



Study on Countermeasures for the Digital Development of Clean Energy Industry in Southwest China-Based on PEST Analysis

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ABSTRACT

China's environmental problems are becoming more prominent, and energy issues face new challenges, while new energy sources are gaining more and more recognition in the industry. The Southwest region is rich in clean energy and a critical research area for clean energy (especially hydropower resources). The digitization of the clean energy industry in Southwest China will help to improve the productivity of the clean energy industry in the region and help integrate clean energy industry resources in the area. However, there is an asymmetry in the supply and demand of new energy information in part, and existing studies do not analyze the digitalization of the new energy industry in Southwest China as a whole. Therefore, this paper uses PEST analysis to examine four aspects of the southwest region's political, economic, social, and technological environment. Detailed countermeasures are formulated for the digital development of the clean energy industry in the area. It also points out the future development direction of the clean energy industry in Southwest China through digital transformation. The study identifies problems such as energy storage systems in Southwest China that still need to be improved and unstable wind and photovoltaic power generation in Southwest China. Finally, some recommendations are given, such as increasing the construction of clean energy over-consumption markets and increasing the construction of clean energy for rural areas.

Keywords: Southwest region, clean energy, digital economy, industry digitization, PEST analysis

1. INTRODUCTION

1.1. Research Background

Energy is the foundation and driving force of modernization. 2014 General Office of the State Council on the issuance of a strategic action plan for energy development (2014-2020) pointed out that due to profound adjustments in the world's political and economic landscape and profound changes in the relationship between energy supply and demand, resulting in increasing energy resource constraints in China. At the same time, China's environmental problems are prominent, and energy development faces a series of new issues and challenges. Since 2001 China's energy consumption structure in coal consumption has been at the top of the list, reaching 90% of energy consumption, which has caused a severe impact on China's

environment. the replacement and utilization of clean energy have gained more and more recognition from the industry. As a critical area for clean energy research, with abundant renewable energy resources, the Southwest region has a natural advantage for developing the clean energy industry. However, there is an asymmetry between the supply and demand of new energy information in the Southwest, so the digital transformation of the clean energy industry should be strengthened. The clean energy industry should develop detailed countermeasures for the digital development of the clean energy industry in the face of its current development advantages and problems.

1.2. Literature Review

Since the introduction of the double carbon target, the issue of carbon emission reduction has become a hot topic

of concern for all sectors of Chinese society. Gu Genyong (2021) suggests that clean energy is at the core of low carbon economic development. It is necessary to explore the optimal path for developing the clean energy industry [1]. Wang Zhongjie and Liu Yiheng (2015) found that government guidance, infrastructure construction, financial and fiscal support, innovation system construction, and talent cultivation are necessary measures for developing the clean energy industry, with innovation-driven strategy and technology standard strategy being the top priorities [2]. Zhao Tao, Zhang Zhi, and Liang Shangkun (2020) proposed the digital economy as a new economic form based on the continuous improvement of the digitalization, networking, and intelligentization of the economy and society through two modes of digital industrialization and industrial digitization [3]. Xie Yunfei (2021) proposes that it can directly promote the improvement of China's energy industry structure and the progress of biased technology, reducing carbon emission intensity [4]. Ma Hongqi, Li Weiqi, and Chi Fudong (2021) found that Southwest China is naturally endowed with clean energy and has the advantages of complementary landscape and water development. However, technical and management problems such as the low operational efficiency of clean energy systems and the energy consumption structure of the end sector still need to be optimized. Ma Hongqi, Li Weiqi, and Chi Fudong (2021) also found that Southwest China is naturally endowed with clean energy and has the advantages of complementary landscape and water development. However, there are also technical and management problems, such as the low operational efficiency of clean energy systems and the need to optimize the energy consumption structure of the terminal sector [5].

1.3. Research Significance

Current research in this area in China has focused chiefly on developing the clean energy industry in the Southwest. It has rarely analyzed the possibilities of its common effect in the digital economy wave. In addition, few existing studies have conducted a pest analysis of the Southwest region. This paper uses pest analysis to investigate the problems and political, economic, social, and technological environments facing the digital development of the clean energy industry in Southwest China and, on this basis, focuses on two breakthroughs, namely policy innovation and technological innovation, and gives targeted countermeasure suggestions for the development path of the clean energy industry in Southwest China from four levels: policy, social and technological. This study will help the clean energy industry in Southwest China to improve the quality and efficiency of energy production and reshape the structure of the clean energy industry chain through digital transformation.

