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Research on Establishment and Application of Evaluation System of Urban Energy Strategy Development Indicators under the Perspective of Carbon Neutrality

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Abstract

A scientific, comprehensive and integrated assessment of urban energy development is of great significance for the establishment of a clean, low-carbon and efficient urban modern energy system. From the perspective of carbon neutrality, this paper sets 25 evaluation indicators in seven dimensions: energy supply, energy consumption, energy efficiency improvement, clean and low-carbon, safety and reliability, low-carbon transport, and scientific and technological innovation, and constructs a secondary indicator system for evaluating the strategic development of urban energy. The system adopts the hierarchical analysis method to determine the weights of the indicators, the double-baseline progression method to standardize the indicator scores, and finally the weighted composite index method to calculate the level of urban energy strategy development. This paper applies the index system to evaluate the current energy development status of Wenzhou city in 2020 and 2022, and to predict the energy strategy development in 2025 and 2030. The scores of Wenzhou city's urban energy strategy development level in the corresponding four periods are 63.56, 70.59, 77.87 and 85.06, indicating that by 2023, Wenzhou city's urban energy development level will go from medium development to high development. Wenzhou City should accelerate the proportion of renewable energy in the future. It is necessary to complement multiple energy sources and improve the integration of heat, electricity, gas and cold. In terms of end consumption, it is necessary to improve the efficiency of energy use, reduce energy intensity, implement electric energy substitution and form an energy consumption pattern centered on electricity.

Keyword: carbon neutrality; energy strategy; modern energy system; indicator evaluation system; two-base asymptotic approach, verification in Wenzhou

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1. Introduction

Energy is an important material basis for human survival and development. China has become the world 's largest energy producer and consumer. In today 's world, the energy pattern is deeply adjusted, the global action against climate change is accelerated, the domestic economy has entered a new normal, and the constraints of resources and environment on energy production and utilization are constantly strengthened. The 17 Sustainable Development Goals set by the United Nations, including three goals: cost-effective clean energy, climate action, and sustainable cities and communities, are highly relevant to the production and use of urban energy. The " Opinions of the Central Committee of the Communist Party of China and the State Council on the Complete and Accurate

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Implementation of the New Development Concept to Do a Good Job in Carbon Peak Carbon Neutralization " clearly requires that by 2060 China will fully establish a green, low-carbon and circular economic system and a clean, low-carbon, safe and efficient energy system. In 2060, the proportion of non-fossil energy consumption in China will jump from 25 % in 2030 to more than 80 %, achieving the goal of carbon neutrality [1-3]. Constructing a scientific evaluation index system for urban energy strategic development is an important way to support the construction of a new energy system, help achieve carbon peak carbon neutrality, and promote clean, low-carbon and efficient use of energy.

It has reached a consensus in the international community to promote the use of renewable energy, accelerate the transformation of energy structure, achieve efficient and clean energy supply, and protect the ecological environment. The proposal of the Energy Internet, which is characterized by the in-depth integration of renewable energy and Internet information technology, will be the key to achieving clean and low-carbon energy substitution and efficient sustainable development. China is vigorously promoting green development and is trying to build a modern energy system. We will continue to reduce energy resource consumption and carbon emissions per unit output, improve input-output efficiency, build a green and low-carbon lifestyle, and form effective carbon emissions from the source and entrance. China 's carbon dioxide emission intensity in 2022 is more than 51 % lower than that in 2005[4-5]. The production and sales of new energy vehicles rank first in the world, accounting for more than half of the world 's total. The proportion of non-fossil energy installed capacity increased to 50.9% [6]. Completely stop the construction of overseas coal-fired power plants, supply 50 % of the world 's wind power and 80 % of the photovoltaic equipment.

The existing evaluation system for urban energy indicators has shortcomings in terms of development theme, content setting, evaluation methodology and data sources [7-8]. The defects in development are manifested in the fact that the city government is the main body of development, and develops the indicators mainly according to the development level and standards of its city, which makes the evaluation indicator system of low value and cannot be used to evaluate other cities [9-11]. Static data, ignoring the dynamic development of city life. At present, most of the data sources for smart city evaluation are government statistics, failing to incorporate real-time dynamic data into the evaluation system. The government data update cycle is long and cannot reflect the real-time status of the city [12-13]. The method is subjective and the data processing lacks scientific. The current evaluation system scores indicators and compares cities with each other by total scores, and the quantification process is interfered by subjective factors [14-15]. Single result, lack of display and dissemination of evaluation results. The current evaluation index system takes the final score as the single result, failing to show the data characteristics more effectively and the evaluation results have a limited audience [16-17]. China urgently needs to establish a set of mechanisms that can reflect the dynamic development process of urban energy levels, in order to achieve an indicator system that scientifically evaluates the level of energy modernisation in Chinese cities [18].

