Analysis of Sichuan power crunch in summer 2022

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***Abstract*—Sichuan, China suffered from a severe electricity crunch in the summer of 2022. As Sichuan is one of the provinces with the largest power generation in China, this electricity shortage shocked everyone. According to our investigation, the main cause of the Sichuan power crisis was the long-term heat and drought beginning that July, which damaged Sichuan's power generation structure dominated by hydroelectric power. This paper demonstrates several potential solutions to Sichuan's problems, such as optimizing the power generation structure, developing energy storage technology and so on, providing theoretical support for further research on development of the Sichuan power system.**

I. BACKGROUND

In the summer of 2022, Sichuan experienced unprecedented high temperatures. The extremely high temperature weather caused Sichuan's electricity load to rise sharply, exceeding the capacity of Sichuan's power grid, causing large-scale intermittent power crunch in Sichuan. This paper will analyze the power crunch in Sichuan, the actions taken by all parties, and the impact on businesses and residents.

A. Introduction of Sichuan Power System

Sichuan is located in the hinterland of southwest China, with extremely rich water resources. Due to the Hengduan Mountains, the water flow drop in some river sections, such as the Yalong River, Dadu River, Jinsha River, etc., is very large. Sichuan is a natural cascade hydropower station development base, and four of the five major hydropower stations in China are located in the Jinsha River reach in Sichuan Province. The total installed hydropower capacity and annual power generation both rank first in China, accounting for 21.2% and 29.8% of the total hydropower in China, respectively. With its rich water resources, Sichuan has become a major province of clean electricity export, with a large amount of electricity exported to central and eastern China [1].

1) The Power Strucutre of Sichuan

The power structure of Sichuan is dominated by hydropower. By the end of 2021, the installed capacity of hydropower had reached 88.87 million kilowatts, with thermal power representing 18.25 million kilowatts, and new energy contributing 7.23 million kilowatts, while the annual maximum power load was about 52 million kilowatts, indicating that there was theoretically no power gap in quantity. In terms of power generation, the total annual power generation of Sichuan Province in 2021 was about 432.9 billion kWh, nearly 80% of which came from hydropower [2].

2) West-East Electricity Transmission Project

China's coal resources are mainly distributed in the western and northern regions, while the hydropower resources are mainly concentrated in the southwestern region. However, the primary energy resources in the eastern region are scarce and the power load is relatively concentrated in that region. The imbalance of energy resources and power load distribution determines the necessity of power transmission from the west to the east. The ‘West-East Electricity Transmission Project’ aims to convert the energy of the western provinces and regions rich in coal and hydropower resources into power resources and deliver them to the eastern coastal areas, where power is scarce [3].

According to the national strategy of the ‘West-East Electricity Transmission Project’, Xiangjiaba, Xiluodu, Jinping, Baihetan and other large cascade power stations in Sichuan are all planned and developed by the state and its electricity is distributed as a whole across the country. There is a fixed proportion of distribution within and outside the province. Sichuan does not give priority to power consumption, and excess electricity is only sent out. Therefore, according to the power distribution, nearly one third of Sichuan's electricity needs to be exported, and it is preferred that it be exported to cities in East China, such as Jiangsu, Zhejiang and Shanghai.

B. The Current Situation Regarding Electricity Demand in Sichuan

In recent years, Sichuan's economy has maintained a rapid growth trend, with an average annual GDP growth rate of 11.78%, which is 10.76% higher than China's average. Corresponding with economic development, the power demand in Sichuan Province has also maintained a rapid growth trend. In 2021, as

shown in Fig. 1, the power consumption of the whole society reached 327.48 billion kilowatt hours, an increase of 40.96 billion kilowatt hours over 2020, or 14.3% year-on-year.