2. PEST ANALYSIS OF THE DIGITALIZATION OF THE CLEAN ENERGY INDUSTRY IN SOUTHWEST CHINA

Southwest China is rich in hydropower resources, with a technically exploitable capacity of 4.2×10^8 kw, concentrated in Sichuan Province, Yunnan Province, and the Tibet Autonomous Region. Natural gas reserves account for 29% of the country, concentrated in Sichuan Province and Chongqing Municipality. Coal reserves account for 10% of the country, mainly in Guizhou Province. Solar energy resources are locally rich, and wind energy resources are generally poor in areas other than Yunnan Province [6]. During the 14th Five-Year Plan for China's national economic and social development, the National Energy Administration has focused on developing and building hydropower plants in key regions such as southwest China and the upper reaches of the Yellow River. It anchored a target of over 1.2 billion kilowatts by 2030 and vigorously developed wind and solar power.

2.1. Analysis Of The Policy Environment

In recent years, the five southwestern provinces of Chongqing, Sichuan, Guizhou, Yunnan, and Tibet Autonomous Region have introduced many policies and measures on "new energy," industrial digitalization, and green low-carbon industries, creating favorable conditions for the digitalization of the clean energy industry.

In April 2019, the People's Government of the Tibet Autonomous Region issued the Notice of the People's Government of the Tibet Autonomous Region on the Implementation Plan for Deepening the "Internet + Advanced Manufacturing" Development of Industrial Internet in the Tibet Autonomous Region [7]. It mainly focuses on improving network foundation, building platform systems, consolidating industry foundation, promoting integration applications, and strengthening security. The Notice also proposes five key projects, including enhancing the network foundation, building a platform system, reducing the industry foundation, promoting integration and application, and strengthening security. In April 2020, the Development and Reform Commission of Yunnan Province announced the "Implementation Plan for the Industrial Internet in Yunnan Province" [8]. It covers the digitalization and intelligent transformation and upgrading of critical industries and backbone enterprises in Yunnan Province, mainly from building an industrial Internet platform system and mobilizing enterprises to actively access the platform. The system mobilizes enterprises to be active on the forum and integrate and collaborate to promote open innovation. In May 2020, the Yunnan Provincial People's Government published a report on the work of

the Yunnan on the construction of "Digital Yunnan," which focuses on the functional layout of new infrastructure and the accelerated cultivation of data element markets [9]. In the report, the Yunnan Provincial People's Government May 2020 discussed the construction of "Digital Yunnan," with detailed tasks deployed in three areas: actively laying out new infrastructures; accelerating the cultivation of data element markets; promoting the "use of data and intelligence in the cloud"; building the industrial Internet.

In October 2020, the Sichuan Provincial People's Government adopted several policies and measures to support the development of the new energy and intelligent vehicle industry in Sichuan Province [10]. To strengthen the organizational leadership and coordination of developing the new energy and intelligent vehicle industry in the region, thereby creating a favorable environment for the sector's development. In August 2021, the General Office of Chongqing Municipal Government in the Chongqing Industrial Internet Innovation and Development Action Plan (2021-2023) accelerated the creation of December 2021 [11]. The Sichuan Provincial People's Government published the "Decision of the CPC Sichuan Provincial Committee on Promoting the High-Quality Development of Green Low-Carbon Advantageous Industries to achieve Carbon Neutrality" which covers the basic situation of the development of clean energy resources and industries in Sichuan Province as well as their advantages [12]. The decision is mainly based on the following seven aspects: to lead the development of green and low-carbon initiatives to achieve carbon neutrality, to improve and strengthen clean energy industries, to develop and enhance clean energy support industries, to accelerate the development of clean energy application industries, to enhance scientific and technological innovation for the development of green and low-carbon initiatives, to promote the accumulation and development of green and low-carbon initiatives, and to create an excellent environment to support the development of green and low-carbon industries. In April 2022, the Guizhou Provincial People's Government announced a series of policies and measures to support digital transformation in the industrial sector [13]. The text proposes to support leading enterprises to build smart factories and lighthouse factories, support SMEs to popularise and apply digital technologies, and support significant projects through funding. Construction shows that Guizhou Province is helping industrial enterprises digitally transform and upgrade while also promoting the high-quality development of the industrial economy.

Since 2019, Southwest China has been deepening the development and innovation of the combination of the Internet and advanced industrial structures with the Internet + Big Data platform and the construction of digital industrialization as the core. Outstanding plans and designs have been made for data collection, industrial

transformation, and the development of information industries to local conditions. "In the opening year of the 14th Five-Year Plan, a complete industrial system requires steady and steady progress. The breakthroughs in digital transformation will require technical and financial support and a community of environmental destiny throughout so that the "Internet + digital" can be deeper and more complete and achieve a high level of quality development with competitive potential.