The evaluation index system of urban energy strategy development refers to an objective, comprehensive and systematic evaluation index system for measuring the effectiveness and gap of ecological civilization construction in a region and guiding the construction of ecological civilization [19]. In order to solve the prominent problems of resource and environmental constraints and realize the sustainable development of the Chinese nation, this study optimizes and adjusts the urban energy strategy, constructs the evaluation index system of urban energy strategy development oriented to carbon neutrality, promotes the adjustment and optimization of industrial structure and energy structure, promotes the construction of new power system, and builds a clean, low-carbon, safe and efficient modern energy system. This study analyses China 's urban energy structure, energy supply and demand, energy production, energy consumption, and major resource consumption. The changes of total carbon emissions and intensity, the changes of total energy consumption and intensity, and the growth of carbon emissions in key areas are studied. This study further studies and analyses the evaluation index system of urban energy strategic development from different links of energy production, transmission, consumption, storage and conversion, and applies the system to evaluate the energy development level of Wenzhou.

2. Interpretation of Urban Energy Strategy Development

The key task of the "dual-carbon" endeavour is to "build a clean, low-carbon, safe and efficient energy system". "Clean, low-carbon, safe and efficient" is the core connotation of the modern energy system, but also the strategic goal of the city's energy strategy development.

Clean mainly refers to the development and utilisation of energy throughout the process to minimise ecological damage and environmental pollution. Clean energy has two meanings, on the one hand, it is to vigorously develop clean energy, such as wind energy, solar energy and other renewable energy and nuclear energy. On the other hand, it is to actively promote the clean and efficient use of traditional energy sources, to achieve green development and clean and efficient use in the whole industrial chain, and to achieve the clean and efficient use of coal is clean energy.

Low-carbon mainly refers to the process of energy production and consumption to minimise carbon emissions. Achieving "carbon peak and carbon neutrality" is a broad and profound economic and social systematic change, and the energy sector is the main battlefield to achieve "carbon peak and carbon neutrality". The research and development of low-carbon technologies, carbon replacement technologies, carbon conversion technologies, carbon sequestration technologies and carbon sequestration technologies in the whole life cycle chain of energy is the most important for solving the problem of carbon emission.

Energy security is an important manifestation of the implementation of the overall national security concept in the field of energy. China's energy strategy will be to develop new energy on a large scale and intensively, and its intermittent and fluctuating nature will have a huge impact on energy security supply. In the face of external turbulence and the uncertainty of new energy, superimposed on the implementation of the carbon neutral strategy, there is a need to strengthen the diversified supply of energy, to ensure the stability of domestic energy supply and demand and security of supply, and to keep the rice bowl of energy firmly in one's own hands, in order to guarantee the high-quality development of the national economy.

High efficiency refers to comprehensively improving the efficiency of the whole life cycle of energy production, conversion, transmission and distribution and consumption, and reducing the consumption of energy and resources. Energy use efficiency is an important symbol of the quality of development of a country and region, and the digitalisation and intelligence of energy is an effective means to improve energy efficiency. Improving energy efficiency is not only an important guarantee to meet China's modern energy growth needs, but also an important prerequisite for achieving a beautiful China and addressing climate change, as well as an important source of new momentum for green development.

3. Establishment of Indicator System and Evaluation Methodology

The design of the evaluation index system adheres to the design principles of orientation, scientific, systematicity, operability, comparability and dynamic optimization.

3.1. Indicator setting and adjustment

The evaluation system of urban energy strategy development indicators is divided into two levels. There are initially seven indicators at the first level: energy supply, energy consumption, energy efficiency promotion, clean and low-carbon energy utilisation, safe and reliable, low-carbon transport, and sci-tech innovation. The weights of the first level indicators are 0.05~0.2.

The initial total of secondary indicators is 25, including Total installed capacity of renewable energy power generation renewable energy substitution rate of urban buildings, photovoltaic coverage rate of roof of new factory building in industrial park, non-fossil energy consumption ratio, the proportion of electric energy to terminal energy consumption demand-side response capability, energy consumption, demand-side response capability, energy consumption per unit of GDP, industrial waste energy recycling rate, percentage of green buildings with two or energy consumption ratio, the proportion of electric energy to terminal energy consumption demand-side response capability, energy consumption per unit of GDP, industrial waste energy recycling rate, percentage of green buildings with two or carbon dioxide emissions per unit of GDP, carbon dioxide emissions per unit of industrial added value, energy storage capacity, new energy vehicle market penetration, proportion of urban green energy storage capacity, new energy vehicle market penetration, proportion of urban green travel, investment intensity of green low-carbon energy technology research and experimental development, and so on. The weights of the secondary indicators are 0.1~1. The complete indicator system is shown in Table 1.

This study has set two types of indicators, including binding indicators and guiding indicators. Binding indicators are the basic conditions indicators that the urban energy efficient use system should have in the context of carbon neutrality, and they are binding. Leading indicators are indicators that reflect the comprehensive characteristics of a carbon-neutral urban energy efficient use system on the basis of the core indicators, and that can lead the global development trend, conform to the national medium- and long-term development strategy, and have forward-looking, strategic and leading demonstration effects. The leading indicators are not binding.

