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The Development of Local Energy in Guangxi from the Perspective of Energy Crisis: Focusing on the Period of Second Sino-Japanese War

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Abstract: Since the late Qing Dynasty, Guangxi has been facing an energy dilemma characterized by a scarcity of coal and oil, which was particularly pronounced during the period of second sino-Japanese war. This paper focuses on the development of local energy resources in Guangxi during second sino-Japanese war, analyzing how Guangxi coped with energy shortages by developing indigenous resources such as charcoal, coal mines, plant oils, and hydropower. The government played a leading role in this process, promoting the development of the energy industry through policy support and financial investment. At the same time, the participation of private capital and technology provided innovative momentum for energy development. Despite issues such as uneven distribution of energy resources in time and space and unbalanced regional development, Guangxi's experience in energy development provides valuable lessons for modern China's energy security and structural transformation, emphasizing the importance of government and private sector collaboration in promoting the development of the energy industry.

Key words: Energy Crisis; Second Sino-Japanese War; Guangxi; Energy Development

1.Introduction

Energy is an essential foundation for the development of human society and plays a significant role in economic development. Since the late Qing Dynasty, Guangxi has been facing an energy dilemma characterized by a scarcity of coal and oil, which was particularly evident during the period of second sino-Japanese war. Before second sino-Japanese war, the energy structure in Guangxi primarily relied on locally produced charcoal and imported diesel. After the second sino-Japanese war, the war led to the interruption of import channels, making it difficult to obtain imported diesel, resulting in a continuous shortage of oil supply in Guangxi and a constant increase in oil prices. At the same time, the relocation of industries from the eastern regions exacerbated the energy crisis, prompting people to seek methods to resolve the energy crisis.

At present, domestic scholars' research on the history of modern Chinese energy is mostly holistic or

focuses primarily on the study of oil and coal as two types of energy. The research tends to concentrate on the development process and impact of specific energy development and supply, with less attention given to combining the transformation of modern energy with the early industrialization of China. There is also a scarcity of studies that focus on the development of energy in modern Guangxi from the perspective of energy history.

Regarding the holistic historical research on modern Chinese energy, many scholars have focused on the overall development of energy in modern China. Wang Qingyi (1988), in his editorial work "China's Energy," comprehensively elaborates on the process, current status, and prospects of China's energy development from the perspectives of coal, oil, natural gas, electricity, and new energy sources, but only briefly mentions the history of the development of modern Chinese electric power energy[75]. Wang Anzhong (2011, 2012) believes that before the outbreak of second sino-Japanese war, the growth in energy demand driven by multiple factors led to an imbalance in energy supply. After the outbreak of the war, the Nanjing National Government intensified the research and application of alternative energy sources such as charcoal, alcohol, and substitute gasoline. However, the alternative energy sources widely used during this period were costly and not suitable for widespread promotion in times of peace[73] [74]. Xing Xinxin (2015) has combed through the history of China's energy development and utilization, and explored the changes in China's energy policies[78]. Zhang Weibao (2020) believes that the development of modern energy industry and its limitations due to the insufficient reserves of primary energy sources such as coal and oil help to understand the special significance of energy security in China. He uses seven case studies from the late Qing Dynasty to the period of second sino-Japanese war to reveal the multiple twists and turns that energy security faced in modern China[80].

Domestic academia in China has primarily focused on the study of coal and oil in the context of modern Chinese energy. For instance, Shen Lisheng (1980), the editor-in-chief of "History of China's Petroleum Industry," and the Compilation Group of the History of Modern Chinese Coal Mines (1990), which authored "The History of Modern Chinese Coal Mines," have respectively elaborated on how two different types of energy—oil and coal—were developed, marketed, and how technical workers were trained between 1840 and 1949. They emphasize the role of oil and coal as industrial fuels[52]. Zhu Yingui (2020) believes that the development of China's mechanized coal mining industry was driven by societal energy demands. At the same time, the development of the mechanized coal mining industry also provided abundant and inexpensive energy, which in turn propelled the development of transportation, industry, and electricity[84]. Huangfu Qiushi and Jia Qinhan (2020) narrated the process in the mid-to-late 1930s where Gu Weijun connected the forces of private enterprises, foreign capital, and the government to jointly develop the petroleum resources in Northwest China. Although production had not yet begun, it laid the foundation for the subsequent development of the Yumen Oilfield [25]. Regarding the research on the history of modern Guangxi's energy, some scholars focus on the development of primary energy in modern Guangxi. For example, Wei Liuyuan (2009) only briefly mentioned the history of the development of coal in modern Guangxi[76]. Fu Rongshou, Jiang Tingyu, Wei Youqun, and others (1993) mentioned in their book "the

use of fire energy, hydropower, wind energy, and animal power in rural Guangxi before the founding of the People's Republic of China[15]."

