



Summary of 2023 Report on Chinese Nuclear Power Generation and Costs Analysis

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Summary¹

This document summarizes a report reflecting information gathered from Chinese domestic and international sources on nuclear power plants and its associated development costs. Spanning 207 references from public sources, 123 are in the Chinese language. The analysis is current as of December 31st, 2023.

Summary Table											
Reactor Generation	Average Capital Cost (CNY/KW)	Average Capital Cost (USD/KW)	Proportion Related to financing (%)	Average Construction Duration (months)	Average Operating Cost (CNY/KWh)	Average Operating Cost (USD/KWh)	Reactors in Operation (number)	Reactors under Construction (number)	Reactors Approved (number)	Date of First Reactor Deployment	Date of Most Recent Reactor Deployment
Gen 2	13,129	1,972	21%	68	0.22	0.031	41	0	0	2/1/1994	6/2/2021
Gen 3	17,599	2,561	16%	76	0.305	0.043	13	24	12	12/13/2018	3/25/2023
Gen 4	43,748	6,683	29%	131	Not available	Not available	1	2	0	12/6/2023	12/6/2023

As of year-end 2023, China’s nuclear power generation capacity consists of 55 operational nuclear reactors. In addition, 26 nuclear reactors are under active construction, and 12 nuclear reactors have received State Council approval to begin construction. The 55 nuclear reactors in operation provide 56.9 gigawatts (GW) of gross capacity with 52.9 GW expected net capacity. Expected total investment in nuclear power generation at the end of 2023 across operational, under construction, and approved Chinese nuclear power units is approximately CNY 1.6 trillion (USD 225 billion) across 100 GW of gross capacity yielding a unit reactor cost of 15,873 CNY/KW (Chinese Yuan/Kilowatt) or 2,341 USD/KW reflecting annual currency variations across the construction period.² Overnight construction costs accounts for 82% of total expected costs with the remaining 18% allocated to financing costs. We gathered data on the total construction costs for nuclear projects in China and compiled interest rates for financing during the construction period. Using this information, we computed both the financing costs and the overnight construction costs for each nuclear reactor.

Across operational nuclear reactors, we calculate total costs of CNY 841 billion yielding 56.9 GW gross capacity, with unit cost 14,755 CNY/KW (2,230 USD/KW accounting for annual currency variations across the construction period), overnight construction costs and financing costs of 79% and 21%, respectively. These costs cover all up-front capital costs to build a nuclear power plant.

For the 55 operating nuclear power reactors, average construction duration was 74 months with the shortest at 51

¹ This document summarizes a detailed report with supporting data that are available by contacting the Anthropocene Institute who sponsored this research. Please request the full report at <https://anthropoceneinstitute.com/contact/>.

² CNY/USD exchange rate at the end of 2023 was 7.10.



months and longest at 131 months. Increased construction duration can be explained by adoption of new technology as second-generation nuclear power units required the shortest duration followed by the third and fourth generation, respectively. Increased construction duration also increases financing costs as a component of total construction cost.

For the 24 reactors currently under construction, total investment amounts to CNY 514.1 billion. These projects will add 28.8 GW to overall power generating capacity, with a higher average unit cost of 18,283 CNY/KW. The cost of financing constitutes 14% of total investment. Expected construction duration for projects under construction is slightly shorter, averaging 71 months. This duration figure combines average estimates from operational reactor construction times and media reports of new projects. While the number of actual nuclear reactors under construction is 26, subsequent analysis excludes Xiapu 1 and 2 fourth-generation sodium-cooled fast-neutron reactors as public information on relevant finances are limited.

In 2023, 12 new nuclear power projects were approved by the Chinese State Council, requiring a total expected investment of CNY 237.45 billion. These approved projects expect to provide a cumulative gross capacity of 14.68 GW, with an average unit cost of 16,177 CNY/KW. The above analysis is summarized below in Table 1 showing all reported reactors across construction status.