2.2. Analysis Of The Economic Environment

2.2.1. The Trend Of Industrial Integration In Southwest China Is Obvious

The digital economy in the Southwest is booming. In terms of digital industrialization, China has been generating digital growth of more than 30% per year since 2015, as high-tech industries such as financial transactions, car networking, and industrial Internet develop at high speed, putting forward new demands for arithmetic power. At the same time, to enhance the role of the digital economy and improve the efficiency of energy use of data centers, China has put forward the strategy of channeling. More computing resources from the eastern areas to the less developed western regions. The scale of investment in its related industries has been rising. As of 2020, the scale of China's arithmetic industry has reached two trillion yuan, eight trillion yuan drive the total economic output, the investment in this field exceeds 400 billion yuan, and the amount of pull to related industries reached 1:8.

Due to the concentration of large hydropower projects in southwest China, moderate relative temperature throughout the year, relatively cheap electricity prices and large data center footprint, and high energy consumption, the data center industry in southwest China is booming. Moreover, the continuous improvement of infrastructure level and communication facilities in southwest China, especially the construction of 5g in recent years, has improved data transmission efficiency, making Tencent Apple Ali and Huawei have also chosen data centers in Guizhou for construction. Not only that, but China has also set up two large data centers in the southwest region, namely the Guizhou computing Hub and Chengdu-Chongqing computing Hub, which have brought new opportunities for the digital development of the clean energy industry in the southwest region of China. The index of industry digitization.

The trend of industrial integration in Southwest China continues to be highlighted, and the index of digitization of industries is increasing. In terms of total volume, the volume of the digital economy in Sichuan province will exceed RMB 1 trillion in 2020, while Chongqing, Guizhou, and Yunnan all have over RMB 500 billion in digital economies. Digital economy growth is faster in southwest China in recent years, with the highest growth

in Guizhou and Chongqing, with more than 15% growth in 2020, growth of 10% in Guizhou, only lower growth in Yunnan province, at about 6%. [14]Although the volume and proportion of the southwestern areas in developing the national digital economy are not significant, there is more room for development with a faster growth rate.

In the southwest provinces and cities, Guizhou Province, although the digital economy and the original foundation are weak, the digital economy growth rate performance is the most outstanding due to the particular location and energy cost advantages. Guizhou Province's digital economy growth rate ranked first for six consecutive years. The added value of the digital economy exceeded 650 billion yuan, accounting for 34% of GDP. In recent years, relying on the advantages of big data technology, the digital economy has been deeply integrated with the real economy, and the industrial digitization has been accelerated, with actions such as the "transformation of 1,000 enterprises" and "integration of 10,000 enterprises" being carried out. The integration of the actual industry with the digital economy is evident. Sichuan Province has the best digital economy

foundation among the southwestern provinces, with the most well-developed digital sector and a high average annual growth rate, and is at the forefront of the southwest region in both the Spillover Index and the Integration Index. Chongqing ranks second in the digital economy index, with a booming industry and 351 key digital economy enterprises. The relatively small scale of the digital economy industry in Yunnan Province, but the high spillover index indicates that the economic drive of the digital economy in Yunnan Province is more promotion. Therefore, to improve the level of digital economy growth and increase the purpose of the digital economy, Yunnan Province has released "Several Policy Measures on Vigorously Promoting the Accelerated Development of the Digital Economy, which mentions the promotion of new infrastructure development, industrial digitization and digital industrialization, A series of subsidy measures and implementation methods on the introduction of talents, attracting enterprise investment, supporting innovation development, platform enterprise development and digital transformation of enterprises. It is expected to bring unprecedented development opportunities to develop Yunnan's digital economy.

