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Analyzing the Drivers of Coal-fired Power in Guangdong Province

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Contents

Preface	1
Guangdong's Progress Toward Achieving Low-Carbon Goals	2
How Coal-Fired Power has Developed in Guangdong	4
The Driving Factors Behind the Development of Guangdong's Coal Industry	7
Driving Force 1: Stimulating Economic Growth	10
Driving Force 2: Addressing Surging Electricity Demand and Ensuring that People Have Power	11
Driving Force 3: Regulating Power Grids Peaks and Integrating Renewable Energy ..	13
Driving Force 4: Optimizing the Coal Power Sector by Shutting Down Small Coal-Fired Units and Replacing Them with Advanced Units That Have a Larger Capacity	15
Conclusions and Suggestions	15

Preface

China is at the forefront of global wind power and photovoltaic development. For many years, it has maintained a leading position in terms of both installed capacity and development speed. In 2022, China's added extra capacity for wind and photovoltaic power plants reached an output of 125 GW; it has exceeded 100 GW for three consecutive years.¹ In March 2023, China's non-fossil fuel capacity surpassed fossil energy for the first time, a pivotal moment in its energy transition. China's wind and solar power industries are expected to continue growing in the coming years. The Energy Bureau predicts that by 2025, wind and solar power will double from 2020 levels.²

Meanwhile, China is still the world's largest consumer of coal and has the largest coal power capacity. In 2021, coal power capacity reached 1110 GW,³ surpassing the combined capacity of all other countries in the world.

China's transition towards low-carbon energy is essential as it will encourage the world to follow suit and ameliorate global warming. China's carbon peaking and carbon neutrality goals are expected to help phase-out coal-fired power in the country and transform the industrial sector. As coal power has historically been a major source of carbon emissions, there has been a large focus on its transition both domestically and internationally.

According to Global Energy Monitor, China newly approved a record 106 GW of coal power capacity in 2022. This was the equivalent of approving two million-kilowatt coal-fired projects per week.⁴ What were the driving factors behind this expansion? Is it justifiable?

This policy brief takes a close look at coal power development in Guangdong Province, which has a strong economy and is known for generating a significant amount of energy using coal. It looks at the driving forces and policy rationale behind expansion in this industry and assesses the validity of current transition strategies. Finally, it puts forward policy recommendations to facilitate Guangdong's power transition to meet China's dual carbon goals.

¹ National Development and Reform Commission (NDRC). (2023). The development of renewable energy in China in 2022. https://www.ndrc.gov.cn/fggz/hjzy/jnhnx/202302/t20230215_1348799.html

² BJX.COM.CN. (2003). The National Energy Administration predicts that newly added wind power capacity could reach 280 GW during the 14th Five-Year Plan period. <https://m.bjx.com.cn/mnews/20230214/1288393.shtml>

³ China Electricity Council (CEC). (2022). <https://www.cec.org.cn/detail/index.html?3-306171>

⁴ CREA & Global Energy Monitor. (2023). China permits two new coal power plants per week in 2022.

Guangdong's Progress Toward Achieving Low-Carbon Goals

Situated on China's southeastern coast, Guangdong has been the country's largest provincial economy for 34 consecutive years. It is renowned for manufacturing and foreign trade, but it is also a major energy consumer and producer of carbon emissions. During the 13th Five-Year Plan, Guangdong made remarkable progress towards going low-carbon by adjusting its energy mix and conserving more energy (See Figure 1). From 2015 to 2020, the share of coal as a primary energy source dropped by 7.3% to 33.4%, while non-fossil fuels rose by 5.4% to make up 30% of the market.⁵ Carbon emissions per unit of GDP were also reduced to 14.5%.

Guangdong's low-carbon transition progress surpassed the national average during this period. Notably, since 2015, Guangdong has demonstrated a clear decoupling trend in terms of carbon emissions and economic growth. The province's economy has expanded while its carbon emissions have decreased (see Figure 2).

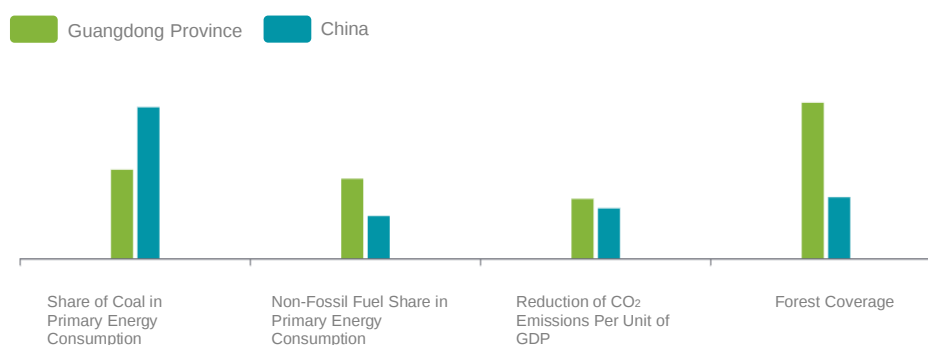


FIGURE 1. Comparison of Guangdong's low-carbon transition progress with the national average in 2020
Source: iGDP, 2023. CCNT provincial action tracker