In summary, it is evident that there is a rich body of research on the history of modern Chinese energy. However, most of these studies focus on the history of the industry and enterprises, or on the development history of primary energy sources. There is a lack of research on the development of local energy in modern Guangxi. Therefore, we should explore the development and application of local energy in the frontier regions from the framework of energy crises, and its impact on the stability and security of energy supply in the economic system of the rear areas.

2.The Blockade by Japan in the Early Stage of Second Siono-Japanese War and the Energy Supply Crisis in the Rear Areas

2.1 The Emergence of Energy Supply Crisis from 1937 to 1940

Since modern times, China has primarily relied on coal and oil, with some cities also beginning to use electricity. A portion of the coal comes from domestic production, while another part is imported from abroad. Oil, on the other hand, is mostly imported. Therefore, an energy structure like China's, which depends heavily on imports, is not stable and secure enough. Before the outbreak of second sino-Japanese war, China had made several attempts to establish a more stable energy structure, but with limited success.

The impetus for domestic energy supply crises in China has a long history. As early as before the outbreak of second sino-Japanese war, foreign troops had been plundering China's energy resources. According to statistics: "From 1912 to 1937, the coal production directly mined by foreign troops accounted for 64% of the national coal production[31]." Among the foreign troops, Japan was the most aggressive in plundering China's coal resources. After the 1930s, such aggression intensified. Following the "Mukden Incident" (also known as the "September 18 Incident"), Japanese troops swept into the Northeast region of China. Since the fall of Harbin in 1932, the Northeast region of China completely became a Japanese colony. Japan transported the coal from Northeast China out for sale or back to Japan by building railways, which caused tremendous losses to China's coal resources.

At the same time, geopolitical conflicts in the 1930s were intense, and the looming shadow of war in Europe also led to instability in the import of foreign oil. According to the "Historical Materials of the Old Customs of China (1859-1948)," from 1930 to 1936, the import volume of diesel, an important energy source for Guangxi at the time, plummeted from 4896 metric tons to just 1 metric ton. The import volume of gasoline also declined, and even in 1932, the customs import volume of gasoline in Guangxi was 0 metric tons[62]. This clearly indicates that before the outbreak of second sino-Japanese war, Guangxi was already facing unstable factors in its oil imports.

Table 1: Import Volume of Diesel and Gasoline in Guangxi from 1930 to 1936 (Unit: Metric Tons)[60] [62] [63]

Product/Year	1930	1931	1932	1933	1934	1935	1936
Diesel	2,487	4896	1176	745	537	400	1
Gasoline	121153	363156	0	7505	94736	73609	83617

Since the outbreak of second sino-Japanese war, the crisis in China's domestic energy supply has become increasingly apparent. After the "Marco Polo Bridge Incident," Japanese troops launched attacks on North China, Central China, and the southeastern coastal regions of our country. In the following year and three months, cities such as Beijing, Tianjin, Shanghai, Nanjing, Wuhan, Guangzhou, and a large area of our country's territory fell one after another. Japan formed an energy blockade of the eastern coastal regions of China, making energy imports difficult. All the coal-producing areas in North China, Central China, and South China fell, leading to a reduction in domestic coal production, and the energy crisis in China continued to intensify.

In Guangxi, the outbreak of second sino-Japanese war also led to changes in the channels for energy transportation. The disruption of the original energy channels exacerbated the energy crisis. Before second sino-Japanese war, the energy structure in Guangxi was primarily based on the import of foreign oil and the use of locally produced charcoal. Prior to second sino-Japanese war, the import of petroleum in Guangxi mainly followed two channels:The first channel, which began in 1890, involved oil from the United Kingdom and the United States landing at the Beihai Customs, and then being transferred from Beihai Customs to Longzhou Customs for use in Longzhou and neighboring counties. The second channel, established after Wuzhou was opened to foreign trade in 1897, allowed oil from the United Kingdom and the United States to directly reach Wuzhou Customs from Hong Kong, or to be transferred from Hong Kong via Guangzhou to Wuzhou Customs. From Wuzhou Customs, the oil was then distributed via waterways to various counties in Guangxi, including Nanning, Guilin, and Liuzhou[33] [44]. During the period of second sino-Japanese war, most of Guangdong Province was invaded by the Japanese forces, and the Pearl River Delta was occupied. The Pearl River and related waterways were blockaded, disrupting the waterway transportation from Hong Kong to Wuzhou, leading to a disruption in supplies and causing Wuzhou to lose its original function. After Guangzhou fell in October 1938, Haiphong in Vietnam became an important port for the import and export of energy in China. The main international energy transportation routes shifted to the Guangxi-Vietnam line in Guangxi and the Yunnan-Vietnam and Yunnan-Burma lines in Yunnan[4]. After the fall of Nanning, the Longnan Highway and Yongzhen Highway of the Guangxi-Vietnam line could no longer be used. To ensure the entry of aid materials to China, in February 1940, the Nanjing National Government allocated funds to rebuild the Heyue Highway. This highway developed into an important international transportation line of the Guangxi-Vietnam route[59].