Table 1. Digital Economy Index of Southwest China by Province May 2021

Province	Digital Economy Index	Industry indices	Spillover Index	Integration index	Infrastructure Index
Sichuan Province	1029	2.7	7.8	47.7	1.0
Chongqing	666	1.7	4.7	42.7	1.0
Yunnan Province	525	0.9	7.5	41.5	0.9
Guizhou Province	309	0.6	4.8	30.8	0.8

(Source: Caixin Intelligence)

2.2.2. South-western Provinces Lack Energy Deployment Systems And Trading Markets

The structure of industrial development differs between regions in the Southwest. Guizhou province has been located in the national status of electricity prices due to its abundant hydropower resources, which also creates development opportunities for Guizhou to develop energy-intensive, high energy-consuming industries such as aluminum manufacturing, both of which have sound complementary and synergistic effects. However, in recent years, due to the national call for carbon emission reduction, Guizhou has relied on its development advantages to promote the modern and clean transformation of the energy industry, with the modern energy industry achieving an output value of 352 billion yuan, an increase of 14.2% year-on-year, ranking first in

the province's top ten industrial sectors. New energy scale industrialization continues to promote 2021. Under the Department of Energy, the area projects a construction scale of more than 27 million kilowatts, water and light wind power integration of clean energy base to speed up the promotion. Five million ten million photovoltaic bases to speed up the rise of the hydrogen energy demonstration project. The proportion of clean energy generation in Guizhou's power grid has reached 37% [15]. The digital development of the clean energy industry is beginning to bear fruit. On January 26, Guizhou Han Case Intelligent Technology Co., Ltd. and Guizhou Hydrogen Energy Efficiency Energy Technology Co.,

Ltd. reached a strategic cooperation agreement, through which the two sides will adopt the "PIX Super Chassis+" and "Fuel Cell Cogeneration Energy Supply

Station. The two companies will jointly develop a modular fuel cell mobile energy supply robot through the "PIX Super Chassis+" and "Fuel Cell CHP Supply Station" programs. They were contributing to the intellectual development of clean energy.

The development trend of clean energy synergy between Chongqing and Sichuan Province has been evident in recent years. Due to its relatively good industrial base and the government's active guidance on energy saving and emission reduction, Chongqing has improved its electronic information industry. In this context, Chongqing has built a complete industrial chain around the "core, screen, instrument, core and network" industry, which has enabled the city to achieve high-quality low-carbon development. The Joint Action Plan for Carbon Neutrality in the Chengdu-Chongqing Twin Cities Economic Circle was publicly released. Sichuan and Chongqing will jointly complete ten critical tasks, including regional energy green and low-carbon transformation actions, regional industrial green and low-carbon transformation steps, and regional transportation green and low-carbon. Sichuan Province is an essential high-quality clean energy base in China, with 148 million kilowatts of technically exploitable hydro energy resources, ranking 2nd in China, 6th in theoretical solar energy resources, and 23rd in academic wind energy resources. These clean energy resources are mainly concentrated in the western Sichuan and western Panxi regions, with good conditions for complementary development in geography and space. The government should establish a scientific and reasonable carbon emission assessment and inter-provincial clean energy exchange compensation mechanism as soon as possible. In addition, the government should explore the establishment of a market-based electricity price mechanism reflecting the carbon reduction value of clean energy, carry out carbon trading, and levy carbon emission tax on the coal-fired power plant. Based on the above series of transformation needs, Sichuan province increasingly needs the digital transformation of the clean energy industry. In Yunnan Province, by the end of 2020, the installed capacity of clean energy will account for 85%, clean energy generation will account for about 90%, clean energy traded electricity will account for 97%, and non-fossil fuel will account for more than 42% of primary energy consumption, with four indicators leading the country and reaching world-class levels. The total amount of clean electricity sent from the west to the east exceeds 1 trillion kilowatt-hours, contributing to national energy conservation and pollution prevention. Yunnan Province has become the front-runner in the federal electricity market reform. From 2014 to 2018, market-based electricity transactions in Yunnan Province increased from 17.8 billion kWh to 85.1 billion kWh, with a compound growth rate of 47.9%. Moreover, Market-based transactions accounted for 51% of the province's electricity consumption in 2018. The

development trend of electricity marketization is more apparent, and the demand for clean energy trading platforms is increasingly prominent.

2.2.3. South West Still Needs Improvement In Energy Efficiency And Low Carbon Incentive Policies

China has proposed a series of energy-saving and low-carbon incentive policies in recent years, while Yunnan Province in the southwest region is striving to issue no less than 20 billion yuan of special local government bonds to construct modern industrial parks. Priority will be given to projects included in the park's recycling list for support from the central budget [16]. While the southwest region still lags behind developed coastal areas in terms of energy-saving and low-carbon incentives, except for Yunnan Province, which has issued energy-saving and low-carbon incentives as described above. Anhui, Shanghai, Beijing, Jiangsu, Zhejiang, and Shenzhen have all proposed energy-saving and low carbon incentive policies that suit their circumstances. Their subsidies and support are higher and more targeted than those in Yunnan Province. Jiangsu Province has even implemented a fiscal policy linked to the effectiveness of reducing pollution and carbon. From the procedures that have been released so far, Beijing has the highest level of subsidies, followed by Zhejiang and Guangdong.

