THE LANTAU GROUP

China Watching Brief

When the Water Runs Out: China's Latest Power Crunch

23 August 2022

The Situation

On 14 August 2022, Sichuan's provincial government announced a round of power cuts for industrial power users lasting six days from 15-20 August (inclusive). By 21 August, the Sichuan blackout had been extended to 25 August and was also including Chongqing. At the time of publishing, almost every region in Sichuan, with the exceptions of Panzhihua and Liangshan, continues to observe a total industrial power blackout. At the same time, other central Chinese provinces including Hubei and Hunan, as well as eastern provinces including Jiangsu, Zhejiang, and Anhui, have all begun implementing some power rationing and peak shaving measures, although nowhere near as severe as in Sichuan.

These measures have been taken to reduce load and ensure power supply to residential power customers during a period of low hydropower production and heightened demand brought on by an extended heat wave. On 21 August, 2022, Sichuan triggered a "Level 1 Emergency Event Energy Supply Guarantee Response." This Level 1 Response prompts the deployment of emergency response measures including backup power supply vehicles, emergency diesel generators, and reallocation of power resources from other provinces, serving as a clear indicator for the deepening severity of the power crisis.

Why is There a Power Shortage?

The main issues leading to the power insufficiency and power curbs are the extended heat wave and accompanying drought that has engulfed most of central and eastern China for over a month now. These hot temperatures have elevated power demand for cooling across the country, leading multiple provinces to record new historical highs for their peak power demand throughout July and August. Not only have the temperatures been hot, but they have been significantly hotter than in past summers, for a longer period of time. For Sichuan, this hotter-than-normal weather has been most pronounced over the past three weeks but goes all the way back to last month. Indeed, even back at the beginning of July, Sichuan was already facing tight supply for both peak power demand and daily power consumption, releasing policies to entice major industries to participate in peak-shaving via preferential power pricing schemes. The recent weeks have seen this extreme heat exaggerated to newfound heights, however, necessitating more decisive action.

Contact for this Brief:

David Fishman
Senior Manager
dfishman@lantaugroup.com
+86 185 1619 4400

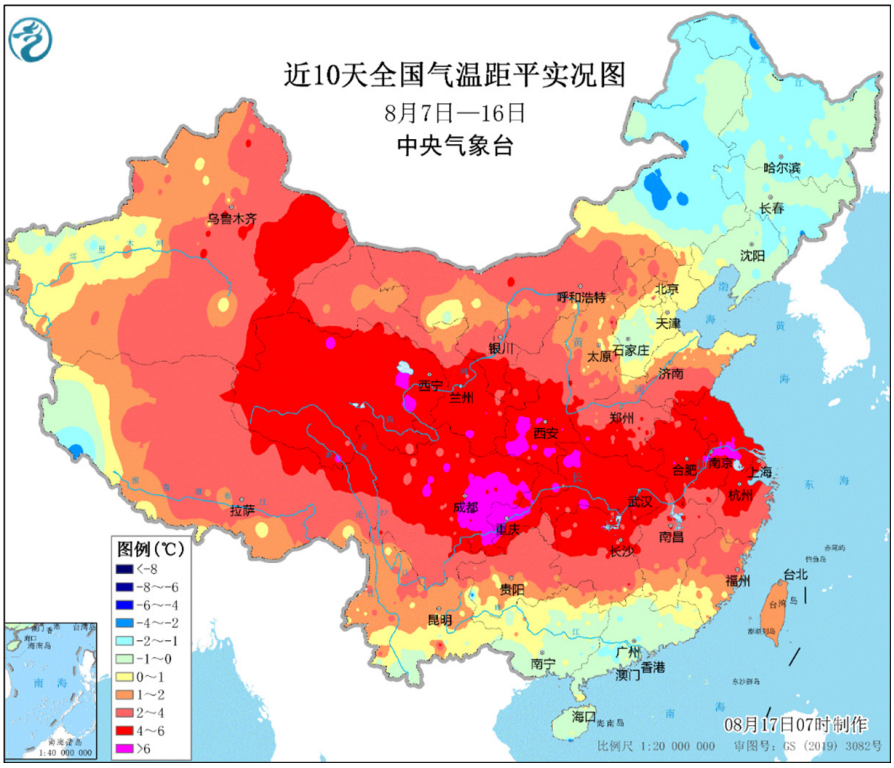
Okay it's Hot. How Hot is it?