2.2 The Complete Cutoff of External Energy Supply to Guangxi from 1941 to 1945.

During wartime, energy can be a crucial strategic material that affects the outcome of the war. In July 1940, the U.S. government "imposed restrictions on the export of all petroleum and scrap metal," marking the first time the United States had imposed energy restrictions on Japan[48]. On July 26, 1941, the U.S. government announced that it would impose economic controls on Japan and freeze all Japanese assets in the United States. Subsequently, the United Kingdom and the Dutch East Indies also adopted the same policy as the U.S. government. The U.S., the UK, and the Dutch not only froze Japanese assets overseas but also ceased the sale of oil to Japan. This made it impossible for Japan

to import any oil from foreign countries[30]. Under the global "oil embargo," Japan faced a very severe oil crisis. To resolve this crisis, Japan accelerated the plunder of China's energy resources, conducting a more thorough plundering of coal and other resources in the occupied areas, and imposing stricter restrictions on China's energy imports. Especially after the Pacific War in 1941, the crisis in China's energy supply became even more severe. Although the rear areas could enjoy priority in energy supply, under the large-scale relocation of factories, the demand for energy in the rear areas continued to grow, and such priority supply was just a drop in the bucket. Therefore, after 1941, the energy crisis in the rear areas continued to intensify, and Guangxi was also affected. Overall, compared with the period before 1941, in the rear areas at that time, especially in Guangxi, the oil import crisis after 1941 continued to worsen. Such an energy dilemma has affected industrial development, threatened social stability, and endangered the success or failure of the war.

3.Development of Indigenous Energy Resources

To address the increasingly prominent energy crisis, Guangxi began to explore the development of local energy resources. The region undertook large-scale development of charcoal, coal mines, plant oils, and hydropower to alleviate the shortage of energy.

3.1 Traditional Energy: The Development of Charcoal and Coal

To alleviate the shortage of petroleum, Guangxi embarked on a large-scale development of coal mines and charcoal to substitute for diesel and other petroleum products, thus promoting an energy transition. Guangxi continuously developed charcoal resources and cultivated fuelwood forests. Guangxi's "mild climate and abundant rainfall are suitable for forest growth, and forests are distributed throughout all counties" [9], which means it has a rich reserve of forest resources. However, after extensive development of these forest resources in the first three decades of the 20th century, the charcoal produced was not only used by local factories and for the daily life of the local people but also exported to places like Shanghai, Guangdong, and Hong Kong [61]. Such unregulated development led to a decline in the area of natural forest resources in Guangxi, and the huge demand for charcoal in the province "could not be supplied by nearby rural areas[82]". The fuelwood forests in the province were mostly artificially planted pine forests or mixed forests, which could be harvested every four or five years, so as early as before second sino-Japanese war, Guangxi began to plant artificial forests, and by 1934, several major state-owned forests in Guangxi had a total afforestation area of 21,237 acres [8]. Since second sino-Japanese war, the Guangxi provincial government has paid more attention to "organizing state-owned forests and promoting public and private-owned forests" and has planted a large number of trees in various affiliated forests of the Guangxi Agricultural Experiment Station, with particular emphasis on "fuelwood and pine forest cultivation[9][32]". In addition to the government's large-scale planting of fuelwood forests, the government vigorously promoted the policy of private forests, leading to the emergence of many privately planted fuelwood forests in places like Beiliu, Rong Xian, Pingnan, Mengjiang, and Teng Xian, most of which were harvested by the owners themselves or sold to firewood merchants for harvesting, and then processed into charcoal for sale by the firewood merchants [83]. During the period of second sino-Japanese war, the cultivation and development of fuelwood forests were also aimed at replacing

diesel for power generation. Chen Xiong, the director of the Construction Department of the Guangxi provincial government, believed that "due to the high cost of fuel and the air raids by enemy aircraft since the war, it was decided to modify the machinery of various power plants to burn charcoal as much as possible[5]" .

