build. In addition, decision to not allow reactors to be built in inland areas had caused delays in the construction of more reactors. Anti-nuclear protests too had led to the stalling of several projects. Cumulatively, these factors resulted in a slower growth rate of nuclear power in China.

Analysts like M. V. Ramana and Amy King also argue that China has been entering into a phase of "new normal". This phase is marked by lower domestic growth rate in the nuclear energy sector. They maintain that China is transforming to a comparatively low-growth economy, shifting from heavy industries to a service providing economy, which sees a relegation in energy demands. They contend that the electricity demand has also reduced as the Chinese economy has been going through some structural changes.[44] Other analysts like Jiang Lin, Gang He and Alexandria Yuan, caution the need to keep up with the changing trends in China's energy sector. These trends that

43. Sam Reynolds, "Why the Civil Nuclear Trap Is Part and Parcel of the Belt and Road Strategy", *The Diplomat*, July 5, 2018, at https://thediplomat.com/2018/07/why-the-civil-nuclear-trap-is-part-and-parcel-of-the-belt-and-road-strategy/, accessed on June 2, 2020.
44. Ramana and King, n. 30.

they refer to are based on their study of GDP and electricity consumption over twenty years, which suggested that there is going to be a quiescent period in energy demand, specifically in richer provinces.[45] For example: Thermal power plants in China operated for about 400 hours less in 2015 than they did in 2014. Similarly, there was a reduction of about 100 hours of nuclear power plants supply of electricity into the grid. There has thus been an electrical supply surplus in China.[46] However, it is not clear if this is a short-term or a long-term trend. Thus, a plateau or a reduction in electricity demand may continue in China, which may result in slower pace of nuclear development in the country. This, however, does not necessarily suggest that the nuclear growth trajectory in China is pessimistic. Some experts perceive this as a "maturing" of the Chinese nuclear industry.[47]

In addition, considering that China is the world's largest emitter of greenhouse gases, its environmental policies have a significant impact on the global fight against climate change. Lately, analysts have been observing a slackening in their renewable energy growth and an increase in its use of fossil fuels. Carbon dioxide emissions by China have increased by approximately 4% in the first half of 2019. Coal consumption has increased, taking it back to the levels China had in 2013.[48] In this regard, it is important to keep the momentum of green energy drive on.

CHALLENGES TO CHINA'S NUCLEAR POWER AMBITIONS

While China's nuclear future appears to be optimistic, it is, however, mired in several challenges.

Safety Concerns

China's nuclear industry holds a safe record, with official documents and statistics suggesting that no serious accidents have taken place in their facilities. The few minor incidents that have taken place have been graded

45. Ramana and King, n. 30.
46. Ibid.
47. Ibid.
48. Zhou Ping, n. 21.

at Level 1 and 2 on the International Nuclear and Radiological Event Scale. The International Atomic Energy Agency—which leads teams of Integrated Regulatory Review Service (IRRS) experts to assess the safety of nuclear regulatory infrastructures of countries with nuclear power capabilities—had also stated in 2016 that China's nuclear safety regulatory framework for nuclear and radiation safety is effective. However, considering the rate of growth of nuclear power in China, experts have emphasised a high focus on ensuring continued safety.[49] Such expressions generally reflect China's poor industrial safety history. For instance, China Labour Bulletin, a Hong Kong based organisation on workers' rights, stated in this regard that while China's safety record has improved over the years "… accident rates, death tolls and the incidence of occupational disease are all still comparatively high …".[50] Official figures estimate that there were, on an average, about 81 deaths every day in the year 2019 from work-related accidents.[51] In addition, considering the poor working conditions and safety culture in China, there are concerns about profits being given priority over safety. Mark Hibbs, author and analyst at the Carnegie Endowment for International Peace, in this regard states that "China faces numerous challenges from its historically weak industrial safety culture and the strain on regulatory capacity that has been exacerbated by nuclear growth."[52] A study undertaken by Jacqueline CK Lam, Lawrence YL Cheung, Y. Han, and SS Wang addressed the question whether China's response to nuclear safety after Fukushima was genuine or just rhetoric. The paper studied the promises made by the Chinese government and followed up the actions it took to enhance safety mechanisms. One of their research findings in this regard revealed that "… China's safety governance has been continuously challenged by institutional fragmentation, inadequate transparency, inadequate safety professionals,