Most of Central and Eastern China, including Sichuan Province, has seen daily high temperatures of 38-42 degree Celsius for over a month.

The below image from the China Meteorological Administration reveals the extent and degree of the extreme weather: for the period of time just before the power rationing began, most of eastern Sichuan (the more industrialised and populated part of the province) has seen temperatures greater than six degrees Celsius higher than normal (indicated by the areas in purple). At the same time, much of the rest of central and eastern China saw temperatures between four and six degrees Celsius higher than normal. This has contributed to skyrocketing power demand for cooling (air conditioning) across not just Sichuan, but the rest of the Central Grid (to which Sichuan belongs) and the Eastern Grid (to which Sichuan exports power).

According to State Grid of Sichuan, the province set new records for peak power load six times over the first few weeks of August, hitting 60GW by 15 August and eventually reaching 65GW by 21 August, representing a >25% increase to peak load versus the same period last year. For comparison, 60GW is roughly the winter peak demand of the entire United Kingdom.

Figure 1: Average Temperature Differential from Normal, 7-16 August 2022



Source: China Meteorological Administration

Title Translation: "Average Temperature Differential from Normal – Last 10 Days, 8/7-8-16"

... Meanwhile, the Timing Couldn't be Worse for Hydropower

A 25% rise in peak power demand would be challenging enough for many grids, but this issue is compounded for Sichuan many times over by the fact that this rise in power demand is arriving after two months of poor rainfall and drought conditions, during what is normally supposed to be Sichuan's rainy season. This means that at the same time as its peak load and power consumption levels are soaring, Sichuan's hydropower, which comprises the bulk of its generation capacity and power consumption, is only able to operate at a fraction of its full nameplate capacity. Sichuan's media have reported that rainfall upstream of its key hydroelectric dams is down nearly 40% this year, drastically reducing the rate at which those reservoirs can be replenished.

Additionally, during periods of extreme hot weather, water evaporates much more rapidly from the surfaces of reservoirs and lakes, reducing water availability and, subsequently, hydropower generation. State Grid Sichuan estimated at the beginning of the power curbs that evaporation and lower head levels had hydropower production declining at a rate of 2% *per day* over the period of extreme heat, a truly startling figure.

Hydropower production has been drastically reduced by the drought, exactly when it was most needed to meet soaring demand caused by the heat wave.

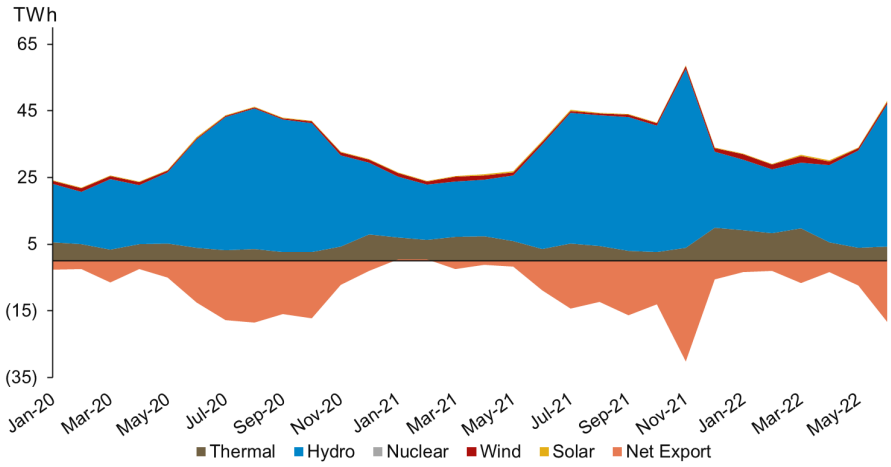
This one-two punch of heightened demand and restricted supply brought on by poor rainfall and an extended heat wave, necessitated the grid company taking actions to curb power demand. According to State Grid Sichuan, this power shortage is a "dual-shortage", that is, both a shortage of capacity to meet peak demand (in GW) and a shortage of generation volume to meet daily consumption (GWh).

How Bad is the Shortage?

Well ... it's bad.