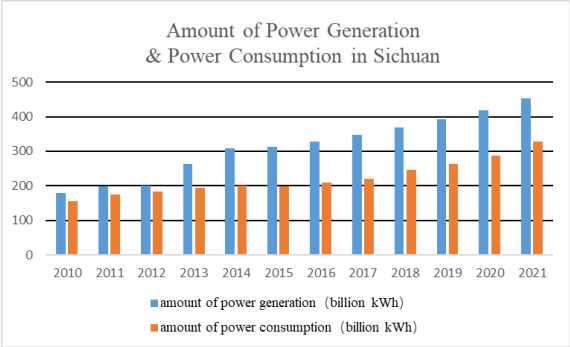

Fig. 1. Power Generation & Power Consumption in Sichuan

Corresponding with power demand, the power generation of Sichuan Province has also increased with the rapid economic and social development and the continuous growth of regional power consumption. In terms of the total amount, as shown in Fig. 2, the power generation in Sichuan Province was consistently higher than the power consumption from 2009 to 2021. From the perspective of growth rate, the growth rate of power generation began to slow down after 2015 and was slightly lower than the growth rate of power consumption, and there was an imbalance between power supply and demand [4].

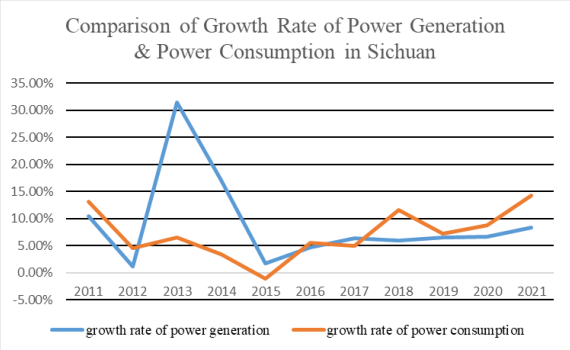

Fig. 2. Comparison of Growth Rate of Power Generation & Power Consumption in Sichuan

C. Extreme Weather in Summer 2022 in Sichuan

Since June 22nd, there have been two regional extreme high temperature events in Sichuan, namely, from the 4th to the 16th of July, and from the 28th of July to the 22nd of August. The highest recorded temperature in history was set in many places in Sichuan, with peak temperatures in some areas, such as Quxian, Dazhou, reaching 44 ℃ and breaking the record set by the National Meteorological Station of Sichuan Province. From July 28th, 2022, the comprehensive intensity of this continuous high temperature event is the most extreme since the establishment ofa meteorological observation record in 1961. The comprehensive intensity of the high temperature event from July 4th to 16th, 2022 also ranks as the third highest in history, second only to one period from the 25th of July to the 19th of August, 2006. Since June 2022 (as of 24th of August), the average temperature in Sichuan has been 2.3℃ higher than that in the same period of the year, and the highest since 1961. The average precipitation in the province is 43% less than that in the same period of the year, which is the lowest since 1961 [5].

D. Relevance to DERSG

The proportion of hydropower in Sichuan is too high, the power generation system is not perfectly constructed, and when the total amount of water resources is insufficient, power supply falls short of demand.

The power crunch caused by extreme high temperature weather in Sichuan is not only relevant because it is recent, but also because it is highly useful for analysing the construction and protection of the modern grid, since it reflects that even hydropower, a relatively reliable renewable energy, will still expose the power system to greater climate risks. Due to these reasons, we believe that this event is appropriate for the Distributed Energy Resources and Smart Grids course.

II. TECHNICAL ANALYSIS

A. Causes of the Electricity Crunch

1) Unreasonable electricity generation structure

Sichuan is one of the most productive provinces in terms of electricity generation in China. So why is a province that generates so much electricity running out of power?

In 2021, the cumulative power generation in Sichuan Province was 432.95 billion kWh, an increase of 34.87 billion kWh compared with 2020, and with a cumulative year-on-year growth of 6.5%. From the perspective of power generation structure, wind power generation in Sichuan Province comprised 10.62 billion kWh in 2021, accounting for 2.45%. Thermal power generation was 66.3 billion kWh, accounting for 15.31%; hydropower generation was 353.14 billion kWh, accounting for 81.57%; solar power generated 2.88 billion kWh, or 0.67 % of the total [6]. This energy generation structure is shown in Fig. 3. However, according to the data presented

above, it is possible to identify a flaw in Sichuan's energy structure: energy is single, and hydropower generation is completely dominant. This means that if Sichuan's hydroelectric power is disrupted, other power producing methods will struggle to compensate. And this is exaclty what happened in the summer of 2022; because of the extremely high temperatures, hydropower was insufficient for meeting needs.