49. "IAEA Mission Says China's Nuclear Regulator Effective; Should Continue to Enhance Safety Programme", *International Atomic Energy Agency*, September 8, 2016, at https://www.iaea.org/newscenter/pressreleases/iaea-mission-says-chinas-nuclear-regulator-effective-should-continue-to-enhance-safety-programme, accessed on September 10, 2020.
50. James Griffiths, n. 19.
51. "Work Safety", *China Labour Bulletin,* March 20, 2020, at https://clb.org.hk/content/work-safety, accessed on May 25, 2020.
52. James Griffiths, n. 19.

weak safety culture, and ambition to increase nuclear capacity three-fold by 2050 …".[53] In addition, the government of China has admitted to 16 safety failures in operating nuclear power plants in 2016. These safety failures were caused due to personnel errors and included reasons such as breaching of operation guidelines and "pressing the wrong buttons".[54] In this regard, the National Nuclear Safety Administration too has discovered a series of flaws and inadequacies in China's nuclear industry ranging from designs to materials. Although these may appear to be small gaffes and oversights, if there is anything that Fukushima has taught regulators it is that minor negligent acts cumulatively add up to cause big disasters.

Concerns of nuclear safety in China are not just limited to their own facilities but also to the nuclear goods and services that they offer to other countries through their nuclear exports. This is even more significant considering that China has been offering nuclear technology know-how to first-timers. In this regard, China thus needs to focus on helping such nations establish the necessary regulatory, security and safety infrastructure, increasing transparency, setting up institutions, establishing stringent quality controls and promoting a safe working environment.

Public Opinion and Anti-Nuclear Sentiments

Decisions regarding nuclear issues in China have historically been made without taking public opinion into consideration. In fact, when China first embarked on constructing nuclear power plants in the 1980s and 1990s, the petitions signed against constructing nuclear reactors were ignored and protestors were arrested.[55] Only recently have the government and nuclear regulators been trying to engage with the public. This is timely, considering the fact that there has been increasing anti-nuclear sentiments brewing amidst the Chinese public. A survey undertaken by the Chinese

53. Jacqueline CK Lam, Lawrence YL Cheung, Y. Han, and SS Wang, "China's Response to Nuclear Safety Post-Fukushima: Genuine or Rhetoric?", Energy Policy Research Group, University of Cambridge, at https://www.eprg.group.cam.ac.uk/wp-content/uploads/2018/11/1834-Text.pdf, accessed on May 18, 2020.
54. Andrews-Speed and Zhang, n. 4, p. 114.
55. Mark Hibbs, n. 17.

As dissent is carefully monitored in China, protests and demonstrations may be curbed if they gain more momentum, especially since the government considers nuclear power to be of strategic national interest.

Academy of Engineering in 2017 revealed that only 40 per cent of the Chinese public supports the development of nuclear power in China.[56] As this dissent gets more vocal, it has been impacting the development of nuclear power. For example, in 2013 and 2016, plans to build nuclear fuel cycle installations were cancelled due to public objections. Protests also led to the plans to build a nuclear waste processing plant in Jiangsu to be cancelled.[57] However, questions about the efficacy of protests remain. As dissent is carefully monitored in China, protests and demonstrations may be curbed if they gain more momentum, especially since the government considers nuclear power to be of strategic national interest.

Xi Jinping has reiterated several times that social stability is a principal priority for him, having stated that "winning or losing public support is an issue that concerns the CPC's survival or extinction."[58] In this regard, the Chinese leadership has recognised the need to communicate with the public and has been taking several measures to address anti-nuclear sentiments.