The evaluation system of urban energy strategy development indicators should be regularly assessed for its sophistication and orientation, to ensure that the indicators serve the needs of urban energy management, focus on the frontiers of energy issues, and point out the key areas of urban energy development, the main directions of transformation, and the room for improvement and potential for development. The indicators shall be adjusted and updated when the following situations occur.

(1) Adjustment of national, provincial and municipal development plans.

(2) Adjustment of national, provincial and municipal energy strategy objectives.

(3) Changes in standards and other requirements.

3.2. Indicator evaluation modelling

Based on the above work, a preliminary evaluation model of urban energy strategy development indicators was constructed to quantitatively analyse and measure the multi-level indicators of energy strategy, which mainly includes index calculation, indicator weights, calculation methods of indicator values and three parts.

Indicator standardisation methods

The purpose of indicator standardisation is to achieve the standardised application of quantitative and qualitative indicators (which can be quantified). Eliminate the influence of the different scales between the indicators, so that the final value of each indicator is within the range of 0~100. At the same time, it can also reflect the relative value of the same indicator among the assessed cities, making the assessment more comparable.

Adopt the double-baseline progressive method to standardise the scores for each indicator (as shown in Figure 1). Two benchmark values (A value and C value) are set for each indicator. Among them, the A value corresponds to a standardised score of 90 points; the C value corresponds to a standardised score of 60 points. Points are assigned to the indicators based on the distance between the current value of the indicator and the two benchmark values, calculated by the following formula:

$$S_i = (S_A - S_c) * \frac{(X_i - X_{c,i})}{(X_{A,i} - X_{c,i})} + S_C \quad (1)$$

In the formula:

S_i——standardized score for the ith indicator;

X_i, $X_{C,i}$, $X_{A,i}$——the current status value, C value and A value of the ith indicator, respectively;

S_C, S_A——are the scores corresponding to the C and A values (60 and 90 points, respectively).

When $S_i < 0$, the value is 0; when $S_i > 120$, the value is 120.

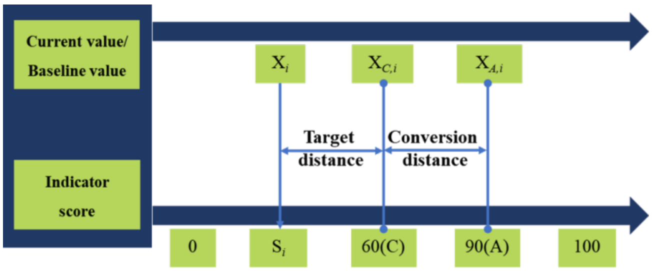

Figure 1. Schematic diagram of the double-base asymptotic method.

Determination of indicator benchmarks

The determination of indicator benchmark values shall observe the following order of priority.

1) Selecting the target values in the programme documents issued by the state or ministry;

2) Selection of national or industry-related standards, plans and requirements;

3) Target values in policy documents issued by provincial administrative units;

4) Based on the characteristics of the local city and the current status of the indicators, taking into account the statistical characteristic values of the indicators of domestic cities at prefecture level and above or international advanced regions, where there is no obvious inter-annual trend of change, the multi-year average value is used; where there is a significant trend of inter-annual change, the data of the status of the most recent complete statistical year from the adjustment period of the indicators is used;

5) For indicators with benchmark values that are difficult to obtain, the average value of existing cities may be used; or the results of information research and expert consultation.

Note: During the indicator adjustment and updating period, the baseline value of the indicator should be adjusted simultaneously, generally every 3 to 5 years.

Methodology for setting indicator weights

The analytic hierarchy process (AHP) is used to determine the weights of the energy strategic development indicator system. The specific calculation process is as follows: first, establish a hierarchical structure model, and stratify the interrelationships among indicators based on the set evaluation system of energy strategic development indicators. Then the judgment matrix is constructed, and when determining the weights between each level and each indicator, the consistency matrix method is used to make two-by-two comparisons, to minimize the difficulty of comparing factors of different natures with each other and improve the accuracy. Secondly, carry out the hierarchical single sorting, for the previous level of a factor, the importance of the factors of this level of sorting, the consistency of the judgment matrix test. Again, the total hierarchical ranking is carried out to determine the ranking weights of the relative importance of all factors at a certain level for the total goal. Initially, the weights of the first-level indicators are 0.05-0.2, and the weights of the second-level indicators are 0.1-1.