China is trying to move away from a resource-based and environmental development approach, improve the quality of economic development and reduce pollutants and carbon emissions. In the 13th Five-Year Plan, China has proposed to control the total amount and intensity of energy. It is required that by 2020 the energy consumption per unit of GDP is 15% lower than that of 2015. The total energy consumption is controlled within 5 billion tons of standard coal, specifically for one degree of electricity that is 0.12283 kg of traditional coal for the standard conversion calculation into the total regional energy consumption index [17]. The southwestern region enacted corresponding energy consumption and intensity control policies to respond to the national dual control target. Guizhou Province issued the "2021 Guizhou Province Orderly Electricity Consumption Program" according to the regional power shortage scale in four levels of red, orange, yellow, and blue warning, combined with the actual arrangement of enterprise peak production. Some factories in Chongqing city were restricted and shut down in early August. However, the southwest region's completion was not as satisfactory in the energy intensity reduction target progress warning level. Yunnan is a level one warning (indicating the form is very serious), Guizhou for the second level warning (indicating the state is more serious), and Chongqing completed the situation better for the third level warning (indicating the overall smooth). For the total energy

consumption control target warning level, Yunnan has reached warning level 1, while Guizhou and Chongqing are better at warning level 3. Part of the reason for this result is that the carbon emission calculation method of the "dual control" policy does not distinguish between clean energy generation and traditional fossil energy generation but uniformly converts electricity consumption into total energy consumption. This calculation method leads to overestimated carbon emissions in the southwest region, where clean energy accounts for a large share of carbon emissions. However,

the carbon emissions from clean energy are, in fact, much lower than those from traditional fossil energy sources, which to some extent constrains the development of clean energy in southwest China.

2.3. Analysis of the social environment

2.3.1. The Proportion Of Clean Energy Consumption In Rural Areas In The South West Is Still Relatively Low

Table 2. urbanization rates and population structure by region in the South West

Indicator / Region	Chongqing	Sichuan	Guizhou	Yunnan
Year-end resident population (10,000 people)	3208.9	8371	3858	4722
Urban population (10,000 people)	2229.1	4749	2051	2363
urbanization rate of permanent residence	69.46	56.73	53.16	50.04
Percentage of children aged 0-14 years	17.08	16.93	11.56	10.75
Percentage of the working population (15-64 years)	67.01	66.97	64.47	69.68
Percentage of older people 65+ years	17.08	16.1	23.97	19.32

(Source: Office for National Statistics)

The urbanization rate in the southwest region is 69.47% in Chongqing, 56.73% in Sichuan, and 53.16% in Guizhou, while the average urbanization rate in China in 2020 is 63.89%. International experience shows that the urbanization rate between 50% and 70% is a period of deceleration [18]. A study showed that southwest China's urbanization rate and residential electricity consumption are positively correlated [19]. The demand for electricity in southwest China is still in the stage of continuous growth. On the one hand, the southwestern region of China is also facing the impact of child-rearing. However, within the Southwest region, the demographic structure of the provinces varies more markedly. Among them, Yunnan Province has already entered the stage of less childbearing, while Sichuan Province and Chongqing City have entered the phase of severe labor. Guizhou province has a younger age structure and is in the background of multiple childbearing, but still faces problems such as a large outflow of the working population. A study showed that the increase in per capita residential electricity consumption brought about by the improvement in living standards accounted for 97.26% of the total increase in electricity consumption from 2001 to

2015, and the impact of population-related factors on the growth of per capita residential electricity consumption in China was not significant [20]. Considering that the southwest region of China is still not affluent and is still in a rapid development stage, there is still a great potential for growth in residential electricity consumption in the southwest region, and a large amount of electricity generation will be needed to meet future household demand. [18]On the other hand, the family structure in the Southwest is slowly transforming from large families to small families, and the society is also changing to atomization, which makes the scale effect of household electricity consumption weaken, thus promoting the growth of domestic electricity demand. The development of power generation in the southwest region has gradually shifted from fossil-based to clean energy-based, with solar and hydroelectric power generation growing more than thermal power generation for a long time. Therefore, during the "14th Five-Year Plan" period, China has proposed promoting the comprehensive development of water and scenery in the southwest region and focusing on some critical watersheds in the southwest region to

develop and build hydropower stations accelerate the transformation of the energy industry.