The Nuclear Safety Law in this regard has made several important provisions. For example, it lays emphasis on increased public engagement. Plant operators are required to hold public meetings with the citizens who live within 30 km of a plant site. This also helps them to communicate the benefits of nuclear power projects with regard to providing jobs and public services. It also enables the National Nuclear Safety administration and nuclear facility operators to provide information related to nuclear safety to the public, by

56. Ibid.
57. Peter Fairley, "China's losing its taste for nuclear power. That's bad news", Technology Review.com, December 12, 2018, at https://www.technologyreview.com/2018/12/12/138271/chinas-losing-its-taste-for-nuclear-power-thats-bad-news/, accessed on May 26, 2020.
58. "China Protest Forcing Nuclear Retreat Shows People Power", *Bloomberg News*, July 15, 2013, at https://www.bloomberg.com/news/articles/2013-07-14/china-protest-forcing-nuclear-retreat-shows-people-power, accessed on July 16, 2020.

including provisions that allow citizens to request information regarding nuclear power projects by local agencies.[59] Since 2014, the National Nuclear Safety administration issued several notices and measures to augment the public information available on nuclear power. Their website too now includes more information on their nuclear programme. China General Nuclear Power Group, the largest nuclear operator in China, too, hosts visitors and works with schools to familiarise them with nuclear science. They have also been devising innovative ways to gain support and promote nuclear power by holding events such as "Most beautiful wedding photos taken at a nuclear power plant."[60] However, China's reputation with regard to its low level of transparency and high level of government control has resulted in questioning of the credibility of the statements and figures that it puts out in public.

China has been signing cooperation agreements with a few countries which do not necessarily have the regulatory requirements to handle a civil nuclear programme. Several countries with whom China has been discussing cooperation agreements are feared to have weak and lax regulatory environments.

BRI: Mistrust and Concerns of Civil Nuclear Trap

As discussed earlier, China intends to use its civil nuclear programme through its BRI projects to push for strategic gains. This has raised concerns by other countries for several reasons. This is primarily because China has been signing cooperation agreements with a few countries which do not necessarily have the regulatory requirements to handle a civil nuclear programme. Several countries with whom China has been discussing cooperation agreements are feared to have weak and lax regulatory environments. For example, Sudan recently signed a nuclear cooperation

59. Philip Andrews-Speed, n. 5, pp. 23-46.
60. "CGN wins honor for innovative social communication", CGN, November 25, 2017, at http://en.cgnpc.com.cn/encgn/c100035/2017-11/25/content_58c264d74cc5492fa6c1bf33550a0d3a.shtml#:~:text=The%20%E2%80%9CMost%20beautiful%20wedding%20photos,%2C%20in%20Shenzhen%2C%20Guangdong%20province, accessed on August 10, 2020.

agreement with China to get its first nuclear power reactor. However, a study by the Institute for Science and International Security in 2017 rated countries based on capabilities to limit nuclear trafficking. Among the 200 countries, Sudan was ranked 194.[61]

In addition, there have been concerns of how having China help in assisting set up nuclear power capabilities may give them a strategic leverage and how they may use this to coerce decisions in their favour in case of discord or tension with partnering countries. For example: China could implicitly threaten to disrupt their nuclear power supply. The most recent example of this is the brewing tensions between the UK and China. Beijing is unhappy with the UK for several reasons. First, China introduced a new security law for Hong Kong on June 30, 2020 which reduces Hong Kong's autonomy and increases China's power to punish protestors and dissenters. In response to this, Britain offered help to up to 3 million Hong Kong citizens who wanted to flee Hong Kong, by making provisions for them to live and work in the UK. This did not go down well with China, who threatened that if the UK does so, it would have to "bear all consequences".[62] In addition, the Chinese company, Huawei, which was given permission to retain a 35 per cent presence in the 5G network in the UK, has witnessed a rescinding of this deal. The recent meeting of Britain's National Security Council decided on new plans that would build western alternatives to Huawei. In this regard, the nuclear power deal between the two countries is speculated to be the next flashpoint, as China has threatened Britain with withdrawal of its support for their new 20 billion pound Hinkley Point C power station. China General Nuclear Power Group (CGN) holds a 30 per cent minority stake in this project, in partnership with EDF.[63] China is well aware of the importance