Comprehensive evaluation calculation method

The weighted composite index method is used to evaluate the level of regional energy strategy development, and the calculation formula is as follows:

$$S = \sum_{i=1}^{m} S_i * W_{\alpha,i} \quad (2)$$

$$S_j = \sum_{j=1}^{n} S_j * W_{\beta,j} \quad (3)$$

In the formula:

S—energy strategy development level score;

S_i, S_j——the score of the ith level indicator, the jth secondary indicator, respectively;

$W_{\alpha,i}$, $W_{\beta,j}$——the weight of the ith level indicator, jth level indicator respectively;

m, n——the number of first-level indicators and second-level indicators, respectively.

According to the results of the above calculation of the comprehensive development level of urban energy strategies, they are classified into four classes, as shown in Table 1. Level A indicates that the development level of energy strategies is highly developed. Level B indicates that the development level of energy strategies is moderately developed. Level C indicates that an urban energy strategy system has been established to a general extent. Level D indicates that the level of urban energy development is very low. The results of the construction of the evaluation system of energy strategy development indicators for Chinese cities are shown in table 2 The evaluation system contains 25 evaluation indicators in seven dimensions.

Table 1. Criteria for grading the level of evaluation of the comprehensive development of urban energy strategies.

Level	Comprehensive Score (S)
A	S≥80
B	70≤S < 80
C	60≤S < 70
D	S < 60

Table 2. Evaluation system of urban energy strategy development indicators of China.

No.	dimensions	Weight of dimension	Indicator (Second-level indicator)	Weight of indicator	unit	Indicator attributes	A-value	C-value
1	energy supply	0.2	Total installed capacity of renewable energy power generation	0.3	10*3kW	binding indicator	900	600
			wind power curtailment rate	0.1	%	guiding indicators	5	10
			photovoltaic curtailment ratio	0.1	%	guiding indicators	3	5
			Renewable energy substitution rate of urban buildings	0.3	%	binding indicator	13	8
			Clean municipal heating rate	0.1	%	guiding indicators	96	80
			Photovoltaic coverage rate of roof of new factory building in industrial park	0.1	%	guiding indicators	60	50
2	energy consumption	0.2	Non-fossil energy consumption ratio	0.3	%	binding indicator	25	20
			The proportion of clean energy in primary energy consumption	0.3	%	binding indicator	40	30
			The proportion of electric energy to terminal energy consumption	0.2	%	binding indicator	35	30
			Demand-side response capability	0.2	%	guiding indicators	4.8	3
3	energy efficiency promotion	0.2	Energy consumption per unit of GDP	0.3	tce/million RMB	binding indicator	0.25	0.35
			Industrial waste energy recycling rate	0.1	%	binding indicator	40	30
			Heat loss ratio of municipal heating pipe network	0.1	%	guiding indicators	18	23
			Percentage of green buildings with two or more stars in new buildings	0.3	%	binding indicator	55	40
			Percentage of buildings meeting maximum energy efficiency retrofit standards	0.2	%	binding indicator	50	35
4	Clean and low-carbon energy utilization	0.15	Carbon dioxide emissions per unit of GDP	0.5	tons/million RMB	binding indicator	0.5	0.6
			Carbon dioxide emissions per unit of industrial added value	0.35	tons/million RMB	binding indicator	0.4	0.6
			Sulphur dioxide emissions per unit of GDP	0.15	kg/million RMB	guiding indicators	0.3	0.4
5	safe and reliable	0.1	The duration of power outage in central urban area	0.5	h	binding indicator	10	50
			energy storage capacity	0.3	MW	guiding indicators	10000	5000
			Scale of integrated energy stations, microgrids, source-grid-load-storage integration and other new modes and new business models	0.2	seat	guiding indicators	900	500
6	Low-carbon transport	0.1	New Energy Vehicle Market Penetration	0.2	%	guiding indicators	45	39
			New Energy Vehicle Ownership	0.2	10^4 cars	guiding indicators	30	20
			Proportion of urban green travel	0.6	%	guiding indicators	75	60
7	sci-tech innovation	0.05	Investment intensity of green low-carbon energy technology	1	%	guiding indicators	4.5	3

			research and experimental development						

*Tce means ton of standard coal equivalent

4. Results and Discussion

4.1. Analysis of the effectiveness of China's energy system

An analysis of China's energy cleanliness and low carbon status was conducted based on official Chinese government data. Data were collected from the China Ecological Environment Statistics Annual Report published by the Ministry of Ecology and Environment of the People's Republic of China and the Statistical Bulletin of the National Economic and Social Development of the People's Republic of China for the Year 2023 issued by the National Bureau of Statistics of the People's Republic of China.

