UxC White Paper: Prospects for China's Nuclear Program

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Overview

As is well known in the nuclear industry, China has the fastest growing nuclear power program of any country in the world today, and it is likely to surpass all the currently leading nuclear power countries, including Japan, France, and the United States, by the middle of the next decade, if not earlier. As many countries are reconsidering their reliance on nuclear power, and, in some cases, renouncing it altogether, China's aggressive nuclear reactor construction program stands not only in stark contrast to much of the rest of the world but it also presents a significant focal point for how the future of global nuclear power may evolve. It used to be said that "all roads lead to Rome," but in the nuclear industry's case, it is quickly becoming apparent that "all roads lead to China."

Factors Supporting Domestic Reactor Expansion

There are many well-documented reasons why China is pursuing such a rapid expansion of nuclear power. First among these is the continued expansion of the country's economy and additional demand for electricity from all sectors, including residential, commercial, and industrial. However, as China's economy shifts from fast growth (i.e., 7-10% GDP growth per year) to a more medium-pace, steady growth (i.e., 5-6% GDP growth per year), the need for electricity alone is not enough to prolong the country's nuclear reactor expansion program.

Like in other countries, nuclear power in China is technically more complex and capital intensive than other electricity generation options, and therefore it is evident that government policies and other drivers are needed to promote nuclear reactor construction. If all that China were looking to accomplish is cheap and fast expansion of electric power generation, it would likely choose to focus primarily on coal-fired generation. However, the coal-only option has not been selected by the government leadership as the country now faces a serious challenge regarding deteriorating air quality in many parts of the country, especially is most big cities, and the related health effects and quality of life issues. A shift away from coal is driven by

necessity, and this is being accomplished through a variety of means, including the increased use of nuclear power, renewables, hydropower, and natural gas. In fact, China's reliance on coal power has dropped from around 75% of all electricity generation just a few years ago to just 65% in 2016.

Another issue that relates to China's coal-fired generation is that most of the large coal mining centers are in the inland north of the country, whereas there are large population and economic centers along the coastline along the south and east of the country. Transporting large quantities of coal by rail and barge is becoming more and more constrained, and thus there is a critical need to reduce reliance on coal generation in these southern and eastern regions. In fact, power shortages have arisen in past years simply because of dwindling coal stocks in key southern regions. The only way for China to solve these issues is through energy diversification away from coal.

Complementary to its clean air objectives, China's nuclear program also fits in very well with the its climate change commitments. In 2016, China's President Xi Jinping ratified an agreement with the U.S. on carbon reduction commitments that led the Paris Climate Change Agreement to go into force. As a result, China is targeting for its greenhouse gas emissions to peak no later than 2030 and to continue to shift away from fossil fuel reliance over the coming decades. Specifically, the country is looking to expand the use of renewables and nuclear power and reach a minimum level of 15% for the share of non-fossil fuels in its overall primary energy consumption by 2020. Also, China has pledged to obtain around 20% of its primary energy from non-fossil sources by 2030. Although there is no definite goal of which we are aware for the share of nuclear power to reach the 2030 climate target, many experts agree that somewhere in the range of 4-5% of total primary energy from nuclear reactors will be needed by 2030, and up to 10% of total electricity from nuclear power is likely needed by 2030.

Beyond the drivers listed above, there are several other considerations for why China continues to advance its nuclear energy program. Among these are local economic development initiatives, as many nuclear plants and related facilities are located in less developed regions. Moreover, given the country's large supply chain that has been built up over the past decade, the only way to maintain the jobs from these sectors is to continue to build new reactors (both at home and abroad). Also, the nuclear energy industry is seen as one of the main high-tech industries that China can develop domestically, which has implications not only for its national prestige but also long-term economic expansion and international export initiatives.

Challenges Impeding the Pace of Growth

The factors propelling nuclear power in China are strong, but this should not allow us to overlook several underlying issues that are already and will likely continue to impede new reactor construction in the country.

Despite the fact that the Fukushima accident is now six years in the rearview mirror, the ramifications of the accident are still being felt in China. While the post-Fukushima safety reviews and reactor design change requirements implemented in China since 2011 have mostly been worked out by now, reactor builders are still in the early stages of embarking on construction of advanced domestic Generation III reactor designs (i.e., the Hualong One, also known as the HPR-1000). It does appear that the first Hualong One demonstration projects at China National Nuclear Corporation's (CNNC) Fuqing nuclear power plant (Units 5 and 6) and China General Nuclear Power Group's (CGN) Fangchenggang nuclear power plant (Units 3 and 4) are going well. Thus, it is imperative that considerably more progress is made on these projects before large-scale construction of these advanced reactor designs can proceed at multiple sites across China.