61. Sam Reynolds, n. 43.
62. Lily Kuo and Patrick Wintour, "Hong Kong: China threatens retaliation against UK for offer to Hongkongers", *The Guardian,* July 2, 2020, at https://www.theguardian.com/world/2020/jul/02/china-could-prevent-hongkongers-moving-to-uk-says-dominic-raab, accessed on July 16, 2020.
63. Catherine Kennedy, "Risk to UK nuclear plants as China threatens to remove support", *New Civil Engineer*, June 9, 2020, at https://www.newcivilengineer.com/latest/risk-to-uk-nuclear-plants-as-china-threatens-to-remove-support-09-06-2020/, accessed on July 17, 2020.

of this nuclear power project for Britain to achieve its decarbonising energy goals, and thus has a leverage of coercing negotiations in its favour. In this regard, Anthony Glees, the director of the Centre for Security and Intelligence Studies at the University of Buckingham considers the Chinese involvement in Britain's civil nuclear power industry as a "ticking time bomb".[64]

China's nuclear export industry too has been facing several challenges, foremost among them being suspicion and scepticism by other countries. State-owned energy corporations like the China General Nuclear Power Group (CGN), for one, has been viewed suspiciously by other countries to be an agency for espionage. The United States, for example, has accused CGN of spying and attempting to steal military secrets of the US. Correspondingly, CGN featured in a list of companies that have connections to the Chinese military put out by the Pentagon.[65] Recently, the Romanian government asked *Nuclearelectrica,* the state-owned energy company in Romania, to terminate its partnership with CGN. Although the deal was signed five years ago to build two new reactors in Romania, it was scrapped after the Romanian Ministry of Economy and Energy—which is a majority shareholder of the energy company—asked the Company to end the cooperation agreement due to concerns over Chinese investments and reliability of Chinese expertise.[66] As more countries are getting sceptical about engaging in nuclear cooperation with China, it has emerged as a major challenge to China's nuclear export projects. China will have to engage in an extensive rebranding strategy to develop its credibility to take its nuclear business further.

64. James Cooke, "Chinese involvement in nuclear power is a 'ticking time bomb', expert warns", *The Telegraph,* July 7, 2020, at https://www.telegraph.co.uk/technology/2020/07/07/chinese-involvement-nuclear-power-ticking-time-bomb-expert-warns/, accessed on July 17, 2020.
65. Tony Capaccio and Jenny Leonard, "Pentagon names 20 'Communist Chinese military companies' operating in US, sanctions likely", *The Print,* June 25, 2020, at https://theprint.in/world/pentagon-names-20-communist-chinese-military-companies-operating-in-us-sanctions-likely/448281/, accessed on July 16, 2020.
66. Ella Kietlinska and Gina Sturdza, "Romania Cancels Deal With Chinese Nuclear Power Company After Raising Concerns In January", *Epoch Times*, June 2, 2020, at https://www.Theepochtimes.com/Romania-Cancels-Deal-With-Chinese-Nuclear-Power-Company-After-Raising-Concerns-In-January_3373821.html, accessed on June 5, 2020.

CONCLUSION

China's aim to meet its goal of achieving 58 GWe of energy by nuclear power by the end of 2020 appears to be unlikely since the operations in October 2019 amounted to only about 45.7 GWe.[67] This, however, does not necessarily mean that the future of nuclear power in China is declining. This could be attributed to the slowing in the development of nuclear power in China post Fukushima, as the country began to ramp up its safety protocols. Owing to the strong policy and financial support of the Chinese government, in addition to its ambitious plans of boosting nuclear exports, it appears that the future of nuclear power in China is optimistic. In addition, it offers numerous advantages to China from strategic, economic, diplomatic to environmental benefits. Analysts also estimate that considering the growth trajectory of nuclear power in China, it may overtake France as the world's second biggest producer of nuclear energy within two years.[68] The annual parliamentary meeting in Beijing that took place earlier this year also illustrated China's continued interest in nuclear development. Delegates during this meeting suggested that China should begin with the construction of six to eight nuclear reactors each year, as it will not only help in curbing the problem of climate change but would also help in creating more jobs, as lack of employment has been emerging as a pressing challenge for China.[69]