To mitigate the instability of imported petroleum energy, Guangxi not only vigorously developed charcoal resources but also continuously developed coal resources. During this period, the development of coal in Guangxi was government-led. First, the government regulated coal mining through the introduction of relevant policies, stipulating that "before coal mining, the government should send personnel to conduct surveys to reduce the time and costs for the public[26]". In 1937, the Ministry of Industry issued the "Methods for Operating Coal Mines during Wartime," which made specific provisions for the establishment of coal mines during second sino-Japanese war[18]. In 1938, the Guangxi provincial government announced the "Request for Mining Rights Regulations," which stipulated that the exploration and mining of coal mines must be approved by the Provincial Construction Department[71]. It has long been a practice for businessmen to invite experts or cooperate with the government to send experts to explore coal mines in various places in Guangxi. As early as 1935, Heshan Coal Mine Company hired engineer Lin Qinliu from Chaozhou, Guangdong, to conduct a field survey in Guangxi, discovering the Lilan and Dalong coal seams[23]. In the same year, the Guangxi provincial government invited the Chinese Society of Engineers to organize a Guangxi investigation team to inspect Heshan, making suggestions for the mining work of Heshan coal mine[11]. Since second sino-Japanese war, the exploration of coal mines in Guangxi has been mainly led by the government, with experts dispatched by the central or provincial government to conduct coal mine exploration. In 1938, Xie Jiarong and Wang Zhi from the Economic Geology Survey Institute conducted a geological survey in the Fuhe Zhong area of Guangxi and wrote "Geology of the Coalfield between He Xian and Zhongshan in Guangxi[34]." The Guangxi Provincial Construction Department dispatched Chen Shoujun, Tao Shaoqin, Niu Zhaowen, Qiu Jiakui, and others to inspect coal mines in Guangxi, writing a large number of coal mine investigation reports such as "Inspection Report on Enyang Baise Coal Mine in Napo Xian," "Inspection Report on Chang'an Midong Coal Mine in Rong Xian," and "Investigation Report on Maping Waikouling Coal Mine," laying a theoretical foundation for the mining of coal mines in Guangxi[35]. At the same time, the relocation of research institutes after the outbreak of the war also promoted the exploration of coal mines in Guangxi. In 1937, with the outbreak of the resistance against Japan, the Geological Survey Institute of the Central Research Institute moved to Guilin[35]. The following year, the Geological Research Institute of the Central Research Institute cooperated with the Guangxi Construction Department, with Si Xingjian, Zhang Wenyou, and Li Youjue conducting a coal resource survey in the Dapu area of Liucheng; Zhang Wenyou from the Geological Research Institute of the Central Research Institute led Yanjing University students to inspect Heshan, believing that the local coal mines have development prospects[81].

Then, the Resources Committee, the Guangxi Provincial Government, and the Bank of Guangxi invested or took shares in the development of coal resources, providing equipment support. In July 1938, the Resources Committee and the Guangxi Provincial Government invested five million yuan to

prepare the Pinggui Mining Bureau in Babu, which was officially established in October of the same year[1]. The Xiwan coal field under the jurisdiction of the bureau, due to the lack of power equipment, only produced 5 tons of coal per day, leading to a "coal shortage," with "mine merchants often urging at the door." However, at that time, the Babu Power Plant of the Pinggui Mining Bureau could not yet supply electricity, so the Xiwan coal field requested the original 150-horsepower steam engine and 100KVA AC generator set from the Wuzhou Sulfuric Acid Factory to be transported to Xiwan for use, which was supported by the provincial government[2][13]. After obtaining electricity for pumping water, the coal output increased significantly, alleviating the "coal shortage." In July 1938, the Guangxi Provincial Government and the General Office of the Bank of China jointly took over the "Qianjiang Heshan Coal Mine Joint Stock Company," officially establishing the Heshan Coal Mine Joint Stock Limited Company to operate coal mining[7][34]. The government also encouraged private development of coal mines, stating that "coal mines are allowed to be operated privately, and specialized technicians are dispatched to help improve them[26]". Many private coal mines sprang up in various parts of Guangxi, with more than 500 private coal mines established in Tianhe, Luocheng, Liucheng, Enyang, Laibin, Baise, Yongning, and other counties. Among them, the larger ones included the Simen Company in Luocheng, which produced 200 metric tons of coal per month[19][35].