⁵ General Office, People's Government of Guangdong Province, 2022. The 14th Five-Year Plan for Energy Development in Guangdong. (http://www.gd.gov.cn/zwgk/wjk/qbwj/yfb/content/post_3909371.html)

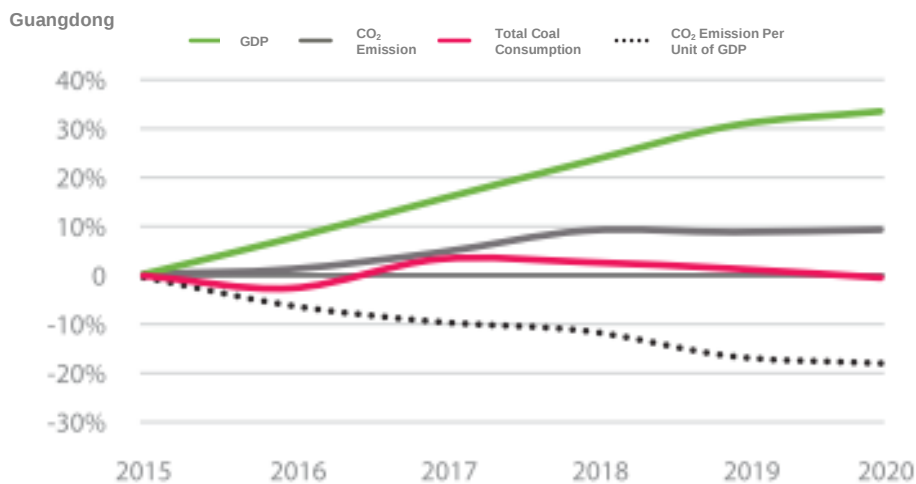


FIGURE 2. The decoupling of economic growth from carbon emissions in Guangdong
Source: iGDP, 2023. Closing the Emissions Gap Through Subnational Climate Actions in China.

Despite making notable advancements towards going low-carbon, Guangdong still faces challenges transforming its power sector. The province has a high demand for electricity compared to developed regions, with annual consumption of 6,000 kWh per capita. Guangdong predominantly relies on coal-fired power and it heavily depends on external sources of power.

As Figure 3 shows, the proportion of thermal power (mainly coal-fired power) in Guangdong has been declining since 2015. However, the overall amount of installed capacity has continued to grow, as has the amount of electricity generated. By the end of 2022, Guangdong had capacity for 68.4 GW of operational coal-fired power. This made Guangdong one of the top five regions with such capacity in China.⁶

⁶ Global Energy Monitor. (2023). Coal-fired power capacity in China (MW).
https://docs.google.com/spreadsheets/d/1sHBsK_Ez7C9XA4HKRQSVopO4IvGSLz65jxdG0GQXeVv/edit#gid=1236850196

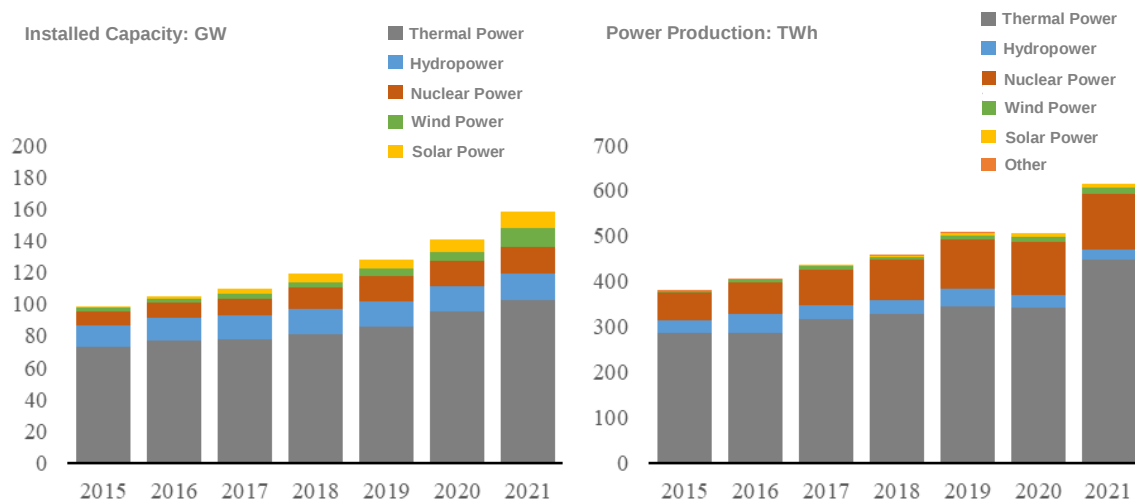


FIGURE 3. Power capacity and production in Guangdong during 2015-2021

Source: CEC, 2023.