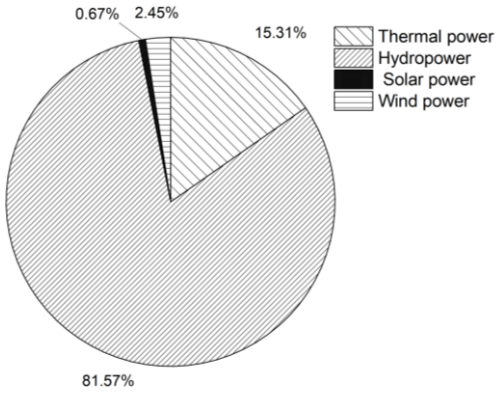

Fig. 3. The energy generation structure.

According to the Ministry of Water Resources, as of August 15th 2022, rainfall in the Yangtze River basin since that July had been 40% lower than usual, the lowest since 1961, and water inflow had been 20-80% lower. The National Meteorological Center predicted that the Yangtze River Basin would experience a heat wave, and that the drought would continue [7]. The extremely hot weather caused the flow of the rivers to decrease sharply, which can be seen in Fig. 4. As a result, the output power of hydropower station has been severely affected.

Fig. 4. A dry tributary of the Dadu River.

According to local media, Sichuan's power grid is facing a serious supply shortage as a result of the extended hot and dry weather, which has pushed some reservoirs nearer to their dead water levels and reduced hydropower generation by half [8]. According to State Grid Corporation of China (SG), during this 2022's flood season, the incoming water from the Minjiang River basin and the tributaries of Yuzixi continued to dry up, and the incoming water decreased by nearly 40% compared with the same period in many other years. The Zipingpu Reservoir's normal operating water level during flood season has dropped from 850 m to 829 m, the lowest level since the reservoir was built in 2006. The current water level in the reservoir area of Dadu River Fushugou Hydropower Station is 812 m, about 30 meters lower than before, and the lowest water level since the construction of the Fushugou plant. The current water level of Tingzikou hydropower Station is 438.78 m, and the dead water level is 438 m. The current water level of Changheba power Station is 1652.56 m, and the dead water level is 1650 m. The normal water level of Monkey Rock Hydropower Station should be 1842 m, however, the current water level was 1804.2 m, while the dead water level is 1802 m. On August 16th, a number of main reservoirs came news when reservoir water fell almost to the dead water level.

Fig. 5. Water level of Monkey Rock hydropower Station.

Without enough height to create a drop potential energy capable of driving the turbine, due to the continuous decline of reservoir storage, the daily electricity generation of hydropower in Sichuan has decreased significantly, and the natural incoming electricity has decreased from about 900 million kWh in the same period to about 450 million kWh, a decrease of 50% and a continuous decrease of 2% a day. Sichuan is a major hydropower province, with the installed hydropower capacity accounting for about 80% of the region's energy production [8]. Due to the precipitous decline of hydropower generation capacity, the power supply-supporting capacity of the whole province has fallen sharply.