In response to the central government's call to "establish power plants by the government and develop coal mines for supply," the Guangxi provincial government and the central government developed many coal mines, among which the development of Xiwan Coal Mine and Heshan Coal Mine was mainly for power generation[71]. The coal produced by the Xiwan Coal Mine was primarily supplied to the power plant of the Pinggui Mining Bureau for electricity generation. The surplus was used for self-consumption by the bureau's own factories such as the tin smelting plant and iron smelting plant, as well as by nearby tin mining companies. The coal produced by the Heshan Coal Mine, in addition to being used by the Heshan Coal Mine Power Plant, was also transported through the Hunan- Guangxi -Guizhou Railway to Liuzhou via the transit in Laibin, supplying the Liuzhou Power Plant for electricity generation[36] [45] [46].

Between 1937 and 1940, with the joint efforts of the government and private forces, the coal and charcoal resources in Guangxi were developed. During these four years, the total coal production in Guangxi reached 173,624 tons, and the total area of new afforestation in county forestry farms was 9,437,623.01 mu (a traditional Chinese unit of area)[9] [28] [29]. Abundant coal and charcoal resources propelled the Pinggui Mining Bureau Power Plant, Heshan Coal Mine Power Plant, Liuzhou Power Plant, and 15 other power plants to use coal and charcoal as substitutes for diesel for electricity generation. The ample electricity supplied by these power plants also enabled some mining areas to use electric power for mining. For instance, numerous tin mining companies in He Xian at that time used electricity from the Pinggui Mining Bureau Power Plant to mine tin[12] [21].

Compared to the period from 1937 to 1940, Guangxi faced a more severe predicament in coal supply from 1941 to 1945. After the Japanese forces approached the northern part of Hunan, the source of coal from Hunan became very difficult. In order to provide a stable supply of coal for wartime, Guangxi continued to strive to develop coal mines and increase coal production. First, the Guangxi provincial government continued to explore coal resources. In 1943, the coal exploration

team of Liucheng in Guangxi conducted an exploration of the coal resources in Liucheng[34]. In addition to exploring new coal resources, ensuring the stable supply of existing coal mines was also crucial during the war. In 1943, the Xiwan Coal Mine faced a severe challenge when it was flooded and the coal mines collapsed, making recovery difficult. With the stockpiled coal depleted within a few months, it was imperative to address the impact on the railway department and the power plant of the bureau. Consequently, Heshan Coal Mine Co., Ltd. requested the Pinggui Mineral Bureau to lend electrical drainage equipment, which was supported by the Guangxi provincial government, allowing Heshan Coal Mine to resume work smoothly[42] [43]. Finally, the Guangxi provincial government provided financial support to ensure the supply of coal mines. With the approval of the provincial government, Heshan Coal Mine obtained a loan of 500,000 national currency from the Bank of Guangxi for the resumption of mining operations[27].

With the concerted efforts of all parties, during this period, the coal production in Guangxi province continued to rise. Heshan Coal Mine and Xiwan Coal Mine became the two largest coal mines in Guangxi at that time. As can be seen from Table 3, from 1940 to the fall of Heshan in 1944, the coal production of Heshan Coal Mine generally showed an upward trend, increasing by 24 times. The coal was mainly "supplied to relocated factories and railway locomotives," and it was acclaimed as the "second largest coal mine in the southwest[35]." The Xiwan Coal Mine also ensured stable mining and supply of coal during the wartime.

Table 2: Coal Production of Heshan and Xiwan Coal Mines from 1938 to 1944 (Unit: Tons)[17] [77]

Year	1938	1939	1940	1941	1942	1943	1944
Heshan Coal Mine	4100	3800	3200	1410	40000	94000	80000
Xiwan Coal Mine	3671	17550	38313	53100	50949	27688	——

3.2 Exploration of the Development of New Energy from Plant Oils

Guangxi is known for its "hills overlapping and a lot of wasteland, which is extremely suitable for the development of forestry." In addition to firewood, the most important forest products include tung oil, tea oil, and anise oil, etc[37]. Before second sino-Japanese war, Guangxi had very rich economic forest resources and a thriving oil extraction industry[39].According to the records in the second edition of the Guangxi Yearbook, in 1933, Guangxi produced 240,022 piculs of tung oil and 173,943 piculs of tea oil[8] . These products, with a small portion used for local handicraft industries within the province, were largely collected and distributed through Wuzhou, then shipped to Hong Kong for sale in countries such as Britain, the United States, and Japan. In the one or two years before second sino-Japanese war, the export of tung oil from Guangxi accounted for about 15% of the national exports. In 1937, the total value of tung oil exports was more than 10 million yuan, accounting for about 23.5% of Guangxi's total export value, making it the leading export product; the export of tea oil from Guangxi accounted for 17.83% of the national exports[6] [37] [64].