How Coal-Fired Power has Developed in Guangdong

Guangdong is actively developing coal-powered projects on a large scale. Data gathered during the preparation of this policy brief shows that, as of 2022, the scale of installed coal power generation in Guangdong Province under development has reached 46.1 GW, ranking first among all provinces in the country. Guangdong's capacity is the equivalent of the combined operational capacity of South Africa, Indonesia, and Germany.

Nearly one-third of these projects have already commenced construction or entered production, and the majority of the remaining projects are scheduled to be operational during the 14th Five-Year Plan period. This suggests that Guangdong's coal power sector is poised for another round of expansion.

This poses a challenge to the objectives outlined in Guangdong's 14th Five-Year Plan for Energy Development, which emphasizes "strictly controlling coal power projects and limiting/phasing out coal consumption."

Coal-fired power plants generally undergo five key stages: they are announced, undergo preliminary development, are approved, constructed, and then become operational. As of 2022, the capacity of coal power projects spread across these five stages has been 10 GW, 10.4 GW, 10.6 GW, 14.5 GW, and 0.6 GW, respectively (a

total capacity of 46.1 GW). Fifty-six percent of these projects are in their later stages (having secured governmental approval, begun construction, or entered operation).

The expansion of Guangdong's coal industry in 2022 was significantly larger than during the previous two years. As shown in Figure 4 below, the scale of coal power under development in Guangdong Province was 18.8 GW and 13.1 GW in 2020 and 2021, respectively. But this surged to 46.1 GW in 2022, a 2.5-fold and 3.5-fold upsurge from the previous two years. The size of installed coal power units under development in Guangdong Province in 2022 was dominated by clean and efficient megawatt units, accounting for 84% of the total, with a total of 34 units. The remaining 16 coal power projects have an installed capacity of over 600 MW. Notably, there are no projects currently under development in Guangdong that have an installed capacity of less than 600 MW.

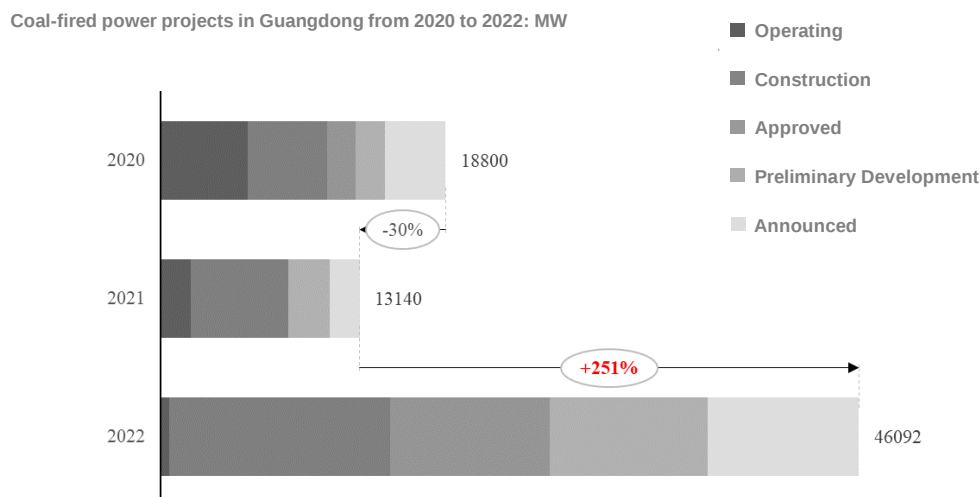


FIGURE 4. Comparison of coal-fired power projects under development in Guangdong from 2020 to 2022
Source: Data for 2020 and 2021 is based on Global Energy Monitor; Data for 2022 is compiled by the author.