Table 1

Metrics on All Reactors Across Construction Status								
Status	Reactor Count	Total Cost (billion CNY)	Total Cost (billion USD)	Total Gross Capacity (MW)	Average Unit Cost (CNY/KW)	Average Unit Cost (USD/KW)	Average Cost of Financing to Overall Investment	Average Construction Duration (in month)
Approved	12	237.45	33.44	14,682	16,177	2,279	13.9%	74
Operational	55	840.81	127.42	56,930	14,755	2,230	21.2%	74
Under Construction	24	514.11	73.81	28,830	18,283	2,626	13.8%	71
Grand Total	91	1,592.37	234.67	100,442	15,873	2,341	18.3%	73

Analysis across geographic locations and power plant sites

Chinese nuclear power plants are located across 8 different eastern provinces surrounding large, high electricity demand industrial and population centers with Guangdong, Zhejiang, and Fujian hosting 35 of 55 operational reactors. Inland provinces that are highly populated like Hunan, Hubei, and Jiangxi are currently under discussion but are not prioritized nor approved by the State Council (entity empowered to grant final approval). Other locations like Sichuan province face frequent earthquakes (a magnitude-8.0 earthquake in 2008) and the Bohai Sea, the nearest sea to Beijing, is a shallow, semi-enclosed inland body of water with limited self-cleaning capabilities making it similar to inland areas. In the event of a nuclear accident, the repercussions would extend to one of China's most densely