2) Increase in electrical load

In recent years, Sichuan's economy has maintained a rapid growth trend, with an average annual GDP growth rate of 11.78%, higher than the national average of 10.76%[6]. Corresponding to the economic development, the demand for electricity in Sichuan Province has also

maintained rapid growth. In 2021, Sichuan's electricity consumption reached 327.481 billion kWh, an increase of 40.961 billion kWh over 2020, with a year-on-year growth of 14.3%. By industry, the first, second and third largest industries have all achieved rapid growth. The electricity consumption of the primary industry was 2.4 billion kWh, up 46.8% year-to-year, with the largest year-to-year increase and the fastest growth rate, up 21.7 % from 2020. The secondary industry consumed 208 billion kWh of electricity, up 15.1% year-to-year and 7.38 percentage points higher than in 2020. The tertiary industry consumed 61.1 billion kWh of electricity, up 20.6% year-to-year and 11% higher than in 2020. The domestic electricity consumption of urban and rural residents was 56.1 billion kWh, up 4.6 percent year-to-year and down 6.1% points from 2020. This is mainly due to the improvement of the pandemic conditions, the reduction of home isolation and the relatively lower demand for electricity. From the perspective of the whole society's electricity consumption structure, the secondary industry accounts for 63.5% of the whole society's electricity consumption, taking up the largest proportion. The tertiary industry accounted for the largest increase in the proportion of the whole society's electricity consumption, accounting for 18.6%, up 0.97% points year-on-year. Residential electricity consumption accounted for 17.1%, and the primary industry accounted for only 0.7%, accounting for the smallest proportion [9].

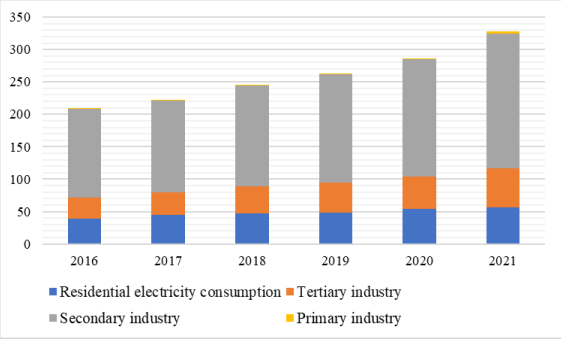

Fig. 6. Electricity consumption of various industries of Sichuan from 2016 to 2021 (billion kWh).

Conversely, because of the high temperatures, residential electricity consumption soared rapidly in this period, with various refrigeration appliances, including air conditioners and electric fans, being installed. In this context, the electricity load in Sichuan has been increasing continuously.

Since May, the power load on the whole Sichuan electrical grid has quickly increased. The maximum power load and daily maximum power consumption have both exceeded the same period in 2021, and power consumption has climbed by 16% since June compared to 2021 [10]. In July, residents in Sichuan nearly doubled their daily electricity consumption to 344 million kWh, with the grid's maximum load reaching 59.1 million kW, up 93.3% year-to-year [11]. The increasing load of electricity leads to power failure caused by excessive load in many places.

3) Pressure of electricity transmission to other provinces

During the electricity shortage, Sichuan was still under great pressure to export electricity to other provinces. As mentioned in Section Ⅰ, Sichuan province bears the significant task that is the West-East Electricity Transmission Project (WEET). As one of the main source provinces of WEET, Sichuan transmits a large amount of electricity to other eastern provinces every year.

In 2021, Sichuan generated 432.95 billion kWh and consumed 327.481 billion KWH, with 105.47 billion KWH transported to other provinces, accounting for more than 24.3% of Sichuan's total power generation [9]. Furthermore, these external power transfers are generally coordinated by the state, which is essentially uniformly deployed by power generation companies and the national grid. Sichuan cannot command these powers at will. As a result, even though Sichuan's overall power generation is large, there will be a power gap if power demand rises rapidly.

During the power crunch in Sichuan, as Sichuan struggled with power shortages, a "letter of request" from Shanghai took many by surprise. The letter asked Sichuan to give priority in suppplying power to the suppliers of SAIC Motor and Tesla Motor Co., the auto industry chain companies, because the power cut had caused them to stop production, affecting the normal production of SAIC Motor and Tesla Motor. This "letter of request" amplified the contradiction between Sichuan's hydropower self-use and external transmission in recent years[12].