Since the outbreak of second sino-Japanese war, Guangxi has seen the establishment of many reclamation companies in counties such as Liucheng, Liujiang, and Luorong, which have been

engaged in large-scale planting of tung forests. Additionally, the cultivation of oil tea trees has been flourishing in places like Liujiang, Rong Xian, and Fuchuan[3] [37]. As Table 4 indicates, the production of tung oil and tea oil at that time was quite considerable. However, due to the impact of the war, transportation was obstructed, exports were hindered, and the sales channels were affected. According to Table 5, from 1937 to 1939, the export volumes of tung oil and tea oil in Guangxi both showed a downward trend. Consequently, with the poor export of plant oils, coupled with the shortage of imported petroleum, although people at that time used tea oil as a substitute for kerosene for lighting, the cost of fuel was "often more than the cost of electricity, and the brightness, aesthetics, cleanliness, and convenience of the lamps were not as good as electric lights [47]."

Table 3: Production of Tung Oil and Tea Oil in Guangxi from 1937 to 1940 (Unit: Piculs)[9]

Year/ Product	Tung Oil	Tea Oil
1937	359641	229469
1938	295199	155532
1939	388093	239493
1940	338671	192188

Table 4: Export Volume of Tung Oil and Tea Oil in Guangxi from 1937 to 1942 (Unit: Metric Tons)[64] [65] [66]

Year/ Product	1937	1938	1939	1940	1941	1942
Tea Oil	23011	55274	2276	——	——	——
Tung Oil	108175	63456	80860	14112	——	——

The exploration of using plant oils as energy in Guangxi began during the period of second sino-Japanese war, although as early as 1935, Shen Yijia, a Chinese mining engineer who studied in France, had already conducted experiments with Chinese plant oils in European factories, successfully refining gasoline, kerosene, lubricating oil, and other petroleum products[40]. However, the technology of large-scale plant oil refining into petroleum products for power generation had not yet been introduced to Guangxi before second sino-Japanese war. Since the outbreak of second sino-Japanese war, some power plants in Guangxi began to explore the use of plant oils for power generation. In 1938, due to the frequent shortage of diesel sources in Guangxi, to ensure the normal supply of electricity, the Liuzhou Branch of Guangxi Power Plant used tea oil as a substitute for oil residue (i.e., heavy diesel) to inject into the oil residue engine for power generation, and found that the effect of tea oil replacing oil residue for power generation was very good[38]. At that time, people commented on the success of the Liuzhou Power Plant in using tea oil for power generation in the following way: "Our province has an abundant daily production of tea oil. If we can switch to using tea oil, there is no need to rely on imported goods. This can not only replace the needs during the war but also promote the production of tea oil in our province[38]." After the successful trial of tea oil at the Liuzhou Power Plant, other power plants in Guangxi gradually began to use tea oil and other plant oils for power generation. However, using direct plant oils as a substitute for oil residue for power

generation can also lead to some problems. For instance, engineers at the Guilin Power Plant mentioned, "The fuel oil residue used by our factory is not only expensive but also the source has been cut off. It cannot be purchased within the province, so we have no choice but to switch to tea oil as a substitute." Additionally, due to "the cold weather today, causing the tea oil to freeze," this has led to occasional "dimness in the electric lights in the city [57]."

Affected by the limitations left over from the two decades before second sino-Japanese war, many power plants and other factories in Guangxi still mainly relied on diesel engines for their large power machinery. Many power plants, due to the lack of petroleum, found it difficult to continue power generation and tried to purchase diesel through various means. However, due to the "petroleum monopoly" policy at the time, it was very difficult for factories in Guangxi to obtain enough petroleum[70]. At the same time, although power plants in Guangxi directly injected plant oils into diesel engines for power generation from 1937 to 1940, such attempts did not solve the problem of diesel shortages in Guangxi and led to many limitations. For example, because the solidification point of tea oil is relatively high and the winter temperatures in Guangxi are relatively low, tea oil is prone to freezing, which led to the city's lights occasionally becoming dim.