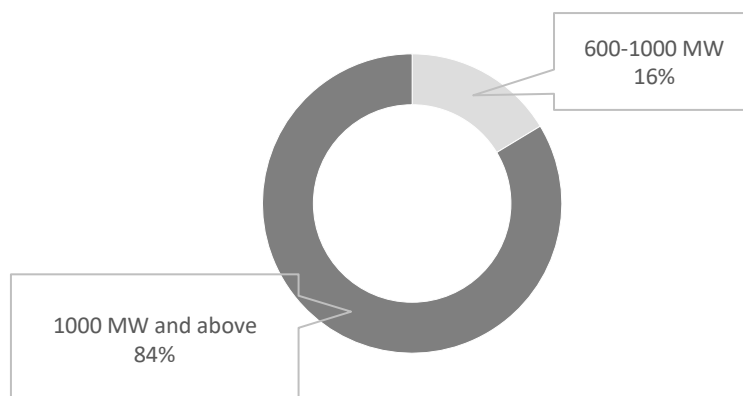


FIGURE 5. Installed capacity of coal-fired power projects under development in Guangdong in 2022
Source: Author's compilation

In 2022, all of the coal-fired power projects under development in Guangdong made varying degrees of progress (see Table 1). All of the projects that had either been announced or were in preliminary stages of development at the beginning of 2022 had gained approval or commenced construction by the end of the year. Projects that were being developed at the beginning of the year had either been approved or had begun construction, and projects that were under construction had progressed significantly. Some had even become operational.

However, it is worth noting that some projects were suspended or even canceled. There are various reasons for this. Some did not meet the conditions for approval, others were canceled due to officials promoting the orderly development of coal power and limiting overcapacity. Among the projects canceled before 2022, some were restarted, with a capacity of 7.3 GW. Some entered the preliminary development phase (3.2 GW), others gained approval (2.1 GW), or began construction (2.0 GW). Other coal power projects were announced, underwent preliminary development, gained approval, or began construction; these collectively had a capacity of 25.7 GW. However, there was no public information available at the beginning of the year on this latter group. Data gathered in the preparation of this report show that most of these projects started from scratch in 2022, so their development process has been extremely quick.

TABLE 1. Operating mines and proposed projects in Guangdong

		Status in 2022: GW				
		Projects Announced	Projects Undergoing Preliminary Development	Projects Approved	Projects Under Construction	Operating
Status in 2022: GW	Announced (4.0)			2.0 (50%)	2.0 (50%)	
	Preliminary development (2.7)				2.7 (100%)	
	Approved (0.0)					
	Construction (6.4)				5.8 (91%)	0.6 (9%)
	Canceled (7.3)		3.2 (44%)	2.1 (28%)	2.0 (28%)	
	None (25.7)	10.0 (39%)	7.2 (28%)	6.5 (25%)	2.0 (8%)	
	Total in 2022	10.0	10.4	10.6	14.5	0.6

Source: Author's compilation

The provincial government supported the massive and rapid development of Guangdong's coal industry. In 2022, 16 of the 25 coal power projects that were undergoing development were categorized as “key construction projects” by the provincial government. Some projects have been listed as such for several years. Some municipal governments took steps to speed up the approval/construction of these projects, e.g. by formulating project management groups and arranging project-focused meetings.⁷ These steps were aimed at fully advancing the development of these projects.

The Driving Factors Behind the Development of Guangdong's Coal Industry

What have been the driving forces behind Guangdong extensively and rapidly advancing coal power projects over the past year? And is there a reasonable basis for these advancements?

This policy brief finds that the most frequently cited reasons include: a need to stimulate economic growth, addressing the surging demand for electricity, and optimizing the coal-fired power structure either by load-balancing or bringing about enhancements (as illustrated in Table 2 below). This has been met with approval by the Guangdong Development and Reform Commission. The Commission has emphasized that coal-fired power projects have been approved because they help “implement national and provincial decisions and deployments on stabilizing the economy and maintaining the supply of energy and electricity and play the role of major electric power projects in stabilizing growth, promoting investment, and maintaining power supply.”⁸ This section presents an analysis of four driving forces and their rationale.

⁷ The People's Government of Jieyang Municipality. (2022). Meeting minutes.
http://www.jieyang.gov.cn/zwgk/jcxcgk/zfgb/2006nian/jyzbdeq/zwtd/content/post_733233.html

⁸ The Guangdong Development and Reform Commission. (2022). The Guangdong Development and Reform Commission permits the Yangxi power station II, No. 7 and No. 8 units.
http://drc.gd.gov.cn/gkmlpt/content/4/4023/post_4023715.html#866

TABLE 2. Reasons for coal-fired power projects under development in Guangdong Province