4) The small capacity of electricity transmission channel into Sichuan

Sichuan is a province with large electricity export, and the connecting lines with other provinces are mainly unidirectional export transmission lines. At present, Sichuan's external power transmission capacity has reached about 30 million kW, with electricity transmission lines including Fufeng DC, Binjin DC, Jinsu DC, Debao DC, Yazhong-Jiangxi, Baihetan-Jiangsu

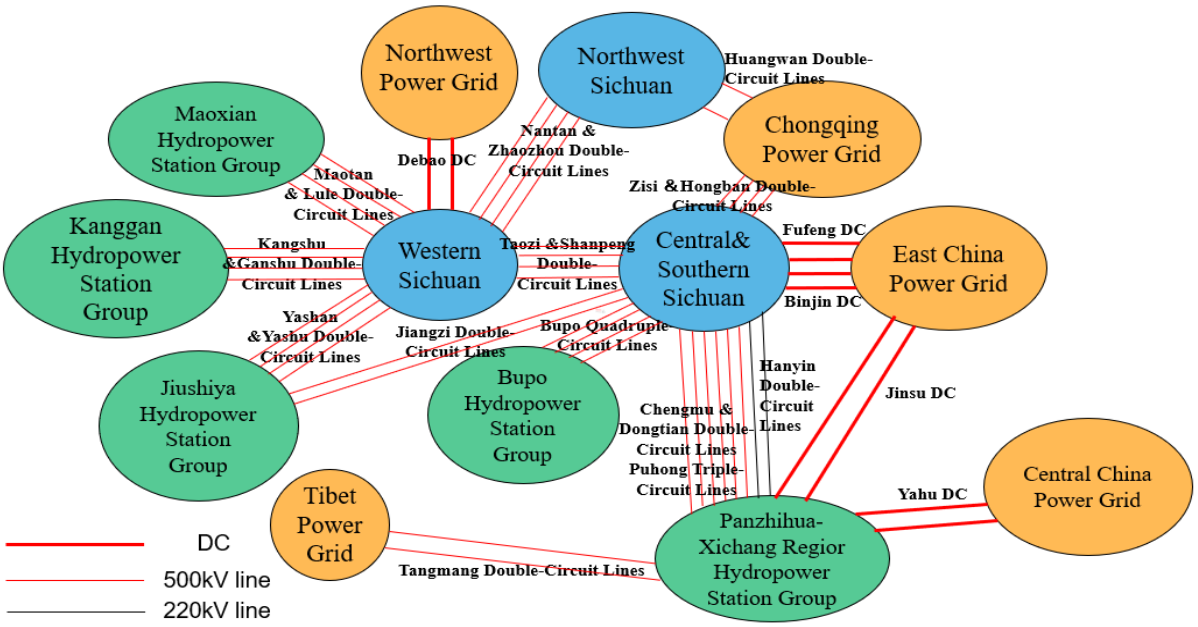

Fig.7. Electricity transmission channel in Sichuan

and many other electricity transmission lines, as shown in Fig. 7.

Of all the connecting lines, the 500kV Deyang-Baoji DC transmission project (Debao DC) is one of the few DC external channels of Sichuan power grid that can transmit bidirectional power. The operation direction is adjusted seasonally. In summer and autumn, the Sichuan power grid transmits surplus hydropower to the northwest power grid, and in spring and winter, the northwestern power grid transmits new energy power and some thermal power to the Sichuan power grid, so as to realize the mutual aid of abundant and scarce resources. In order to alleviate the problem of power shortages in Sichuan, the DC transmission channel from Baoji, Shanxi province to Deyang, Sichuan province, operates at full power. In addition to eight support lines from the China Southern Power Grid, Gansu and Hubei, the daily support power outside Sichuan has reached 132 million kilowatt hours and about 6 million kilowatts. Even so, compared with the export channel, the power channel into Sichuan is smaller.