The rapid rise in primary education and urbanism action in the Southwest of China has led to profound changes in people's lifestyles and energy consumption concepts as their education, and income levels continue to rise and their awareness of environmental protection increases. Clean energy consumption and installed capacity in southwest China are growing fast, but the proportion of clean energy consumption in rural and poor areas in southwest China is still lower than the proportion of clean energy consumption in urban areas for a long time due to the level of education and the availability of clean energy [21].

2.3.2. Clean Energy Remains Challenging To Trade On The Market Due To High Volatility And Low Forecast Accuracy

In Southwest China, the clean energy line market has developed rapidly in recent years with massive subsidies and policy support. The lack of a market-based mechanism to promote renewable energy has become an important cause of abandoned wind and light due to the system of fixed feed-in tariffs, tariff subsidies, and guaranteed consumption, which has put enormous financial and consumption pressure on local governments [22]. Therefore, the National Development and Reform Commission (NDRC) proposed in June 2021 the Notice on Matters Relating to the New Energy Feed-in Tariff Policy 2021, which stipulates that new projects will no longer receive central subsidies and will be implemented at parity. However, the marketization of clean energy in the southwest still faces many difficulties. For example, except for Sichuan, where clean energy trading is based on complete guaranteed purchase and does not participate in the spot market, all other provinces in the southwest have not yet started the marketization of clean energy. This is mainly because of the high volatility of clean energy, the low accuracy of forecasts, and the risks involved in participating in market-based trading.

2.4. Analysis Of The Technical Environment

2.4.1. Power Infrastructure Improvement And Communication Technology Development Drive Smart Grid Construction

A smart grid is a collection of power and communication technologies built based on an integrated, high-speed two-way communication network with the help of big data technology. It is a new power system network that combines automation and information technology structures into our existing power networks by applying advanced sensing and measurement technologies and advanced decision support system technologies. Combining these technologies allows for

reliable, safe, economic, efficient, environmentally friendly, and safe grid use [23]. In 2019, the State Grid of China had set out the strategic goal of building a world-class grid.

In 2016, the Southwest Power Grid covering Sichuan, Chongqing, and Tibet was already grid-connected and regulated, becoming the regional grid with the highest proportion of clean energy generators to the total number of generators in China time. By 2020, the scale of installed clean energy power generation in Chongqing will reach 11.4 million kilowatts, accounting for 43.7% of the city's total installed power capacity, including 1.64 million kilowatts of new energy [24]. The installed hydropower capacity in Sichuan reached 80.82 million kilowatts, with an annual power generation capacity of 351.4 billion kilowatt-hours, accounting for 21.8% and 25.9% of the country, respectively. By 2025, the province's installed wind power will exceed 10 million kilowatts. In solar energy, Sichuan is in a period of rapid development of scale. By 2025, the province's installed photovoltaic power generation scale will exceed 12 million kilowatts [25]. Guizhou has an installed power capacity of 74.78 million kilowatts, 43% over 2015. Guizhou's proportion of installed renewable energy power will reach more than 58% by 2025. From 2019 to 2020, the scale of photovoltaic power generation construction in Guizhou goes 8.82 million kilowatts, accounting for approximately 20% of the national ranking of new buildings [26]. The improvement of power infrastructure provides equipment for the construction of smart grids. In addition, the State Council has established Chengdu as a communications hub in southwest China. Since then, Chengdu has been the fourth most significant communications technology and equipment research and development center in China after Beijing, Shanghai, and Shenzhen, and it is also at the forefront of the development of the communications industry and communications service capacity, which provides technical support for the construction of smart grids.

The smart grid has been effectively applied in the southwest. In the summer of 2021, Sichuan found the peak difference in electricity consumption between the Sichuan and the northwest grid through the intelligent grid during the peak season. The province used technical means to obtain 570 million kWh of electricity, avoiding extensive power restrictions while eliminating 300 million kWh of abandoned electricity for hydropower in Sichuan and 220 million kWh of abandoned electricity for new energy in the northwest [27]. The intelligent grid plays a significant role in eliminating abandoned electricity and ensuring peak. The role of smart grids in absorbing abandoned electricity and ensuring peak electricity consumption is remarkable.

In 2018, the first intelligent substation in Yunnan Province was implemented. Through the digital

technology of the smart grid, Yunnan Province can scientifically predict the supply and demand of electricity, accurately dispatch water, fire, wind, and light power generation, expand electricity consumption in the province while expanding outward power transmission, and solve the problem of hydropower abandonment.

2.4.2. A Growing Pool Of Talent For The Digital Economy

The talent required for digital transformation comprises three main categories: digital leaders, digital application talent, and digital professionals.