Coal-fired Power Project	Installed Capacity: MW	Economic Growth and Social Progress	Surging Demand for Electricity	Peak-Shaving	Shutting Down Small Coal-Fired Units and Replacing Them with Advanced Units That Have a Larger Capacity	Heating Supply	Environmental Protection, Energy Saving and Emission Reduction	Integration of Wind Power, Thermal Power, Photovoltaic Power and Energy Storage
Zhanjiang Power Plant of Guangdong Energy Group	2x1000							
Lufeng Jiahuwan Power Plant Expansion Project	4x1000							
Zhanjiang Power Plant of Guangdong Energy Group	2x1000							
Meixian Heshuyuan Power Plant IV	2x1000							
Zhanjiang King Sun Donghai Power Plant II	2x1000							
Zhujiang Power Plant Upgrade Project	2x600							
King Sun Jieyang Thermal Power Project	2x600							
Datang Leizhou Power Plant	2x1000							
Huadian Fengsheng Shantou Power Plant	2x1000							
Shenhua Guohua Yuandian Taishan Power Plant	2x1000							
Yuedian Huilai Power Plant	2x1000							
Huaneng Shantou Haimen Power Plant	2x1036							
Yuedian Bohe Power Plant	2x1000							
Shanwei Power Plant II	2x1000							

Coal-fired Power Project	Installed Capacity: MW	Economic Growth and Social Progress	Surging Demand for Electricity	Peak-Shaving	Shutting Down Small Coal-Fired Units and Replacing Them with Advanced Units That Have a Larger Capacity	Heating Supply	Environmental Protection, Energy Saving and Emission Reduction	Integration of Wind Power, Thermal Power, Photovoltaic Power and Energy Storage
Guangdong Huaxia Yangxi Power Plant	2x1036							
Yuedian Dapu Power Plant	2x1000							
China Resources Xijiang Power Plant	2x660							
Guangdong Lufeng Jiahuwan Power Plant	2x1000							
Huadian Fengsheng Shantou Power Plant	2x660							
China Resources Haifeng Power Plant	2x1000							
Guoyue Shaoguan Comprehensive Power Plant	1x700							
Shenhua Guohua Qingyuan Power Plant	2x1000							
Shenhua Guohua Qingyuan Power Plant	2x1000							
King Sun Zhanjiang Donghai Power Plant	2x600							
Xinhui Shuangshui Power Plant	1x600							
50 generating units, 46.1GW		19	24	15	16	15	10	4

Source: Author's compilation

Driving Force 1: Stimulating Economic Growth

Last year, 19 of the 25 coal-fired power projects undergoing development in Guangdong emphasized that their purpose was to drive local economic growth. Coal power plants require substantial investment as they have lengthy construction and operational timelines. Shanwei, a prefecture-level city in Guangdong, had tax revenue of 2.978 billion yuan in 2021. According to the city's project feasibility report, a coal-fired power project with a capacity for 2×1000 MW entailed investment of eight billion yuan. When it is complete and operational, this project is expected to contribute an extra 560 million yuan in local profits and taxes annually. This will be approximately a fifth of the city's tax revenue.

The economic benefits brought by large coal projects make them highly appealing to local governments, especially in less-developed regions. The total investment towards the aforementioned 25 projects was 189.7 billion yuan, and they are largely being carried out in relatively underdeveloped areas within the province, e.g. Shaoguan, Jieyang, Shantou, and Shanwei.

Due to the scarcity of coal resources in Guangdong, coal is primarily transported to its power plants by sea and/or land from Indonesia, Shanxi, Shaanxi, and Inner Mongolia. Many of these projects require additional investment of around 1 billion yuan so that recipients can establish dedicated terminals with berths capable of accommodating 700,000 to 1,000,000 tons of coal.

In recent years, coal enterprises have incurred widespread financial losses, not only due to having shorter running hours, but due to the price of coal escalating. This has raised questions about how viable it is to invest in coal as a way of sustaining economic growth. According to statistics from the state-owned Assets Supervision and Administration Commission, in the year 2021, high coal prices led to electricity companies sustaining a cumulative loss of 101.7 billion yuan in the coal sector alone.⁹ Data from Polaris¹⁰, and energy services platform, also revealed that eight out of 20 listed thermal power companies reported losses in 2022, and the majority of those saw losses exceeding 2 billion yuan.¹¹

⁹ chinapower.com. (2022). SASAC: China's coal-fired power sector faced a loss of 101.7 billion yuan in the preceding year as power companies ensured a stable electricity supply. <http://mm.chinapower.com.cn/xw/zyxw/20220421/145282.html>

¹⁰ www.bjx.com.cn

¹¹ BJX.COM.CN. (2023). Unfortunate news: major thermal power enterprises report annual losses. <https://news.bjx.com.cn/html/20230203/1286412.shtml>