B. Potential solutions to Sichuan's power problems

1) Optimization of the electricity generation structure

Sichuan is in a critical period of energy transformation. The province has been working hard to increase its use of renewable energy and reduce its dependence on coal [13]. The province has built a large number of hydroelectric dams, and also installed some wind and solar power plants. However, the speed of Sichuan's energy transition is still not fast enough, resulting in the number of wind power plants and photovoltaic power plants being far less than that of hydropower stations, thus resulting today's unreliable power generation structure dominated by hydropower, which is heavily affected by weather and season. Therefore, it is urgently necessary to strengthen the construction of wind power and photovoltaic power generation to form a complete energy structure. With the complement of wind and solar energy, the power system of Sichuan can be more flexible, which means it can strengthen its resilience to extreme weather.

2) Develop energy storage technology

Energy storage is an important part of meeting the flexibility needs of new power systems, and it is also an imperative component of renewable energy [14]. The large-scale development of renewable energy has brought great challenges to the safe and reliable operation of the power system, and as an important means to improve the flexibility of the power system, the development of energy storage is expected to be high. However, in China, compared with the rapid leap to new energy, the development scale of the energy storage industry is relatively behind. Pumped energy storage remains the primary mode of energy storage in China, accounting for 89.3%, and the proportion of new energy storage structures remains small [15]. On the other hand,

energy storage is currently used primarily for short-term scale regulation and control functions, with less application on medium and long-term scales.

A variety of storage types should be used extensively to meet the comprehensive demand of the new power system for large-scale, multi-timescale, power-energy balance. Energy technology has the potential to achieve multi-time scale power and energy balance in the new power system, while providing the best technical and economic benefits.

3) Improve transmission lines capacacity.

Sichuan can only handle a maximum of 500 kV of power transmission. Small-capacity transmission channels impede electricity assistance from both within and outside the province. According to public reports, the State Grid Corporation of China clearly stated during the power shortage period that it had previously implemented cross-provincial and cross-regional support for Sichuan based on the maximum transmission channel capacity. However, due to the limited transmission capacity, these approaches still failed to solve the problem of Sichuan's power shortage [16]. Therefore electricity from outside the province could not be brought in, and electricity from within the province could not be delivered to energy-scarce areas. As a result, the capacity and number of transmission lines connecting other provinces to Sichuan, as well as within Sichuan, need be increased.

4) Optimize the power dispatching strategy

As previously stated, even when power is scarce, Sichuan is under enormous pressure to transmit electricity to other provinces, which places the province in an unreasonable position.

H. Wang, deputy director of the Sichuan Provincial Party Committee and Provincial Government Decision Advisory Committee suggested that power plants should transition the 'point-to-grid' transmission mode (that is, directly connected from the power plant to the power grid) to 'grid-to-grid' mode (electricity generated by the power plant first enters the Sichuan power grid and then is transmitted to the power grid of the power consumer) [16]. In this manner, Sichuan can improve its power regulation capacity by first meeting their own electricity consumption, and then transmitting electricity to other provinces.

Alternatively, strengthening cross-provincial power mutual assistance with the northwest and other places and seeking national support for the construction of power channels from Gansu and Tibet have been proposed to ensure that Sichuan serves the national west-to-east power transmission strategy while also ensuring the province's energy and electricity supply.

III. ACTION & IMPACTS

A. Sichuan Government

The Sichuan government required the Department of Economy and Information Technology, the Department of Water Conservancy, the Provincial Meteorological Bureau, the State Grid Sichuan Electric Power Company and other departments to:

First, do their best to ensure people's livelihood electricity consumption and ensure the security of the power grid;

Second, to take a variety of measures to ensure the supply of thermal coal, strengthen coal production in the province and coal purchase outside the province, and ensure smooth transportation;

Third, to scientifically dispatch energy resources, closely monitor the supply of primary energy, such as water, coal and gas, optimize the operation mode of the power grid, ensure the maximum utilisation of power generation resources, and strive for power support from outside the province and maintain power, which is generated in large hydropower stations in Sichuan;

Fourth, do a good job in the operation and management of generator sets and power grid equipment, reasonably arrange unit operation and maintenance, equipment maintenance, etc., and strictly prevent unplanned shutdown and obstruction of output;

Fifth, do a good job in ensuring the electricity consumption of key enterprises, strictly implement the 'white list' system of key enterprises for power guarantee in peak summer, and make every effort to ensure the electricity demand of key enterprises, such as the top 50 industrial enterprises;

Sixth, do a good job in publicity and guidance, information release, communication and explanation, etc., and advocate for the whole society to overcome difficulties and save electricity [17].

