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Energy Statistical Method Limitations and Innovative Improvement Path Design

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Abstract: This paper comprehensively analyzes the core problems existing in current energy statistical issues, such as data coverage, new industry accounting, and data quality. It clarifies the induced systematic biases and related decision-making risks. Then, on this basis, the study proposes an innovative improved path of tri-dimension: one, statistical extension and accounting adjustment to solve the problems brought by new energy sources; two, establishing a refined multi-dimensional multi-level indicator system to improve the statistical profile; three, using big data technology to promote the data governance. Three pathways are interconnected to build a more accurate, comprehensive and applicable modern energy statistical system to meet the needs of high-quality development of energy transition and "dual carbon" decision-making.

Keywords: Energy Statistics; Methodological Limitations; Improvement Pathways; Data Governance; High-Quality Development

1. Introduction

The global change in energy and the development of dual carbon goals show that energy data work provides an important basis for making decisions. The current methods that collect and measure energy data show limitations when examining distributed energy forms, new types of industry, and requirements for more detailed oversight[1]. These limitations include incomplete coverage of data, indicators that do not provide adequate measures for different conditions, and data that show problems in quality. If these issues are not identified in a complete manner and addressed using systematic approaches, they affect the scientific basis of strategies at the large scale and the degree to which policies produce intended outcomes. This work examines the limitations that appear in the current system for energy data collection and measurement. The analysis that follows from this examination provides a basis for designing improvements that use logical structure and consider future requirements. The improvements that this work presents provide theoretical support and guidance for methods that allow development of a modern system for energy oversight.

2. Theoretical Framework and Current Analysis of Energy Statistical Methods

2.1 Core Concepts and Basic Methodology of Energy Statistics

The study of energy in a form that provides measures examines how systems that produce and use energy show patterns in operation. The main approach uses a particular group of ideas and methods for placing energy in different categories and for providing measures of amounts[2]. This allows the analysis to show the process that includes producing energy and changing energy from different forms and providing energy to different groups and using energy in a final form. The method uses a central means that follows a main principle in the study of energy and heat. This principle indicates that energy in a system shows a particular relationship in different forms. The analysis combines measures in physical forms and measures using a common form. It also uses different approaches for providing estimates of values and for examining data from groups. The approach that provides these methods indicates that data show similar patterns across different periods of time and across different areas in space. This provides a single basis that uses the same methods for data from different sources. The analysis reveals patterns that show how energy moves in systems and provides measures of how systems use energy in relation to the energy that the systems contain. It also provides a basis for

examining changes in the structure that characterizes how systems produce and use energy. The method provides the main foundation for work that involves decisions and work that involves providing direction for systems in this area.

2.2 Current Status of Mainstream Energy Statistical Methods

China's main approach to energy data collection uses the system that the national statistical investigation establishes, and this system focuses on large industrial operations and uses reporting that follows different levels[3]. The method covers data on production and use for traditional energy forms such as coal, petroleum, and natural gas in practice, and it also covers major energy products such as electricity, and results provide energy balance information for the country and for different regions. The approach shows limitations in covering energy systems that are distributed across areas, that operate at small scale, and that represent emerging forms such as photovoltaics that are decentralized and energy from biomass, and data that the method provides also show delays in time. This model that uses conventional statistical surveys as the main basis encounters challenges that increase as energy systems undergo change that occurs rapidly.

2.3 The Critical Role and Requirements of Energy Statistics in Decision-Making

Data on energy provide a basis for developing strategy for national energy and for applying regulation that affects the overall approach to the economy and for moving toward goals that include reducing forms of output that affect the climate[4]. The data provide a basis in specific forms. The data allow forecasting what demand for energy will occur. The data allow establishing what targets for reducing energy use should include. The data allow examining whether policies produce effects that are intended. The data allow participating in discussions between nations that focus on climate. The role of data in these areas establishes that work on statistics for energy must follow standards that are high. Data must show accuracy in measures that are used. Data must appear in time frames that allow use in decisions. Data must include all factors that are important to measure. The range of statistics must include all forms of energy, and this range must change as development of technology for energy occurs. Results from calculations must allow comparison across nations using methods that are similar. These requirements that are stringent show that identifying limits in systems for statistics that are current is important and that addressing the limits is important. Limits in the systems could produce bias in decisions that are made, and the limits produce demand for improvements that are systematic.

3. In-Depth Analysis of the Multi-Dimensional Limitations of Current Energy Statistical Methods

3.1 Systematic Bias in Data Sources and Accounting Scope

As can be seen from the current energy statistics, there are obvious "systematic biases" in accounting scope. The survey system is based on formal reports from large-scale enterprises, and the energy consumption of many small-scale enterprises, dispersed individual enterprises and rural areas are either simply estimated or simply ignored due to the high statistical costs. As a result, the total energy consumption is underestimated, especially for non-commercial energy sources such as biomass and scattered coal. This "big picture and small detail" method of statistics results in fragmented and distorted energy flow diagrams within society, which cannot adequately support national-level energy conservation and carbon reduction potential assessments and resource optimization allocations, thereby bringing risks of uncertainty to macro decision-making.

3.2 Inadequate Adaptability of Statistical Indicators and Accounting Methods for Emerging Energy Sources

In front of the speed of energy structure adjustment, traditional statistical indicators and accounting system are obviously not adaptable to new types of energy, including photovoltaic, wind power, hydrogen energy, etc. There are no accurate indicators in statistics for the "self-generation and self-

consumption" feature of distributed energy. There is also a lack of accounting system for its real emissions reduction effect. There are no statistical classification for new business models such as integrated energy services and virtual power plants, nor there are value assessment indicators.Emerging energy sources are either "present but invisible" or "visible but difficult to assess" in the statistical system, which hinders the accurate judgment of development trends and precise implementation of relevant policy support, and further hinders the effective monitoring of energy transition process.