Assessment and analysis of energy clean use development situation in China

About 66 percent of global NO_x emissions and most particulate matter emissions come from the energy sector, with the thermal power, heat and non-metallic mineral products industries being the main contributors to SO_2 emissions in China. According to China's environmental statistics (Figure 2), from 2010 to 2022, the emissions of SO_2, NO_x, and particulate matter show a decreasing trend, decreasing from 21.85 million tonnes, 18.52 million tonnes, and 12.77 million tonnes to 2.435 million tonnes, 8.957 million tonnes, and 4.934 million tonnes, with an average annual decrease of about 19.89%, 7.23%, and 9.12%, respectively. Among them, the reduction of SO2 is relatively large, especially around 2015, showing a precipitous downward trend. Analyse the reason is mainly because China vigorously promote the energy revolution, continue to adjust the energy structure, moderate control of coal production capacity, and at the same time strengthen the end of air pollution control efforts. Obviously, the emissions of particulate matter, SO_2, NO_x, and particulate matter of per unit GDP also show a decreasing trend year by year (Figure 3), with an average annual decrease rate of about 23.93%, 13.52%, and 141.65%, respectively. After 2013, particulate matter emissions and particulate matter emissions per unit of GDP increased significantly, which may be related to the environmental protection ' Twelfth Five-Year Plan ' canceled the total control of smoke and dust.

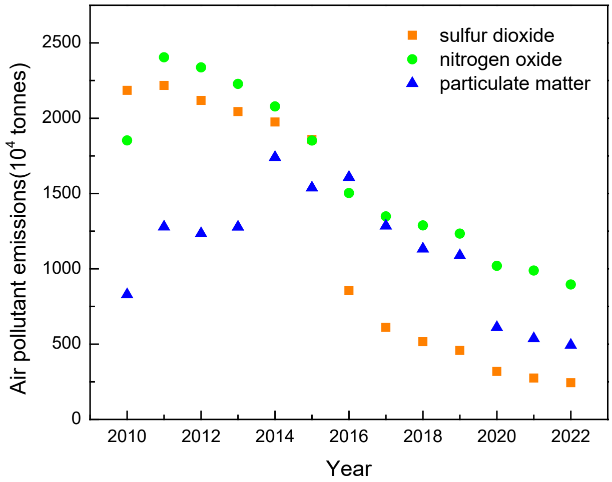

Figure 2. Emission trend of air pollutants in China.

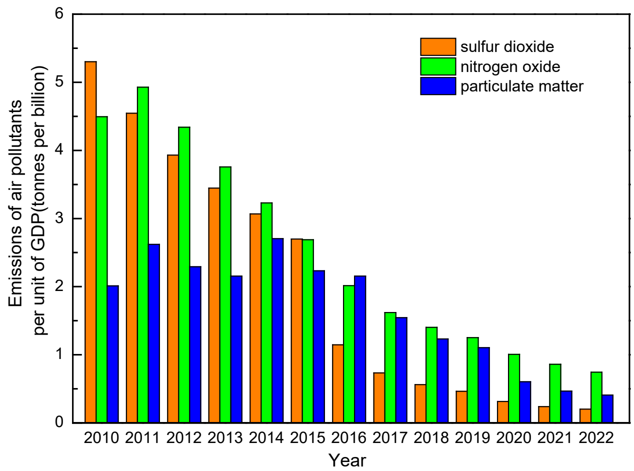

Figure 3. Emission trend of air pollutants per unit of GDP in China

Assessment and analysis of energy low-carbon development situation in China

From 2010 to 2022, China's total CO_2 emissions will grow from 8.146 billion tonnes to 11.477 billion tonnes, with an average annual growth rate of about 1.93%, which is lower than the average annual growth rate of energy consumption during the same period, and further indicates that China's energy low-carbon transition development has been effective. Figure 4 shows four carbon emission intensity-related indicators, from which it can be seen that CO_2 emissions per unit of energy consumption and CO_2 emissions per unit of GDP have been on a downward trend, with an average annual rate of decline of about 1.36% and 4.69%, which is mainly related to the government's introduction of relevant environmental protection policies, industrial technological progress, industrial upgrading, and the gradual increase in environmental protection awareness. On the other hand, per capita CO_2 emissions and CO_2 emissions per unit of industrial added value are both on the rise, with average annual growth rates of about 1.41% and 1.54% respectively, mainly due to the fact that China's economy is currently in a phase of high growth, and that economic growth has not yet been decoupled from energy consumption, so that CO_2 emissions have not yet reached their peak.

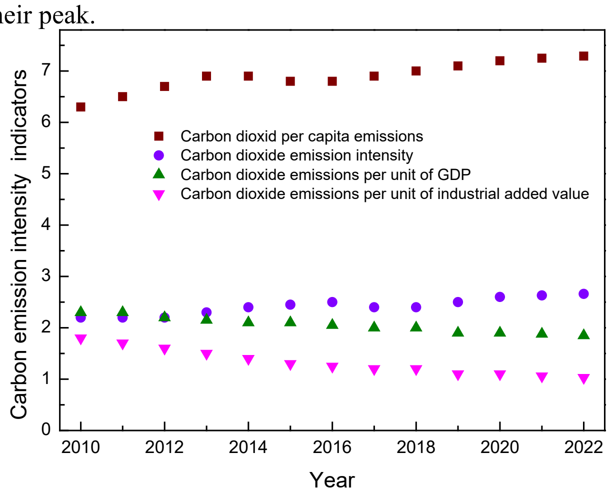

Figure 4. Change trend of relevant indicators of carbon emission intensity in China

4.2. Analysis and Prospect of Wenzhou Urban Energy System Level Assessment

Based on the above index system and evaluation method, the urban energy strategy development level of Wenzhou City was evaluated in 2020, 2022, 2025 and 2030, and the results are shown in Table 3. The results show that the scores of urban energy strategy development level of Wenzhou city in the corresponding four periods are 63.56, 70.59, 77.87 and 85.06, which are C level, B level, B level and A level, respectively. Figure 5 shows the evolution of the indicator scores for the seven dimensions.