Feasibility reports often provide optimistic assessments of the economic benefits of newly-built coal power plants, based on the assumption that their utilization hours will be high (exceeding 4,500). However, according to data published by the China Electricity Council, the amount of coal power used in China has been on a downward trend since 2015; currently it is used approximately 4,400 hours per year.¹² As the country has set targets to go “dual carbon,” and because more renewable energy facilities are being installed, it is expected that coal power will continue to decrease; there could even potentially be the premature closure of coal plants. As a result, there is a dim forecast on the investment returns of long-term coal power. What’s more, around 80% of the funding for these projects currently comes from bank loans. If ventures persistently incur losses, this could adversely affect the financial solvency of enterprises. It could lead to a rise in firms defaulting on their bank loans and potentially trigger credit risks within the banking sector.¹³

Driving Force 2: Addressing Surging Electricity Demand and Ensuring that People Have Power

Guangdong has consistently ranked first in terms of GDP in the country, but more electricity is consumed there than anywhere else in China. Consequently, the province emphasizes that it needs to have a stable power supply. Nearly all of the firms in Guangdong that have earmarked coal power projects have stressed that their projects meet the escalating demand for electricity and are there to ensure people are properly provided with power - these points are specifically highlighted. The cogency of this argument has undoubtedly been shaped by recent power shortages both inside and outside the province. In 2021, Guangdong saw an increased demand for power; this was driven by factors like post-pandemic economic recovery and extreme temperatures. Between January and August, the electricity consumed across Guangdong surged 17.33% compared to the previous year; this surpassed the national growth rate. In September, the province’s peak load soared to 141 million kilowatts, setting a national record.

Numerous industrial enterprises in Guangdong have been confronted with a tight power supply, and so they have tried to stagger the use of electricity with various schemes in order to prevent power cuts, e.g. operating for three days and suspending

¹² CEC. (2023).

¹³ Ma Jun, Sun Tianyin. (2020). Methodology and application of assessing climate transition and physical risks: a case study of coal-fired power and mortgage loans. Tsinghua Financial Review, 09:31-35. DOI:10.19409/j.cnki.thf-review.2020.09.006.

operations for four, or operating for two days and suspending operations for five. Some energy-intensive enterprises have even resorted to reducing or halting production during specific time frames.

Although Guangdong did not encounter widespread power shortages last year, the pace at which coal power projects were approved in Guangdong notably quickened following severe and well-publicized power cuts in Sichuan in August. Between August and October 2022, the Guangdong Development and Reform Commission approved nine projects, with total capacity of 17.2 GW. Between 22 and 31 August, the Commission approved four projects (7 generating units) that have total capacity of 6.7 GW. Between 9 and 22 September, two further projects (4 generating units) were approved, with a total capacity of 4 GW. And from 1 to 17 October, three more projects (6 generating units) were approved, with a total capacity of 6.5 GW.

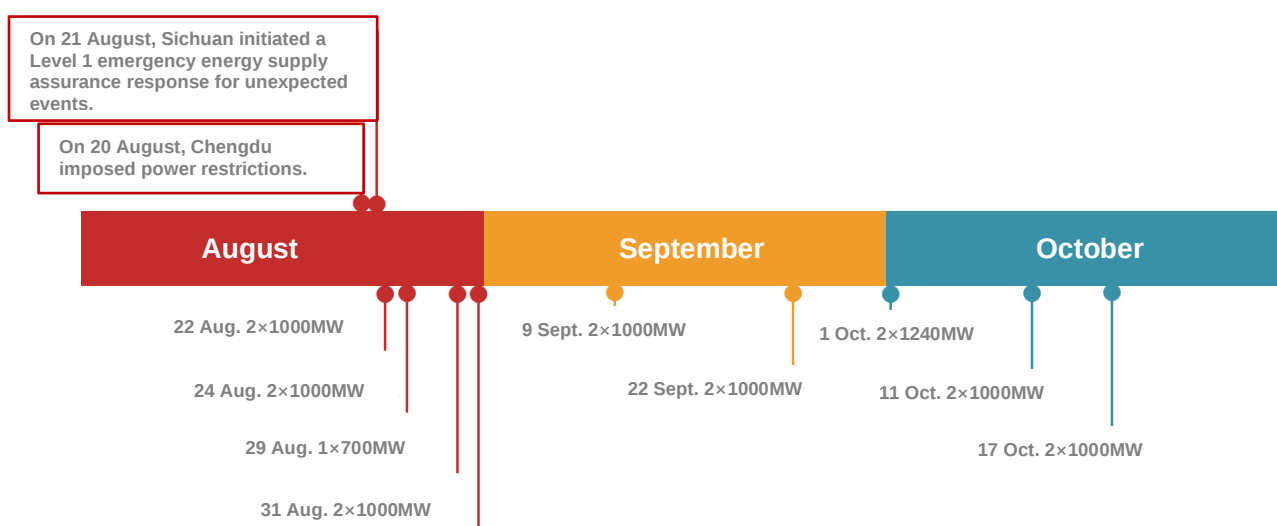


FIGURE 6. Coal-fired power projects approved in Guangdong between August and October 2022

Source: Guangdong Development and Reform Commission, 2022.