Let's start with what we know. According to the State Grid Corporation of China, Sichuan has around 120GW of total generation capacity, comprising 94GW of hydropower (the most in China), 18GW of thermal power, and less than 10GW of wind, solar, and biomass combined. Overall, hydropower makes up over 78% of Sichuan's total nameplate capacity and under normal circumstances meets over 80% of Sichuan's power consumption needs, both among the highest rates in the nation. Traditionally, Sichuan is a huge exporter of power, sending about a third of its hydropower generation to other provinces during the rainy season (April-October).

Figure 2: Sichuan Monthly Power Generation, January 2020 - May 2022



Source: TLG Analysis

Because of its reliance on hydropower, Sichuan is therefore one of the provinces MOST vulnerable to the effects of droughts (the only other province even comparable is Yunnan). Sichuan's rainy season should ordinarily be a period of time when its reservoirs are full and power prices cheap. Indeed, a number of major energy-intensive industries have set up operations in Sichuan in recent years to take advantage of the lower-cost surplus hydropower (even including Bitcoin miners, before they were chased out by government policy in 2021). But an extended, severe drought such as we've seen this year can have a crippling effect on hydropower production, as reservoirs take progressively longer to refill and be ready to generate again. Pictures from the Houziyan Hydropower Station made available by State Grid Sichuan on 17 August showed water within the reservoir nearly 40 meters below its normal level, nearly completely disabling generation from that plant.

Figure 3: Houziyan Hydropower Station Water Level Comparison

Source: State Grid Sichuan Power Company

Top Label Translation: "Regular water elevation level,1842 meters"

Bottom Label Translation: "Current water level 1804.2 meters (dead water level 1802 meters)"

At the same time, a report from Chuanguan News[1] stated Sichuan's 94GW of hydropower capacity was generating only 450GWh per day in mid-August, implying that Sichuan's hydropower fleet was operating at an average capacity factor of roughly 20%, or about half of what it was at this time last year (recall that last year was also a relatively poor year for hydropower; July/August 2020 saw capacity factors as high as 75-80%). By the time this piece is published, hydro production should have dropped even more, since the heat wave has only continued.

But That's Not All ...

With such drastically reduced hydropower output, Sichuan is unable to even meet local power demand, yet is still expected to export power to other provinces.

It gets worse. Despite the poor generation performance, Sichuan must still honour its contracted power exports to the rest of the country. There are five operational 800kV UHVDC lines bringing Sichuan hydropower to Shanghai, Jiangsu, Zhejiang, and Jiangxi, with further customers in provinces neighbouring those. The total export capacity of these five lines exceeds 30GW (and is expected to expand to over 65GW by 2025). On 19 August, Sichuan media indicated these lines were still operating to deliver their contracted power volumes, despite the local shortages. It's unclear how long this power will continue to be exported ex-province, considering the severity of the local power shortage, but cross-province transmission is usually given highest priority in China's power dispatch planning. If these exports are suspended, already-tight power supply in eastern China, which is enduring its own heat wave, will be further affected. Zhejiang, for instance, would be hard pressed to give up its Sichuan power imports considering it has already been forced to adopt some milder peak-shaving measures itself, trimming near 10% of its peak load (12.5GW) via provincial order.[2] It's likely the declaration of a Level 1 Energy Supply Emergency in Sichuan could prompt Sichuan's ex-province power supply contracts to be temporarily nullified under their Force Majeure clauses.

1 https://www.thepaper.cn/newsDetail_forward_19572792

2 http://news.sohu.com/a/578949971_121305425

Once we look past the hydropower to other energy types, we find more stability, but not enough capacity. Sichuan's 18GW of coal capacity is usually dispatched as firm backup when hydropower production dips in the dry season and would see light use in the rainy season when hydropower is producing at high levels. Those coal plants are certainly running at full capacity right now, as long they are able to get enough fuel. For the sake of argument, let us assume Sichuan's 18GW of coal plants are currently able to operate at a 90% capacity factor, yielding a daily production of approximately 389 GWh of power.

Finally, Sichuan has its variable generation, which should be making some small contribution (especially the solar, in this hot weather) but can't be treated as firm supply. Even if we are generous and assume Sichuan solar and wind each get 5 hours of production/day, they can only contribute an additional 50GWh of power.