B. State Grid-State Grid Sichuan Electric Power Company

The State Grid mobilized 50 emergency power generation vehicles to carry out emergency power supply in Guangan, Dazhou, Nanchong and

Bazhong in Sichuan. Sichuan activated 778 emergency power generation vehicles, generating 5.5 million kWh [18].

State Grid Sichuan Electric Power Company stressed that, first, it is necessary to strengthen the maintenance of important transmission channels and equipment, strictly enforce dispatching discipline, and ensure the normal operation of all types of units. Give play to the role of the resource allocation platform of the large power grid, organize cross-regional and cross-provincial surplus and mutual assistance, and strengthen the power guarantee in key areas, such as Sichuan and Chongqing. Second, it is necessary to excel further in real load management and dig deep into various adjustable load resources to ensure the electricity consumption of residents, public services and important users. Third, it is necessary to make further preparations for emergencies. This involves improving emergency response mechanisms and dynamically optimize emergency plans. Publicity and guidance must also be strengthened and information must be released in a timely manner; social concerns should be responded to understanding should be enhanced [19].

C. National Energy Group

The National Energy Group fully mobilized the power generation resources in the Sanbei region, and cashed 55 medium- and long-term transactions sent to Shanghai, Jiangsu, Zhejiang, Anhui, Jiangxi, Hubei, Hunan, Sichuan, Chongqing and other provinces, with a cumulative transmission of 8.4 billion kWh. On the basis of fulfilling the annual transaction of Lingshao DC transmission to Zhejiang, Ningxia Electric Power completed emergency external transmission of 140 million kWh in July and supported Sichuan-Chongqing transaction in August to sign another 88 million kWh; all units in Shanxi closely cooperated with Debao DC reverse transmission, and continuously participated in the incremental transaction of sending Sichuan since August. Medium- and long-term inter-provincial power contracts were performed as scheduled, providing strong support for the recipient provinces to alleviate the power shortage [20].

The National Energy Group Coal Trading Company mobilized all forces, implemented resources and transportation capacity in various forms, closely visited a number of internal and external large mining coal source units, closely coordinated the entry of coal from Shanxi, Gansu and Xinjiang into Sichuan and Chongqing, further increased the number of approved trains by the National Railway, and made every effort to ensure the coal demand of power plants in Sichuan-Chongqing region by combining the supply of self-produced coal and trade coal. From the 1st of August to the 17th, 190,000 tons of coal were shipped, a year-on-year increase of 89.6%, the best level in the same period of the previous year [21].

D. Thermal Power Generation Enterprises

All 67 thermal power plants in Sichuan were generating electricity.

Sichuan Guangan Power Generation Co., Ltd. is the largest thermal power plant in Sichuan, and as of August 19th, 2022, six units had been running at 100% full capacity for 19 consecutive days, with a cumulative power generation capacity of 1.073 billion kWh, an increase of 166% year-on-year.

Chengdu's only large-scale thermal power plant, Guoneng Chengdu Jintang Power Generation Co., Ltd., was generating more than 27 million kilowatt-hours of electricity per day since July, more than double the same period of previous years.

As of August 22, Sichuan's 67 thermal power plants had produced 12.75 million kilowatts of electricity, accounting for about 25% of the maximum load of the entire Sichuan power grid on that day [22].

Thermal power enterprises successfully [23]:

- Optimized the connection and unloading process
- Improved the connection and unloading efficiency
- Strengthened coal storage management;
- Regularly measured temperature to prevent spontaneous combustion
- Burned old coal supplies and stored new ones
- Scientifically took turns in burning coals, reducing the loss of calorific value
- Strictly implemented the early warning report of thermal coal inventory
- Coordinated and strengthened emergency coal supply dispatch
- Ensured the stable supply of thermal coal.