Environmental impact assessment reports show that most coal power projects indicate their intention to be operational for over 4,500 hours annually. However, on average, since 2015 the number of hours that coal power plants are operational in Guangdong is in the region of 4,000 hours. Even in 2021, when the region's power supply was under strain, coal power was only used for some 4,390 hours. This suggests that the actual utilization rate of these projects may be significantly lower than anticipated.

In recent years, China has managed to meet the new demand for electricity to a significant extent by introducing facilities that use renewable energy sources. The 14th

Five-Year Plan led to the accelerated growth of wind power and photovoltaic installations, making it less likely that there would be a demand for further, large-scale coal power projects. This has been the case with Guangdong.

Guangdong's 14th Five-Year Plan for Energy Development predicts that the electricity consumed in the province will reach 880 TWh by 2025 (an increase of 187 TWh from 2020). There are plans to install new wind power, photovoltaic, biomass power, nuclear power, and natural gas power generators, with a combined capacity of 80.4 GW. Based on the average number of hours that energy was used nationally in 2021, these newly-planned power stations will be able to meet the rising power demand in Guangdong without needing to augment coal-fired power generators. They will have capacity to supply an additional 209 TWh of electricity.

Driving Force 3: Regulating Power Grids Peaks and Integrating Renewable Energy

Renewable energy generators are characterized by their intermittency. As the number of renewable energy plants, i.e. wind and solar plants, continues to expand, it has become more important that regions adjust how they produce electricity while maintaining grid balance. Fifteen of the 25 coal power projects that have been under development in Guangdong over the last year have outlined commitments to aid the balancing of the grid. Notably, 16 of the 19 units that have stipulated this have an individual capacity of 1000 MW or more.

More wind and solar power plants will mean greater demand for grid flexibility and standby capacity. However, the extent to which demand should be met by coal plants, especially new million-kilowatt coal-fired units, needs to be carefully assessed.

Guangdong has placed a large emphasis on the development of flexible resources in the power sector. Documents such as the 14th Five-Year Plan for Energy Development and the Implementation Plan for Carbon Peaking emphasize the importance of a number of measures. These include: promoting the flexible retrofitting of existing coal power units; accelerating the construction of power stations with pumped storage facilities; adapting power stations with new energy storage facilities according to local conditions, and rationalizing plans for reducing carbon peaks in the gas and electricity sector, i.e. with load centers in the Pearl River Delta region.

Guangdong plans to introduce an additional 2.4 GW of pumped storage capacity by 2030 and approximately 36 GW of installed gas and electricity capacity. By 2025, the amount of installed capacity for new energy storage is expected to reach 2 GW. By 2030, the installed capacity of power stations with pumped storage facilities is expected to exceed 15 GW.

It will also be possible to prevent peaking by utilizing grid-side and load-side resources, e.g. with inter-provincial cooperation projects and demand-side responses. After these additional, flexible resources have been incorporated, Guangdong should conduct a thorough evaluation to determine whether there is still a need for additional peak-shaving. That should be addressed and could determine whether there is a need to introduce new coal-fired power stations.

On the other hand, even if coal is needed to ensure system regulations, new, large coal-fired units do not necessarily have advantages over retrofitted units. Guangdong should explore whether the service life of small, existing units could be extended, with more enhanced regulation over the amount of energy consumed, and carbon emissions. With faster response speeds, small units have advantages over large units in terms of start-stop times, ramp rates, and minimum output. In terms of costs, newly-built units are under higher financial pressures to repay debts and interest during their early operational stages. Units that have been operating for a longer period of time have lower financial costs and their finances depreciate at a much slower pace. Although the fuel consumed by large units is lower than that of small units due to optimal operating conditions, supercritical units with a capacity of one million kilowatts and 600,000 kilowatts during low-load operations see a much more pronounced drop in energy efficiency compared to subcritical units with capacities of 600,000 and 300,000 kilowatts. As a result, there is a significantly narrower gap in terms of coal consumption and carbon emissions per kilowatt-hour.

Guangdong has many coal-fired units that have been operational for under 15 years with a capacity of 300 MW. These units could leverage their advantages to a greater extent by being retrofitted and extending their service life. They could thus play a vital role in enhancing the flexibility of the power sector.