Totalling the rough daily output for hydropower, coal-fired power, and renewables, our rough estimate for Sichuan's daily generation capacity in mid-August is around 889 GWh of power, even before accounting for power exports or hydropower's continued decline in output (supposedly -2% per day). We expect nearly half of that is directly consumed by the residential sector, which was already consuming a daily average of 344 GWh back in mid-July[3], well before the hot temperatures went into overdrive in August. Power for commercial buildings, the agricultural sector, and the volumes earmarked for exports probably use up the rest of the daily generation, leaving very little for the industrial sector (which is normally around 60% of Sichuan's power demand). This assumption is supported by the reports that some commercial buildings in Sichuan have started rationing power[4], indicating the insufficiency is deepening, even freed from the burden of the industrial load.

From a peak load perspective, the situation was even more grim at the time the power curbs went into effect, although it should be alleviated for the moment. By our calculations, Sichuan currently only has 40-45GW available at any given moment to meet peak load. This would result in very tight supply during peak hours, *even during normal times*, necessitating peak shaving. Furthermore, because of the way the current power load is structured, with Sichuan residents running their ACs all day long, there are no peaks or valleys to observe in the Sichuan power load curve; the whole day is one continuous peak. At the current moment, with the industrial load removed from Sichuan's grid, they're ok from a peak load perspective, but it will still be nigh-impossible to restart industrial production until residential and commercial cooling demand eases.

What About Commercial and Residential Power?

At this point, Sichuan's power generation is just enough to cover daily residential, commercial, and agricultural consumption, leaving nothing for the industrial sector.

While power cuts are not yet broadly mandated for commercial buildings in Sichuan or other provinces, a number of commercial facilities including shopping malls and office buildings have implemented power saving measures on a voluntary basis, including disabling elevators and limiting/disabling air conditioning. Last week, images from office buildings in Chengdu with office workers at their desks alongside large blocks of ice blown by electric fans gained traction Chinese social media.[5] In some of the most severely affected parts of Sichuan, there have been reports of rolling blackouts lasting up to six hours for residential power customers in parts of Guang'An and Dazhou[6], although these seem to be more localised and non-reflective of the state of supply for the provincial grid as a whole, but rather weaknesses in local distribution grids. At the time of publishing, (23 August 2022) the Sichuan grid is still able to maintain power supply for residential and most commercial power customers (along with agricultural power demand) across the province, as is mandated by provincial power dispatch rules.

3 https://xw.qq.com/amphtml/20220816A04L5Z00

4 https://www.scmp.com/economy/china-economy/article/3189225/chinas-power-crisis-sichuan-sparks-widespread-rationing-amid

5 https://std.stheadline.com/sc/realtime/article/1865411/

6 https://k.sina.com.cn/article_6489420874_m182ccb44a0010139b3.html?from=society

What Happens Next?

The shortages are likely to persist in some form until reservoir levels recover to normal seasonal levels, which could take months.

This isn't going away anytime soon. Although the initial round of industrial power cuts for Sichuan and Chongqing was initially scheduled to conclude on 20 August, an understanding of the underlying features of the power shortage made it clear to us that this was entirely too optimistic. As long as the as the un-derlying conditions restricting supply (drought, insufficient water flow) have not been resolved, Sichuan (and the rest of the central grid) will continue to be vulnerable to spikes in demand and be forced to ration power, even beyond 25 August.

Sichuan has little-to-no backup options beyond its limited coal-fired power. Having missed nearly an entire cycle of its normal rainy season, Sichuan's rivers are likely to remain at depleted levels through the fall and winter, even after the heat wave ends and power demand returns to normal levels. With the main river for hydropower production in Sichuan, the Jinsha River, feeding directly into the Yangtze, these water shortages will continue to influence other river systems and impact hydropower generation potential, both throughout central China, as well as regions that import power from central China (including eastern China). As long as the river flow rates remain depressed, Sichuan hydropower genera-tion loses the capacity to be treated as baseload, instead becoming a variable generation source that can produce power at high capacity for part of the day, but then must be operated at lower levels in order to allow the reservoir to refill from upstream during the rest of the day. While this is normal behaviour for hydropower plants in other parts of the word, or during other seasons, this is definitely not how Sichuan hydropower normally operates during the rainy season.