The global warming crisis has also become an important impetus for China to develop nuclear power, especially considering that it contributes to 27 per cent of the global greenhouse gases (excluding land use, land-use change, and forestry), making it the largest emitter of greenhouse gases in the world.[70] While China claims to achieve its 2020 carbon emission goals three

67. Ramana and King, n. 30, p. 128.
68. François Morin, "China is still on track to become the world's leading nuclear power", *Energypost.eu,* December 7, 2017, at https://energypost.eu/china-is-still-on-track-to-become-the-worlds-leading-nuclear-power/, accessed on May 20, 2020.
69. "China to dominate nuclear power as Beijing bets on home-grown reactors", *The Japan Times,* June 2, 2020, at https://www.japantimes.co.jp/news/2020/06/02/business/china-nuclear-power-homegrown-reactors/, accessed on July 20, 2020.
70. "China, Country Summary", *Climate Action Tracker,* at https://climateactiontracker.org/countries/china/, accessed on September 10, 2020.

years ahead of its target,[71] it is important to note that its Nationally Determined Contribution to achieve the 2030 Paris Agreement goals are graded by the Climate Change Tracker as "highly insufficient".[72] In this regard, there is a need to accelerate its green growth policies, in which nuclear power can play an important role.

China is also likely to dominate the global nuclear industry. This will not only have domestic implications but will also have a wide range of impacts, from altering the global nuclear architecture to international trade and climate change mitigation. China's growth in nuclear power could also give rise to a new dimension to world power politics among countries such as the US, China and Russia. For example, US President Donald Trump has already been calling for efforts to revitalise the US nuclear industry in order to prevent China and Russia from creating spheres of energy dependencies around the world.

The Fukushima accident invoked the much needed attention to nuclear safety. It brought in the realisation that nuclear safety cannot be taken for granted and there is no place for laxity or negligence. China was quick to learn these lessons, as discussed earlier, as they examined their safety systems and instituted more measures to enhance safety.

The ongoing COVID-19 crisis has also gone to prove the efficiency of China's nuclear power industry. No immediate setbacks are expected in the nuclear industry because of the current pandemic. In this regard Tang Bo, Director of the nuclear safety inspection department at the Chinese Ministry of Ecology and Environment (MEE), stated that the operational reactors have not been affected by the pandemic as none of them had to be suspended and the construction work of new reactor units too has resumed.[73]

71. "China Meets 2020 Carbon Target Three Years Ahead of Schedule", *United Nations Climate Change,* March 28, 2018, at https://unfccc.int/news/china-meets-2020-carbon-target-three-years-ahead-of-schedule, accessed on September 10, 2020.
72. Ibid.
73. "China says virus outbreak will not impact nuclear power plant construction", Reuters, April 15, 2020. https://www.reuters.com/article/us-china-energy-nuclear/china-says-virus-outbreak-will-not-impact-nuclear-power-plant-construction-idUSKCN21X0B4, accessed on June 18, 2020.

Although the future of nuclear power appears to be going on a successful trajectory, there are several challenges that require more attention by Chinese authorities. How China manages these risks and challenges would go a long way in determining its future not just in China but in other nuclear power pursuing countries. First, this positive trajectory could slow down, considering the increasing contradictions in China's green energy and electricity policies. In addition, nuclear safety remains to be a critical challenge. Although China has ramped up efforts to enhance nuclear safety in the wake of Fukushima, it still requires more scrutiny. China's nuclear export strategy, too, if not handled with utmost levels of precaution and safeguards, could lead to disastrous effects in other countries.

These are important factors, which have the potential to change the trajectory of the development of nuclear power in China. In addition, other factors such as breakthroughs in alternate power generation and storage technologies could also impact this growth trajectory. All in all, the way China manages these risks and makes constant, systematic changes to manage them will go a long way in determining China's future in civil nuclear power development.