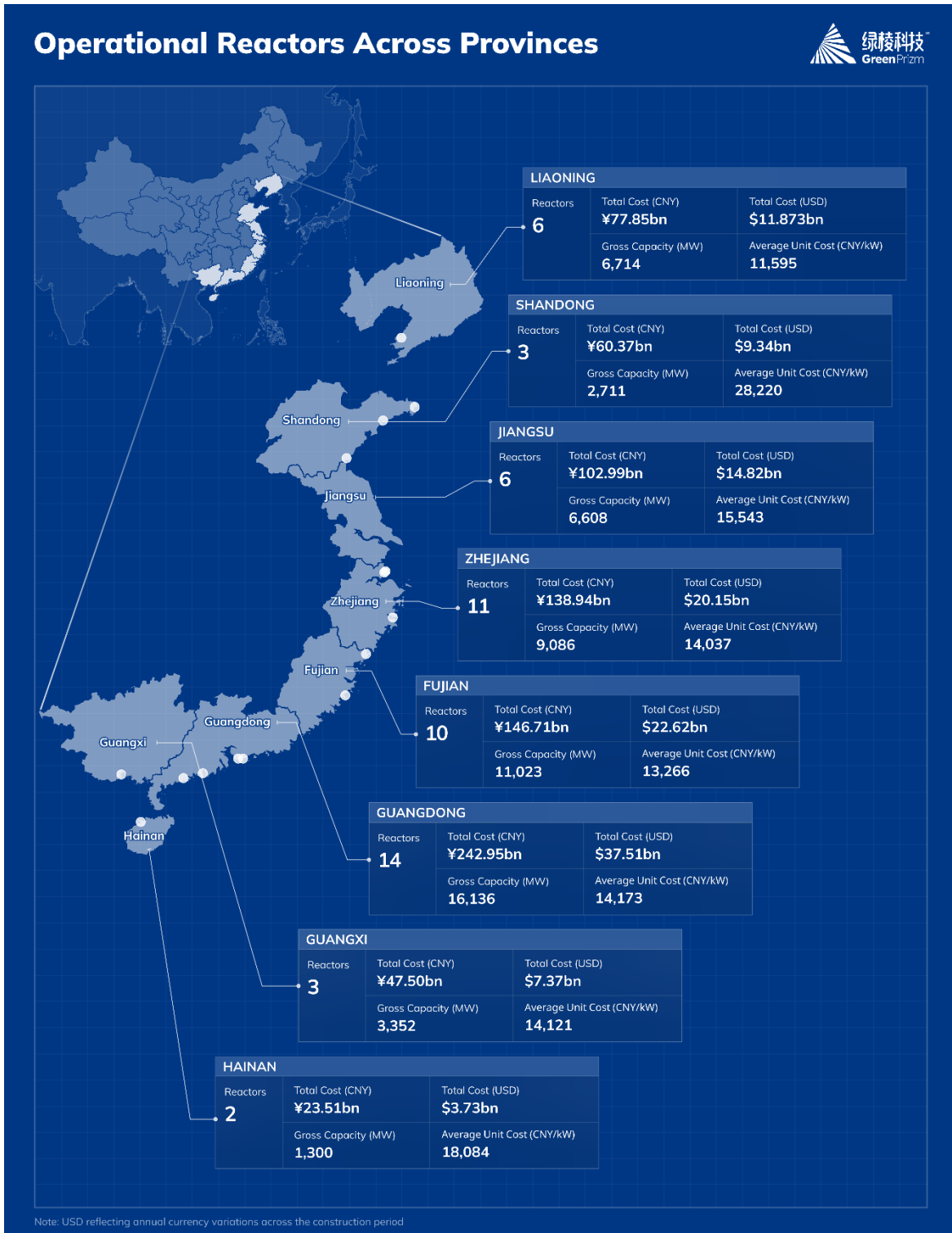


populated areas, home to over 100 million people³. Nevertheless, given the high demand for electricity in the Beijing region, the construction of nuclear power plants is continually underway. Currently, the operational nuclear power site, Hongyanhe, is located at the far end of the Bohai Sea. Additionally, two nuclear reactors in Xudapu, which are closer to the inland area, are currently under construction. Another potential nuclear power project is in Haixing, Hubei province, approximately 200 km from Beijing. This project aims to house six reactors with a total capacity of 7.2 GW and is expected to receive approval from the State Council in the near future. Newly approved and under-construction reactors are still located exclusively within these 8 provinces growing around population centers and provinces of Shandong, Liaoning, and Hainan which expect a significant increase in reactors, from 11 to 24, and gross capacity, from 10.7 GW to 26.2 GW. In Figure 1, we present for each of the 8 provinces, the number of reactors, total costs in CNY and USD, gross capacity, and average unit cost.

³ Source: http://paper.people.com.cn/zgjzk/html/2018-11/05/content_1892254.htm



Figure 1





References

In this research report, data and information are referenced from materials collected on the public Internet, and these references are archived. There are a total of 203 archived reference sources, including:

- 78 reference sources come from the IAEA website, which lists the basic information of nuclear power reactors in operation and under construction in China as of December 31, 2023 (such as reactor name, location, model, gross capacity, construction date, commercial date, etc.).
- 42 reference sources come from the annual reports of the 4 companies qualified to operate nuclear power plants in China. Currently, only CCNP, CGN, SPIG and CHNG are qualified to operate nuclear power plants in China. CCNP began publishing annual reports in 2011 and the other 3 companies began in 2013. Annual reports of these 4 companies up to 2022 were collected along with the nuclear power reactor budgets included in the annual reports of each company during this time. A total of 46 nuclear power reactors budgets for at least 1 year and at most 8 years were obtained.
- 83 reference sources come from multiple scattered data sources, including authoritative official releases data, media news reports, academic reports, securities research reports. This part of the data source helped to improve the list and information of nuclear power reactors (such as including information on nuclear power reactors that have been approved by the State Council but have not yet started construction), supplemented the nuclear power reactors construction budget not listed in the annual report, supplemented the breakdown data of construction cost and power ongoing charge cost, and also helped to complete the definitions of Gen 1 to Gen 4 nuclear power reactor and the definitions of various reactor models implemented in China. In addition, this part of the reference sources also includes some basic information that were used for conversion, such as CNY-USD exchange rate and China CPI inflation that released by the People's Bank of China and the World Bank.