A positive outcome in China of the Fukushima disaster is that the country's nuclear regulatory structure has been upgraded. China's Ministry of Environmental Protection (MEP) and the National Nuclear Safety Administration (NNSA) were tasked with improving domestic nuclear oversight and inspection regimes. Therefore, these agencies have been awarded new budgets and resources to implement additional safety requirements. This process naturally has taken time, and thus some reactor project reviews have been delayed beyond initial projections.

Issues at some of the other nuclear power plant projects throughout the country may not be entirely in the Chinese companies' control, such as the delays with the reactor coolant pumps supplied by Curtiss-Wright for the AP1000 projects at Sanmen and Haiyang nuclear power plants or the questions surrounding AREVA's forging and manufacturing of reactor components for the EPRs at the Taishan nuclear power plant. However, these delays with the initial AP1000 and EPR projects in China have meant that any follow-on projects that envision using these designs have also been on hold. As the Sanmen and Haiyang projects are now at least three years beyond their originally scheduled startup dates, there has been a freeze on other AP1000 projects both at those sites and at other identified sites (e.g., Lufeng, Xudabao, etc.).

It does not appear that China's nuclear industry is suffering very much from a lack of human resources or financing for new nuclear power plants, but these are naturally areas to maintain vigilance on for various reasons. On the supply chain side, most of the reactor technologies expected to be built in the coming decade (e.g., the Hualong One as well as the Chinese AP1000 and CAP1400) have domestic supply chains capable of supplying up to 90% total

local content. These supply chains are mostly proven already, but there continue to be some questions about some key components and the ability of Chinese suppliers to provide advanced products with the same quality assurances as foreign-sourced equipment. This is clearly an area that will continue to require high attention to detail as more and more nuclear components are sourced domestically.

Financing for new nuclear power plants in China has heretofore been accomplished through a variety of funding mechanisms, and there continues to be strong assurances by the government that investments in new reactors can and will be recoverable. However, the government is also dealing with a complicated situation these days as it begins to implement reforms to the electricity markets that may remove some of the power tariff protections previously granted to nuclear electricity generators. Moreover, as some parts of the country have actually experienced overcapacity issues, nuclear plants have also not been immune from reducing power output or delaying start of operations. Any time a large, baseload nuclear reactor is not operating because of a lack of load requirements on the electricity grid means it is also not able to earn revenues and recover its high upfront capital costs. Whether the power market reforms in China will eventually create issues for new reactor financing remains to be seen, but as experience from the U.S. and other countries shows, any kind of liberalization of power tariffs typically is not good for nuclear power.

As China's economy continues to develop and the country becomes more and more prosperous, there is also a growing awareness among the country's public citizenry around a number of environmental and local issues. Given its proximity to China, the Fukushima accident in Japan naturally created anxiety among the Chinese people as well. The indefinite delay of inland nuclear plant projects in China after Fukushima came directly as a result of local farmers and fishermen raising concerns about the potential impact that a nuclear accident would have on local water resources. There have also been a few high-profile public demonstrations against nuclear projects in China in the past few years, including against a proposed nuclear fuel complex in Jiangmen City, Guangdong Province and against a proposed spent nuclear fuel reprocessing complex in Lianyungang City, Jiangsu Province. And, while protests against a nuclear power plant construction project have yet to matieralize, the possibility definitely exists.

Conclusions

As this paper has helped to elucidate, there are many drivers and challenges for China's domestic nuclear power expansion. Although the national government continues to emphatically insist that it will reach the target outlined in the current 13th Five Year Plan for nuclear power capacity to reach 58 GWe in 2020 with another 30 GWe under construction at that time, UxC takes a slightly more cautious view of the potential future growth. Given the delays discussed above as well as other factors that will likely continue to impede new reactor

projects in the coming years, it is expected that China will probably only reach approximately 50 GWe by 2020. As the pace of new construction starts is expected to quicken in the coming years, the post-2020 period will certainly see even more nuclear capacity coming online. Unless there are any major setbacks in the country's nuclear program, we would expect China to become the world's leading nuclear power country no later than 2030.

UxC Special Report: China's Nuclear Reactor and Fuel Cycle Program

UxC recently issued a comprehensive special report covering all aspects of China's nuclear reactor and fuel cycle market sectors. This report provides in-depth coverage and forecasts for China's nuclear power and reactor exports as well as the individual fuel cycle markets. Additional insights and discussions on the current role and potential future direction of China's nuclear program are also included. Some of the main questions addressed by this report include:

- What reactor technologies will China look to build in the future?
- How many reactors will China have operating in 2020, 2030, and 2040?
- Where will Chinese companies build reactors outside of the country?
- How much of its uranium needs will China be able to satisfy through domestic and foreign mine projects?
- What are China's intentions regarding enrichment capacity expansions and SWU exports?

For more information and to order a copy of this valuable, in-depth report, please contact Jonathan Hinze at jonathan.hinze@uxc.com or +1-603-425-1185.