Until the situation re-normalises, coal-fired power will be required to fill in the gaps, and any additional demand beyond what can be met by hydropower and coal will be subject to curbs. Additional production from wind and solar can also help as every MWh generated by non-hydro eases the need for hydro generation in any given period, allowing more time to replenish reservoirs. Additionally, any upstream rainfall at this point will be helpful but pinning the recovery effort on the fickleness of the weather is an uncertain waiting game. You cannot know when the weather will finally turn, so you have to be conservative in case the rains come later than you were expecting, creating an even more severe problem later.

This will have lasting effects for power users in Sichuan, especially energy-intensive industries that are more likely to see their power restored last. This includes key upstream suppliers for the battery supply chain like lithium producers, with Caixin recently quoting an anonymous source from the battery industry saying the disruption to the Sichuan battery supply chain will soon force production halts for electric vehicles.[7]The same Caixin article also points out that Jinko Solar also has a silicon production facility in Sichuan with no timeline on resumption of production. Already, automotive industries in Shanghai including SAIC and Tesla have been reporting production stoppages due to the manufacturing interruptions affecting their upstream suppliers in Sichuan.[8]

7 https://www.caixin.com/2022-08-22/101929121.html

8 https://www.bloomberg.com/news/articles/2022-08-18/tesla-asks-chinese-government-to-help-secure-power-to-suppliers

About The Lantau Group

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About the Author:

David Fishman is a senior manager at The Lantau Group with 8 years of experience in the Chinese power sector, covering nuclear, coal, solar, wind storage, and grid infrastructure. At TLG, he focuses on our transactional and commercial due diligence work for energy developers, lenders, and financiers looking to buy, sell, or invest in Mainland China energy assets. His work in China also involves supporting MNCs with their evaluation and execution of their long-term power strategies, including evaluation and procurement of low-carbon power and renewable energy certificates. David is based out of the TLG office in Shanghai, serving the needs of our customers across Mainland China.

Could Anything Have Been Done Differently?

While all countries have heat waves, the one affecting China has been record-setting in both intensity and duration. Chinese media have referred to it as a once in 60-years event, accentuating just how exaggerated these high temperatures have been. While Sichuan was indeed overexposed to hydropower, with relatively little coal-fired power to back it up, there was also little historic precedent to anticipate and plan around an extended extreme weather event like this (such as building more backup coal capacity that would see little use under normal conditions). This is a record-smashing event, but a remarkably disruptive one, since the effect of the event once it happens is so long lasting. For other types of rare events like the unusual failure of a generation unit or breakdown of transmission elements, workarounds or repairs can be conducted much faster and the impact can be limited - for instance, only requiring more aggressive peak shaving - rather than resulting in a sustained, broad-based reduction in available electricity generation.

That being said, Sichuan also suffers from relatively poor regional transmission and distribution infrastructure, with most of its cross-province lines focused on transporting Sichuan hydropower to distant importing provinces, not supporting Sichuan with imports in the event of local power insufficiency. Had this infrastructure been more robust, Sichuan would have had more channels for imports to make up for local insufficiency and manage available hydro resources differently. Even now, renewable generators in Northwest China are suffering from low demand and weak power prices for their generation, while at the same time Sichuan labours under crushing power demand and faltering hydropower generation. Long-distance transmission infrastructure between Gansu and Sichuan doesn't currently exist, and the economic case for building such infrastructure was likely very weak before. Perhaps those calculations are now changing.

Events like this provide an opportunity for the emergence of more sophisticated discussion around security of supply and the need for more accurate hydro resource optimisation and system planning. For instance, when New Zealand experienced several separate extreme drought events in the early 2000s and late 2010s, it elevated this discourse considerably among public policymakers and industry stakeholders. Surely, countries like Norway, Brazil, or Venezuela[9] will also be paying close attention to the situation in Sichuan and examining whether any similar vulnerabilities exist in their generation systems. At the same time, Sichuan could also be looking to those countries to fine-tune best practices in signalling when and how other generation resources are needed, or how to compensate or structure arrangements for generation flexibility to accommodate infrequent but massive shifts in power supply/demand, such as those caused by droughts and extended heat waves. Certainly, current climate science indicates such events are only trending to occur more frequently as we make our way deeper into the 21st century.

9 92%, 85%, and 69% reliant on hydropower for electricity generation, respectively.