E. Companies

Due to the government's policy of ‘giving electricity to the people’, enterprises in many industries have been affected to various extents.

Zhongfu Industry, a leading aluminum industry, stopped production for a week from August 14th, affecting the total electrolytic aluminum output by 12,900 tons. Sichuan Meifeng Company, a leading fertilizer company, was affected by the power supply and temporarily stopped production. The temporary suspension of production affected urea production of about 15,000 tons and compound fertilizer production of about 6,000 tons. The power rationing policy affected the production of electrolytic aluminum by about 73,000 tons, which reduced the net profit of related companies by about 55 million yuan [24].

The power cuts in Sichuan have affected a number of key local industries, including the automobile and parts industries, and battery and chip industries. Taking the automobile manufacturing industry as an example, Toyota Motor Corporation said on the 16th of August that, due to the emergency notice issued by Sichuan Province, industrial electricity enterprises stopped production from the 15th of August to the 20th. High temperature power rationing not only led to the scheduling difficulties of automobile and spare parts manufacturers, but also caused a certain degree of difficulty in the aftermarket, particularly in electric vehicle battery charging. Tesla officially announced that, as of the 17th of August, only two (Pidu Bailun Plaza and Chenghua Longtan Temple) of the 14 supercharging stations in Chengdu were to remain open; the rest were in a state of limited or temporary closure and the supercharging stations in Chongqing were all limited or temporarily closed.

Sichuan is an important city in the photovoltaic manufacturing industry. It should be pointed out that the power consumption levels of photovoltaic silicon production and rod drawing are high, and the impact of power curtailment on these two links was therefore greater. Therefore, this round of power cuts has further aggravated the imbalance between supply and demand in the industrial chain, which was already a concern in the market.

Sichuan has the second largest production capacity of photovoltaic and semiconductor silicon wafers in China, accounting for 14% of the national production capacity. Affected by the current round of power cuts in Sichuan Province, all silicon materials, wafers and cell enterprises in Sichuan have stopped production and work. Market analysis believes that, due to the high concentration of polysilicon industry, the power rationing and shutdown of any leading manufacturer would lead to an overall supply shortage, which in turn would cause polysilicon prices to continue to rise. The power limit and production suspension notice undoubtedly increased the uncertainty of polysilicon production capacity release [25].

F. Residents

According to relevant statistics, the drought disaster has cumulatively affected nearly 6.094 million people in Sichuan Province. Since July, three people have died of heat stroke in Nanchong, Sichuan [26].

Due to the shortage of electricity, office buildings and shopping malls began to lose power. During the day, people went to work in the company and could only cool off using ice cubes due to the power cuts in the office building.

LED advertising signs on the pedestrian streets all over Chengdu were collectively blackened, and the subway stations were dark except for necessary signs. The entire city was in the dark at night.

Communities across Sichuan had irregular power outages, and were considered to be lucky if the blackout was during the day. If the power went out at night, many people would be too hot to sleep [27].

IV. CONCLUSION

The shortage of hydropower caused by extremely hot weather was the direct cause of Sichuan's power crunch, but was not, however, the root cause. In fact, according to the investigation of this paper, Sichuan's power crunch has been foreshadowed for a long time from the perspective of its single energy structure, low power transmission line capacity and unreasonable power dispatch strategy.

In order to solve the existing problems of Sichuan's power system, this paper provides optimization suggestions from the aspects of energy structure, energy storage technology, transmission lines and dispatching strategies.

The electricity crunch indeed caused great damage to the whole Sichuan society, however, it is inspiring that many high-power consuming enterprises and factories shut down work and production, sacrificing huge economic benefits to ensure the normal use of electricity for residents. This gained significant time for subsequent power assistance from other provinces and the re-planning of power generation in the province from other power sources, such as thermal power, photovoltaic power and wind power.

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