In 2020, Wenzhou city has a low level of urban energy strategy development, and there are large differences in different dimensions. Wenzhou has a better foundation in low-carbon transport dimension and energy consumption dimension, with scores of 67.6 and 65.6 respectively. sci-tech innovation dimension has the lowest score, only 56.3. This indicates that Wenzhou's universities and enterprises are weak in science and technology innovation in energy development and utilization. In 2022, under the strategic drive of China's carbon peaking and carbon neutral policies, Wenzhou City has a higher improvement in each energy dimensions. In particular, the three dimensions of safe and reliable, energy supply and energy efficiency promotion have progressed by 13.84%, 13.34 and 12.65 respectively. The development level of energy strategies in Wenzhou is moderately developed. In 2025, the last year of China's 14th Five-Year Plan, the development level of urban energy strategy in Wenzhou City has developed by leaps and bounds. The scores of all dimensions have increased by 20.12% to 28.83% compared to 2020. low-carbon transport, energy supply and energy efficiency promotion all score over 70. The development level of energy strategies in Wenzhou is moderately developed. The development level of energy strategies in Wenzhou is moderately developed, which is further reduced from highly developed.2030 is the final point in time that the Chinese government has committed to achieving peak carbon. This is 11 years after China's dual-carbon target was proposed in 2019. Wenzhou City has made a leap forward in the development level of its urban energy strategy, with a composite score of 85.06. sci-tech innovation improved from 56.23 to 76.89. The other six evaluation dimensions scored 83.01 to 89.65 points. The development level of energy strategies in Wenzhou is highly developed.

Table 3. The score of evaluation index of urban energy strategy development in Wenzhou (current situation, recent and medium term).

No.	dimensions	Indicator (Second-level indicator)	Indicator attributes	2020	2022	2025	2030
1	energy supply	Total installed capacity of renewable energy power generation	binding indicator	65	73	76	83
		wind power curtailment rate	guiding indicators	61	69	78	86
		photovoltaic curtailment ratio	guiding indicators	58	65	75	85
		Renewable energy substitution rate of urban buildings	binding indicator	61	69	76	84
		Clean municipal heating rate	guiding indicators	69	78	85	92
		Photovoltaic coverage rate of roof of new factory building in industrial park	guiding indicators	56	67	73	84

2	energy consumption	Non-fossil energy consumption ratio	binding indicator	66	73	79	82
		The proportion of clean energy in primary energy consumption	binding indicator	66	76	82	89
		The proportion of electric energy to terminal energy consumption	binding indicator	69	78	86	93
		Demand-side response capability	guiding indicators	61	68	75	81
3	energy efficiency promotion	Energy consumption per unit of GDP	binding indicator	68	73	79	86
		Industrial waste energy recycling rate	binding indicator	58	65	73	81
		Heat loss ratio of municipal heating pipe network	guiding indicators	60	65	70	80
		Percentage of green buildings with two or more stars in new buildings	binding indicator	62	71	78	83
		Percentage of buildings meeting maximum energy efficiency retrofit standards	binding indicator	61	68	73	81
4	Clean and low-carbon energy utilization	Carbon dioxide emissions per unit of GDP	binding indicator	64	69	78	85
		Carbon dioxide emissions per unit of industrial added value	binding indicator	65	71	79	87
		Sulphur dioxide emissions per unit of GDP	guiding indicators	66	68	78	86
5	safe and reliable	The duration of power outage in central urban area	binding indicator	69	78	85	91
		energy storage capacity	guiding indicators	53	61	72	81
		Scale of integrated energy stations, microgrids, source-grid-load-storage integration and other new modes and new business models	guiding indicators	55	63	75	83
6	Low-carbon transport	New Energy Vehicle Market Penetration	guiding indicators	66	75	82	91
		New Energy Vehicle Ownership	guiding indicators	65	73	81	90
		Proportion of urban green travel	guiding indicators	69	72	81	89
7	sci-tech innovation	Investment intensity of green low-carbon energy technology research and experimental development	guiding indicators	56	61	69	76
8	The comprehensive evaluation results of urban energy strategy development in Wenzhou City			63.56	70.59	77.87	85.06