Driving Force 4: Optimizing the Coal Power Sector by Shutting Down Small Coal-Fired Units and Replacing Them with Advanced Units That Have a Larger Capacity

One of the main driving forces behind developing coal power projects in Guangdong is that new projects help to optimize the industrial sector. Over half of the projects that are currently in development state this as an objective; they are launched with the aim of shutting down small coal-fired units and replacing them with advanced units that have a larger capacity (an individual capacity of 600 MW or more). Some of these projects have also set aims to have higher parameters (e.g. higher steam parameters that enhance unit efficiency), consume less energy, and produce fewer emissions. Such aims will help them to develop coal plants that are cleaner and more efficient.

However, this could lead to an increase in carbon emissions. The 2007 Plan for Shutting Down Small Coal-Fired Units in Guangdong states that "building a 600,000 kW unit requires shutting down 420,000 kW of small units; building a 1,000,000 kW unit requires shutting down 600,000 kW of small units."¹⁴ These estimated replacement ratios might not be met in practice. At one such power plant in Zhanjiang, only 298.03 MW of small units were shut down while two new 600 MW ultra-supercritical units were built. Therefore, the total installed capacity could become much greater with newly-built units than it was before, even with the phasing out of small units.

Many oil-fired units are being phased out and shut down in Guangdong. However, even advanced coal units that have a larger capacity and higher parameters produce more carbon emissions per unit compared to small oil-fired units. Therefore, even if new coal-fired units were built with the same capacity as the oil-fired units they replace, this could still lead to the production of more carbon emissions.

Conclusions and Suggestions

Guangdong's significant economic size and huge demand for electricity have driven the large-scale development of its coal industry. There have been a number of motivations for developing this industry: the desire to stimulate economic growth with investments, the need to meet growing electricity demands and ensure a stable power supply, and the goal of promoting energy efficiency and reducing emissions.

¹⁴ General Office of People's Government of Guangdong Province. (2007). The plan for shutting down small coal-fired units in Guangdong.

However, the reality is that coal is not a panacea for achieving such objectives. Continuing to promote large-scale projects will drive up the cost of investments, and there will be additional costs in the pursuit to drive transitions across the energy sector, as well as costs attached to the environment.

In order to pursue high-quality development, improve efficiency, and meet the dual carbon goals, China's regions should tap into the value of existing coal-fired power units, actively promote renewable energy and create space for renewable energy storage. This will be the most cost-effective way of achieving such objectives. In Guangdong Province, the following would be beneficial:

- 1) Strictly limiting further expansion in the coal industry and instead promoting the upgrade of existing coal-fired power units. It is essential that the construction of new coal-fired power units be immediately halted, and that Guangdong reduce its reliance on traditional coal energy sources. Guangdong needs to promote space in the market for renewable energy sources that can be used to produce electricity. At the same time, it is important to take into account the different power resources spread across different regions in the province, e.g. the amount of installed capacity and the distribution of alternative power resources. There should be a detailed roadmap for upgrading and transforming coal-fired power units, and this should be developed to meet the specific needs of each region. It is also important to ensure that in the short-term, actions are aligned with long-term, low-carbon objectives. The province needs to factor in long-term policies that have been signaled and the expectations for relevant investment in the market. It needs to maximize opportunities and avoid a situation where future costs could be incurred from further transformations.
- 2) Quickly develop and roll out renewable energy. Renewable energy sources will help transform industry, spur economic growth, and will help the province to simultaneously undergo high-quality economic development while meeting low-carbon goals. Guangdong should focus on playing to its offshore advantages and developing wind energy resources in the region. It should promote the large-scale development and usage of offshore wind farms, and establish offshore wind energy bases. Guangdong should also actively implement photovoltaic systems, and adapt its power generators in specific regions, e.g. industrial parks and rural areas.

- 3) Guangdong should introduce a wide range of approaches to alleviating electricity/power shortages in the province; these should cover energy storage, demand-side responses, and inter-provincial power transmission mechanisms. It should promote the storage of new energy sources, drive innovation by demonstrating new energy storage technologies, and introduce pumped storage stations that factor in local conditions. Market reform and certain pricing mechanisms will help industrial actors to establish a variety of programs that incentivize users to participate in demand response and strengthen demand response capacity. Guangdong should also actively roll out “clean power” projects, and explore establishing cross-grid and inter-provincial mechanisms for providing mutual assistance in case of emergencies.

As an economic powerhouse with an intense need for electricity, especially along the eastern coast of China, Guangdong’s low-carbon transformation of its power sector will set a precedent for other coastal provinces with equally substantial electricity demands. This transition will make a significant contribution to China’s carbon peaking and neutrality goals.