Under the aforementioned circumstances, Guangxi quickly adjusted its plant oil development strategy and began to explore the refining of locally produced plant oils into substitute gasoline and diesel. During the period of second sino-Japanese war, a large number of scientists responded to the national call and came to the rear area of Guangxi to conduct experiments on the refining of plant oils into substitute petroleum products. Wu Yixin, a Bachelor of Science from Central University, and Zhu Jiahu, a Bachelor of Science from Guanghua University, are typical representatives of this endeavor. They used "local raw materials such as rosin to refine diesel," and conducted experiments with the finished products in Guilin, finding that the substitute diesel performed well, with "no ash or residue left inside the machine" after use. It was also tested by various institutions in Guilin, and they "all expressed great satisfaction[49]." Due to the fact that the substitute diesel they produced "does not contain acidity or impurities, making it most suitable for power use," in 1942, they established the "Kaiyuan Liquid Fuel Factory" near the county town. The factory used locally produced rosin to produce substitute diesel, with a monthly output of 4 tons of substitute diesel. They also set up sales points in Guilin, Liuzhou, Hengyang, and other places[55] [68]. In addition to scientists establishing factories to refine substitute petroleum products, the Nanjing National Government and the Guangxi provincial government also set up a number of factories that used refined substitute diesel and gasoline. Among them, the larger factories included the Liuzhou Branch of the China Plant Oil Factory and the Guangxi Enterprise Company Oil Refinery. In 1942, due to "the current lack of gasoline sources and the abundant production of tung oil in the province," the Guangxi Enterprise Company co-established the Guangxi Enterprise Company Oil Refinery with the Bank of Guangxi. This factory used rosin, pine roots, and tung oil to refine gasoline. In February of the same year, the China Plant Oil Factory, funded by the Nanjing National Government's Ministry of Economics, set up a branch in Liuzhou. This factory specialized in treating domestic plant oils through deacidification and degumming, and then "according to European and American specified methods," manufactured gasoline, kerosene, diesel, and refined fuel oils, and other substitutes for petroleum. The product

performance was good, and people at that time commented that the product "in terms of heat resistance, lubricity, and oil consumption, is said to be similar to imported mineral machine oils[56]."

During this period, the production of substitute diesel, substitute gasoline, and other substitute petroleum products in Guangxi could not be separated from the financial support of the Nanjing National Government. The government encouraged the production of substitute petroleum products through bank loans. In 1942, the 110th meeting of the Joint Conference of the Four-Bank General Office, which was jointly discussed by the Central Bank, the Bank of China, the Bank of Communications, and the Farmers Bank, was convened. The meeting decided to "reorganize, expand, or establish public and private plant oil refining factories," and to make full use of tung oil to refine substitute petroleum products[67]. In July of the same year, the Ministry of Economics of the Nanjing National Government "assisted existing private refineries to expand their equipment and increase production," granting a loan of 50,000 yuan to the Kaiyuan Liquid Fuel Factory[67]. In addition to private refineries, the Ministry of Economics also strongly supported state-owned refineries in the production of substitute petroleum products, providing a loan of 800,000 yuan to the China Plant Oil Factory[67].

With the joint efforts of the government and the private sector, the manufacturing of substitute diesel, substitute gasoline, and other alternative petroleum products in Guangxi developed rapidly, providing a continuous supply of fuel for power plants and other factories. During the period of second sino-Japanese war, the Nanjing National Government implemented a monopoly on petroleum, and "apart from a portion supplied by Gansu Oil Mine, other needs were met by various substitutes [53]." At that time, the generators of Guangxi Hydropower Company could "use domestic oil residue (diesel) as fuel." Not only was the fuel readily available, but it also had the advantage of low cost. According to precise calculations by people at that time, "the cost per kilowatt-hour of electricity was twelve yuan and three cents and four mils[50]." We speculate that the domestic diesel used by Guangxi Hydropower Company is the substitute diesel refined from plant oils produced in the province. In addition, at that time, many factories in Guangxi also used locally produced substitute diesel, which provided sufficient fuel for power generation and factory production, thereby alleviating the energy crisis to some extent.

3.3 Attempts to Develop Hydropower

In addition to encouraging the use of plant oils to refine substitutes for diesel and gasoline, Guangxi is also actively developing a new source of energy — hydropower. Guangxi, with its "abundance of high mountains and rapid rivers, has many places suitable for the construction of hydroelectric power stations [16]. "Before second sino-Japanese war, Guangxi had already begun to plan the development of hydropower, but the use of hydropower for electricity generation was still "in the research phase[10] ." In 1932, Guangxi Governor Ma Junwu and Li Zongren invited water conservancy experts Mai Yunyu and Wang Silian to inspect potential sites for hydroelectric power generation in Quanzhou, Liuzhou, He Xian, and other places. However, due to "lack of funds, the project could not be implemented." [20] At that time, the Fuhe Zhong mining area in Guangxi also utilized hydropower for mining. They "constructed aqueducts, installed water pipes, and channeled

mountain streams to use the flow of water to flush the mining area and extract minerals[10] ." Guangxi also had the idea of hydroelectric power generation: The Guangxi provincial government planned to "establish a hydroelectric power plant in Babu, He Xian," using the water power of the He River for electricity generation to meet "the needs of developing mining affairs," but later "abandoned the plan due to the high cost of electricity [10]." In addition to the government's initiatives, there were also practical attempts at harnessing hydropower by the local people in Liuzhou. According to Yun Zhen's report from the Guangxi Inspection Team, at that time, someone had built a dam near Jila, hoping it could be used for "a large-scale rice milling factory." However, due to a lack of understanding of engineering principles, the design and construction were not well done, leading to the collapse of the water dam and all previous efforts being wasted[10].