On May 8, 2021, Sichuan Province launched its digital talent training program. The Sichuan Big Data Industry Federation and Dr. Peng Telecom Media Group officially signed a contract to launch the "City Partner" digital talent training program to construct the digital economy and launched a nationwide inclusive action to help enterprises' digital transformation. In 2022, the "Digital Economy Talent Market," sponsored by Chongqing Human Resources and Social Security Bureau, was launched in Chongqing. This is not only the first "new position" to gather and cultivate digital economy talents in Chongqing but also the first digital economy talent market in China. Since its establishment, the service center has conducted more than 1,000 employment and entrepreneurship activities and served 710,000 college students. Chongqing's digital economy enterprises have reached 18,500, with 351 key platform enterprises, and the scale of professional talents in the city's digital economy-related disciplines, such as extensive data intelligence, exceeds 250,000 [28]. The concentration of knowledge and technology talent is conducive to the digitalization of industries in the South West.

2.4.3. Energy Storage System To Be Improved

The wind and photovoltaic industries in the South West are an essential part of its clean energy industry. The instability of sunlight and wind power has limited the development of wind and photovoltaic power generation in the southwest. Moreover, this non-continuous and stable power supply access to the grid can also harm the regular operation of the grid. Therefore, a perfect energy storage system is essential to solve the problem of non-continuous distributed power supply access to the grid in the wind and landscape category. On 28 March 2022, the Changshou Enlage Energy Storage Station was officially connected to the grid and implemented in Chongqing. It is the largest megawatt-scale customer-side electrochemical energy storage plant in Southwest China. Customer-side energy storage plants can be used as the backup capacity to ensure the stable operation of the power system and the quality of electricity used by customers in case of power grid emergencies. It can also

reduce the impact of unstable currents on the power grid and ensure the power grid's safe, economical, and efficient operation. However, according to the current distribution of energy storage projects in China, the southwest is the region with the lowest density of energy storage project distribution. The overall layout of energy storage facilities is still relatively weak, which restricts the development of the clean energy industry.

3. COUNTERMEASURES FOR THE DIGITALIZATION OF THE CLEAN INDUSTRY IN SOUTHWEST CHINA

3.1. Networking Clean Energy Deployment Systems

A new integrated and complementary "energy internet" can make up for the unbalanced regional distribution of clean energy. Southwestern provinces should effectively use digital means such as 5G and the energy internet to promote the intellectual development and construction of clean energy exchange mechanisms within the southwest region. For example, Southwest China can use the intelligent power system as the basis for linking the oil and gas pipeline network, heat pipeline network, and electric transportation network of each province, thus promoting the interconnection of clean energy production and consumption data between regions to realize a multi-directional flow sharing network of clean energy and compensate for the seasonal distribution of resources and regional distribution inequality between areas [29].

In addition, it is essential to work on both the supply side and the demand side at the same time. On the production side, it is necessary to focus on local conditions, build power generation facilities that match local clean energy resource endowments, and use the energy internet to share clean energy. On the consumption side, to promote an improved energy consumption structure, Southwest China should invest more in bright charging piles and exchange station projects so that residents have more access to clean energy consumption in their lives.

3.2. Optimising Low Carbon Incentives And Energy Control Policies

Southwest China should follow the existing low-carbon incentive policy for coastal areas, issue special government bonds to construct green and modern industrial parks, and implement a fiscal policy of subsidizing enterprises according to their effectiveness in reducing pollution and carbon emissions. On the other hand, in terms of energy consumption control policies, a carbon emission calculation method of China's energy intensity and total energy consumption control policy does not differentiate between clean energy generation

and traditional fossil energy generation. It uniformly converts electricity consumption into total energy consumption, which leads to carbon emissions caused by energy consumption in Southwest China, which has a high proportion of clean energy. To a certain extent, it also restricts the development of clean energy in southwest china and is not conducive to adjusting China's energy structure. Therefore, a digital and intelligent energy consumption management system should be established in the southwest region to monitor the real-time operation and electricity production and consumption of clean energy and traditional energy units in real-time and change the statistical standards for clean energy consumption.

3.3. Supporting The Digitization Of Clean Energy In Rural Areas

Southwest China should accelerate the rural revitalization strategy and improve the construction and renovation of rural clean energy infrastructure, gradually replacing the old fossil energy-driven model with electric boilers, electric kilns, electric heating for agriculture, and electric drainage and irrigation in industrial and agricultural production and manufacturing. Invest more in the construction of clean energy in rural areas and build digital clean energy management systems based on digital technology according to local conditions. Support the development of small-scale wind power plants in rural areas, distributed rooftop solar energy for the countryside and grid, intelligent biogas online monitoring systems to help transform rural areas from traditional fossil energy to clean energy sources in rural areas, promote economic growth, and encourage synergistic clean energy and agriculture development.