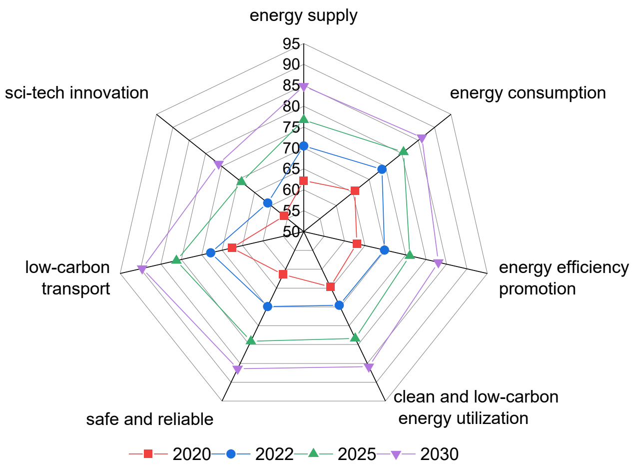

Figure 5. The comprehensive evaluation results of urban energy strategy development in Wenzhou City (current situation, recent and medium term).

Figure 6 shows the evolution of the scores for the 24 corresponding secondary indicators in the six categories of key dimensions. In the energy supply dimension, five of the secondary indicators scored between 83 and 92. The fastest improvement is Photovoltaic coverage rate of roof of new factory building in industrial, which increases by 50.01% in 2030 compared with 2020. This indicates that Wenzhou city is making rapid progress in the utilization of energy photovoltaics in new buildings. clean municipal heating rate scores the highest in 2030, at 92. In the dimension of energy consumption, the four secondary indicators score between 81 and 93. The fastest improvement is the proportion of clean energy in primary energy consumption, which increases by 34.85% in 2030 compared to 2020. the proportion of electric energy to terminal energy consumption scores the highest at 93 in 2030. energy consumption scores the highest at 93. This indicates that Wenzhou has achieved significant results in promoting the use of electrification. In the dimension of energy efficiency promotion, the scores of the five secondary indicators range from 81 to 86. industrial waste energy recycling rate and percentage of buildings meeting maximum energy efficiency retrofit standards both have a score of 81. efficiency retrofit standards are both 81. This indicates that Wenzhou has a low level of energy efficiency and needs to increase its scientific and technological investment and application in the future. In the dimension of clean and low-carbon energy utilization, the scores of the three secondary indicators range from 85 to 87, and the improvement in 2023 over 2020 is 30.03% to 33.85%. In the dimension of safe and reliable, the scores of the three secondary indicators range from 81 to 91. The energy storage capacity score is only 81, which needs to be further improved. In the dimension of low-carbon transport, the scores of the three secondary indicators range from 89 to 91. This is due to the booming development of new energy vehicle industry in Wenzhou. However, due to the small number of metro and other rail transport in Wenzhou, the construction difficulty and long period, there is little room for improvement in the low-carbon transport dimension.