Since the outbreak of second sino-Japanese war, the Nanjing National Government has encouraged all regions to "make full use of the naturally endowed water resources to plan and build hydroelectric power plants, in order to supply power for relocated and newly established factories." Subsequently, the Resources Committee also regarded "focusing on hydroelectric power generation" as one of the three principles for the development of electricity[69] [72] [79]. In response to the electricity industry in Guangxi, people at that time believed that "where there is a water source available for power generation, hydroelectric generators should be installed to save raw materials. Efforts are being made to quickly handle the establishment of hydroelectric power plants, in order to achieve widespread power supply[54]." During this period, the exploration of hydropower resources in Guangxi could not be separated from the dual forces of the government and the private sector. It can even be said that the successful exploration of hydropower generation in Guangxi during the period of second sino-Japanese war more reflected the wisdom of the local working people. Among them, the development of hydropower in He Xian is a good example. In 1941, brothers Huang Shizhen and Huang Dezhan founded Zhenji Agricultural Company at the Chushuitang in Xiadao Village, Etang Town. They installed a 3-kilowatt generator set, "using spring water as power to mechanically comprehensively process rice, flour, sugarcane, and bone meal[22] [24]." In the same year, the Dacheng Machinery Factory in He Xian invented a type of water-powered engine capable of generating thirty horsepower, which could be used for rice milling, flour, sugar and oil extraction, and was awarded and publicized by the government[15] [41] . In 1943, more than 50 investors, including overseas Chinese from Guangdong and local capitalists, jointly invested more than 70,000 yuan to establish the He Xian Guangming Chemical Factory. Yu Hexiang and others developed the hydropower resources of Guposhan and utilized a canal left over from the discontinued Dadong Mining Company to build a small hydropower station with an actual power output of 93 kilowatts and an annual electricity generation of 670,000 kilowatt-hours[22]. Compared to the achievements made by private sector hydropower development, during this period, although the Guangxi provincial government made numerous attempts to develop hydroelectric power, all ended in failure.

4. Conclusion

During the period of second sino-Japanese war, Guangxi vigorously developed local resources, making full use of the province's resource endowment advantages, and widely developed coal,

charcoal, plant oil, hydropower, and other energy sources. The aim was to open up a path of localized energy development under Japan's energy blockade, ensuring a stable supply of energy during wartime. Although there were many limitations in the development of local energy during this period, such as the inability to solve the uneven distribution of energy in time and space and the very unbalanced regional development, the government-led energy supply system ensured the security of energy supply in Guangxi. Additionally, from the development and application of local energy in Guangxi during the period of second sino-Japanese war, we can also see the relationship between the government and the private sector behind it.

Our research on the power energy construction in Guangxi during second sino-Japanese war is of great significance for energy security and energy transformation in modern China. Since the reform and opening up, while pursuing high economic growth, China's energy structure has gradually become unbalanced due to the imbalance between economic development and energy demand. Fortunately, since Xi Jinping became of the General Secretary of the Central Committee in 2012, China has refocused its attention on low-carbon transition and high-quality development. The energy development of Guangxi during second sino-Japanese war also has important reference significance for the transformation of modern energy structure and the embodiment of safe energy supply.

Firstly, Guangxi has been alleviating the tension of traditional power generation resources (such as coal, charcoal, and oil) in some areas by developing renewable energy sources—hydropower, through hydroelectric power generation. Secondly, it is important to pay attention to the relationship between the government and the private sector behind energy development. In this process, cooperation between the government and the private sector is crucial. The government needs to formulate reasonable policies and regulatory measures to ensure the sustainability of energy development and the fairness of the market, while encouraging the participation of private capital to stimulate market vitality and technological innovation. Private enterprises should actively respond to policy guidance, invest in funds and technology, and promote the improvement of energy development efficiency, achieving a win-win situation for both economic and social benefits. Through this collaborative cooperation between the government and the private sector, the healthy development of the energy industry can be effectively promoted, ensuring national energy security and promoting the continuous growth of the economy. Finally, we should actively build a safe energy system. From the energy transformation process in Guangxi during the comprehensive resistance period, we can see that promoting energy transformation and supply security, and using government power to increase the adjustment of industrial structure and energy structure, plays an important role in building a strong barrier for national energy security.

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