3.4 Promoting Intelligent Trading Platforms For Clean Energy

Southwest China should rely on the existing significant data industry advantages to carry out scientific, refined, and intelligent management of clean energy. With the mature electricity market system as a template and smart grid as a basis, we should build a communication and docking platform for clean energy power market-based trading parties. Improve the efficiency and symmetry of information communication, and promote the market parties to reach trading intentions. Focus on constructing a clean energy over-consumption market through spot market trading to expand the electricity market, reduce the cost of electricity for users, and help clean energy consumption. A flexible internet-based trading platform for clean energy will be established to support direct transactions between wind power, photovoltaic power, hydropower, and other green and low-carbon energy sources and electricity users. Explore the environmental protection benefits of clean energy, create corresponding energy

derivatives, and provide differentiated clean energy packages for different user groups. We will foster new forms of green energy production, consumption, and trading, including third-party operation and maintenance and point-to-point energy services.

4. CONCLUSION

4.1. Key Findings

This paper uses the analytical method of pest to analyze the current situation and the many problems faced by the clean energy industry in the southwest region: political, economic, social, and technological. The study found that in terms of policies. Provincial governments in Southwest China have introduced a series of policies and measures to promote the digitization of the clean energy industry and the development of green and low-carbon profitable industries, creating favorable conditions for the digitization of the clean energy industry. In terms of the economic environment, the digital economy in Southwest China is relatively small and growing at a fast pace, with a clear trend towards industrial integration. In terms of the social environment, the rising urbanization rate of the population in the Southwest has led to an expansion in energy demand. However, the growth in electricity generation in the Southwest has gradually shifted from fossil-based to clean energy-based, with solar and hydropower generation both experiencing higher year-on-year growth than thermal power generation for a long time. However, Southwest China still faces the problem that clean energy consumption in rural areas has long been lower than the proportion of clean energy consumption in urban areas. In terms of the technological environment, the improvement of the power infrastructure and the development of communication technologies in Southwest China have contributed to constructing intelligent grids, making clean energy generation systems more efficient and environmentally friendly. Meanwhile, the continuous improvement of the digital economy talent cultivation system has provided academic support and talent security. However, the energy storage system in Southwest China still needs to be improved to solve the problem of unstable wind and photovoltaic power generation in Southwest China.

4.2. Future Studies

Therefore, Southwest China should use the mature electricity market system to build a communication and docking platform for all parties in the market-based trading of clean energy and electricity, significantly increasing the market's construction for excess clean energy consumption. The government should include rural energy development in its economic and social development plans, strengthen support for rural energy in poverty-stricken areas, encourage financial institutions to

innovate financing methods and service models and give differentiated support to high-quality rural energy projects in terms of loan access, term, and interest rates. We will vigorously promote solar and wind energy heating. The roof of the farmhouse, open space of the yard, and the roof of the relocated house are used to develop solar heating. In rural areas in Chongqing, Guizhou, and other key areas of air pollution prevention and control, central heating systems such as "scenery + storage thermoelectric boilers" have been developed in whole counties. In agricultural and pastoral areas such as western Sichuan and Xizang, off-grid photovoltaic power generation + battery power supply is adopted, and household thermoelectric heating is used. We will actively promote clean heating using biomass energy. Rationally develop biomass boiler heating based on agricultural and forestry biomass and biomass molding fuel, promote central heating such as biomass pyrolysis gas in light of local conditions, encourage the use of large and medium-sized boilers, and provide central heating in rural areas, towns, and other population centers in southwest China. In rural areas that are not key areas for air pollution prevention and control, the household heating model of molding fuel and clean stoves will be promoted in light of local conditions. We will promote geothermal heating in light of local conditions. In large townships and towns in southern Tibet, western Sichuan, and western Yunnan, where geothermal resources are abundant, priority will be given to developing geothermal energy central heating. In economically developed counties, we will accelerate the construction of smart energy big data platforms and adopt digital methods to collect rural energy data. In less developed counties, full-time personnel shall be designated to conduct a comprehensive general survey of rural energy production and consumption using household collection and form investigation. Issue special government bonds to construct green and modern industrial parks and implement a financial policy of subsidizing enterprises according to their effectiveness in reducing pollution and carbon emissions.

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