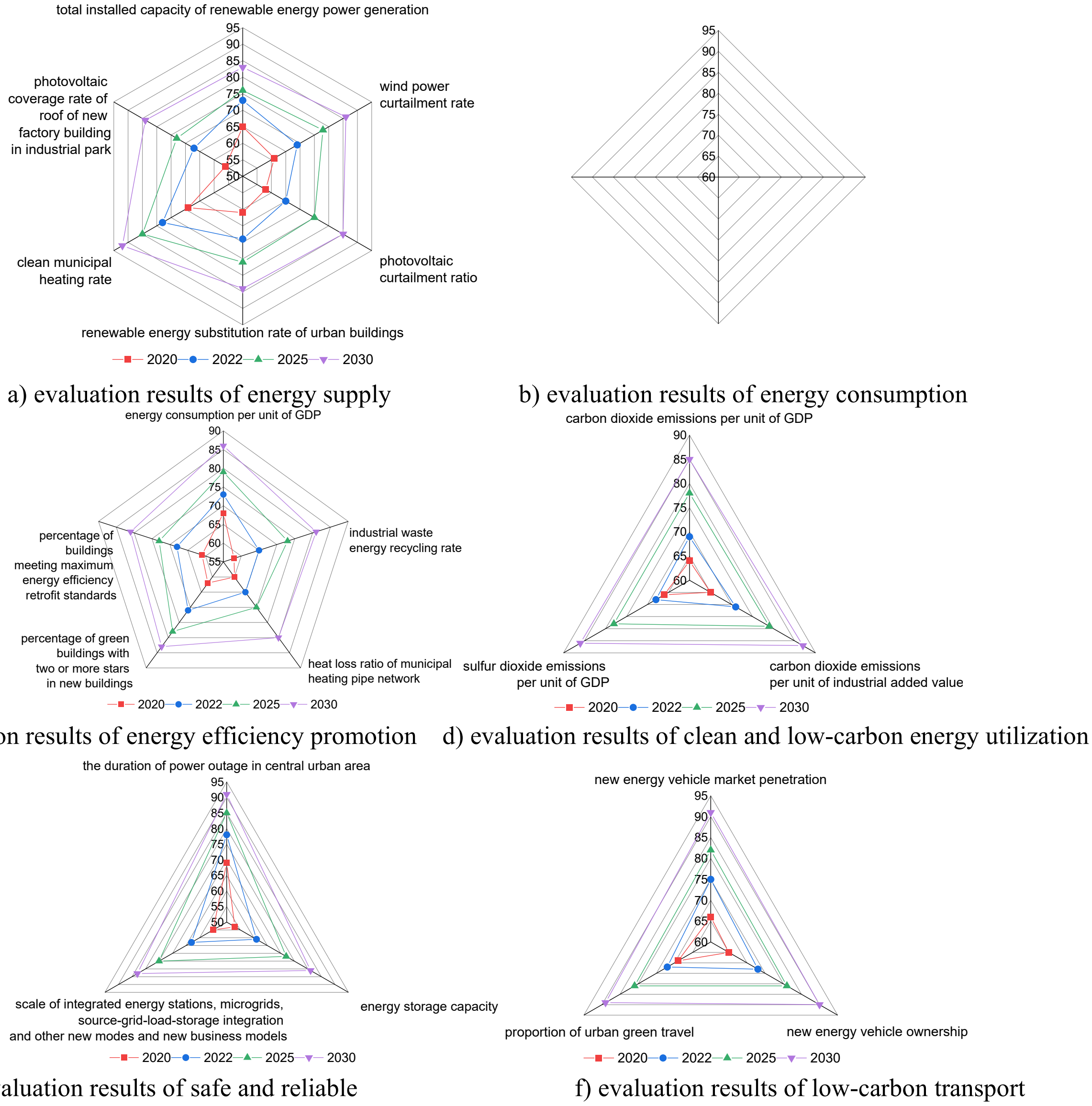

Figure 6. The specialised evaluation results of six dimensions of urban energy strategy development in Wenzhou City (current situation, recent and medium term).

5. Conclusion and Recommendation

This study constructed an evaluation system for urban energy strategy development indicators from seven different dimensions, including energy supply, energy consumption, energy efficiency improvement and clean and low-carbon use of energy. The system used the hierarchical analysis method to determine the weights of the indicators, used the double-baseline progressive method to assign standardized scores to the indicators, and finally used the weighted composite index method to calculate the level of urban energy strategy development. The system and methodology improve the comprehensiveness, scientific and practicability of the evaluation of urban energy strategy development indicators, and provide technical guidance and specific methods for the comprehensive assessment of urban energy systems. Using the indicator evaluation system and method, the current situation of energy development in Wenzhou City in 2020 and 2022 is evaluated, and the strategic development of energy in 2025 and 2030 is predicted. The scores of urban energy strategy development level of Wenzhou city in the corresponding four periods are 63.56, 70.59, 77.87 and 85.06, indicating that by 2023, Wenzhou 's urban energy development level will be from moderately developed to highly developed.

It points out that the city has a strong foundation, a large development potential, and areas in need of technological breakthroughs, and puts forward the city's energy development goals and suggestions for the development of the city's energy strategy, providing a guiding direction for the city's energy development. The results of the study show that since General Secretary Xi Jinping proposed the carbon peak and carbon neutrality targets in September 2020, Wenzhou's urban energy modernization level has been rapidly improving, with each indicator in 2022 showing a large increase from 2020 levels. Wenzhou has a strong foundation in energy consumption, energy efficiency improvement and clean and low-carbon use of energy; it still needs to strengthen the construction of a multi-energy complementary energy supply system. In energy science and technology innovation, especially green low-carbon energy technology research and experimental development funding intensity of development level is not high, Wenzhou need to increase the university and energy enterprise R&D investment and scientific and technological innovation.

The results show that Wenzhou city has a strong foundation, a large development potential, and areas in need of technological breakthroughs. The clean development and utilization of energy in Wenzhou city still has a long way to go. It is suggested that Wenzhou should accelerate the construction of a modern energy system with renewable energy as the main source and fossil energy as the supplementary source in the future. To multi-energy complementary, integrated heat, electricity, gas, cold, enhance the flexibility of thermal power units. In terms of end consumption to improve energy efficiency, reduce energy intensity, the implementation of electric energy substitution, the formation of electricity-centered energy consumption pattern. Overall, it is suggested that Wenzhou should accelerate its green transformation during the period from 2025 to 2030, actively increase the proportion of renewable energy, promote the clean, low-carbon and efficient utilization of traditional energy sources, improve the level of scientific and technological innovation, accelerate the formation of a green, low-carbon mode of production and way of life, and build a green and diversified energy supply system and a clean, low-carbon system for the efficient utilization of energy, so as to ensure that Wenzhou achieves peak carbon in 2030.

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