3.3 Inherent Defects in Data Quality and Cross-Regional Comparability

The methods in use at present show defects that cannot be overcome in relation to the quality of data and the ability to compare across cases. For data quality, the source data appear to have problems with reliability. These problems occur because of factors including standards for measurement that differ at the level where data collection occurs, measurement that does not provide adequate precision, and interference from individuals. For the ability to compare across different regions, barriers that result from the methods themselves appear between regions. These barriers include differences in the factors used to convert energy measures, differences in the approach to determining the efficiency of conversion processes, and differences in the approach to assigning consumption in the final stage to particular uses. The defects make comparison across regions of important measures difficult to conduct in a manner that is objective and fair. The measures include the intensity of energy use and the intensity of emissions that contain carbon. This affects efforts to develop strategies that involve regions working in a manner that is more integrated. The defects also create problems of a technical nature for the system that operates across the nation to measure carbon and to allow exchange of carbon allowances between participants.

4 Innovative Improvement Path Design for Energy Statistics Aimed at High-Quality Development

4.1 Expanding Statistical Boundaries and Refining Accounting Methods for Emerging Energy Sources

The main road would be to systematically increase the range of energy statistics and corresponding new accounting. It is necessary to establish new statistical classification for diversified energy sources outside the current statistical classification of fossil fuel energy and electricity, including photovoltaic power generation, solar thermal energy, biomass energy (such as straw, biogas), geothermal energy and hydrogen energy. The statistical range should be expanded from large enterprises and commercial energy to residential communities, rural areas and small and medium-sized enterprises, so as to fully include the decentralized models such as "self-generation and self-consumption" and "feeding surplus electricity into the grid". In terms of accounting methods, it is necessary to break through the current physical quantity statistics and establish corresponding conversion coefficients and carbon emission factors for different types of energy. For example, a complete carbon footprint accounting model for hydrogen energy should be established to extend from "grey" to "green", and distributed energy should be quantified by smart metering and representative sampling methods.These diversified and zero-carbon energy sources will be fully included in the national energy balance system in a true and comparable way. The main aim of this approach is to address the bias and areas that lack data in measures of developing forms of energy, which occur from limited coverage and methods that require updating. The approach provides a means to include forms of energy that previous work did not examine or that present difficulties in measurement within the framework that official data use. This allows the development of a more complete and accurate view of energy supply and demand across the nation. The analysis provides a data basis that is substantial for assessing the progress of the goals relating to dual carbon. It also reveals the actual impact and the possible extent of changes in energy structure. This shows that all forms of energy receive representation that is fair and management that is effective in decisions at

the macro level, which occurs regardless of the scale of energy or the source that produces it. The approach provides a means to direct the allocation of resources toward the direction that supports low carbon outcomes that are correct.

4.2 Constructing a Multi-Dimensional and Integrated Refined Energy Statistical Indicator System

The approach moves from the single focus on total use and intensity to provide a system with multiple dimensions. This system includes the main indicators that measure total amounts but also uses indicators that show quality and structure in greater detail. These indicators include measures of emissions per unit of output at the level of different regions or sectors, the share of energy from sources other than fossil forms, the capacity of the energy system to respond to changes in demand and to manage periods of high use, measures of how well key processes use energy, and indicators that relate costs to the benefits that result. The system also combines energy data with data from other areas. It uses measures that cross different types of information, such as emissions per unit of total economic output, the number of individuals working in the energy sector, and the relationship between energy use and water use. These measures that combine information from different areas allow for assessment of the overall value that energy development provides and the effects that occur outside the main system.

The development of this improved system for measures directly addresses issues that current measures show in responding to industries that develop in new forms and in providing support for development that occurs at high levels of quality. A framework that integrates multiple dimensions can provide a standard for assessment of performance that appears more scientific and more equitable across different regions and different industries, and this considers factors relating to energy security, to efficiency in economic terms, and to sustainability of the environment. The system will not only allow identification of sectors that show leadership in energy efficiency and sectors that appear to lag, and this provides a basis for specific approaches that differ by case, but it also allows following over time of the relationship between changes in energy and development in socio-economic terms. This approach will separate the large-scale objectives relating to dual carbon into measures that allow assessment and comparison and that indicate actions, and this produces a change at a fundamental level that moves toward a model for development that includes more groups and that occurs at higher quality.

4.3 Leveraging Big Data and Technology to Enhance Data Quality and Collaborative Governance

To use information approaches fully, large-scale data should provide means to increase data quality and improve governance across multiple groups. For data collection, the use of devices that measure and detect at important points (such as equipment that uses significant energy and sites that distribute energy) should increase to allow collection that occurs at high rates and provides precise measures in real time, reducing errors from individuals and other issues from the source. For processing data and conducting analysis, a platform operating at the level of the nation or region should combine data from multiple sources that differ in form, such as data from systems that provide power, conditions relating to weather, movement of vehicles, and operations in industry. The platform can use approaches that examine data and methods based on artificial intelligence to check data across sources, identify values that appear unusual, and address missing values, showing substantial improvements in how reliable and consistent data appear.

This approach provides the foundation for addressing issues relating to the quality of data and the ability to compare data across different areas. Using technical means to establish limits on data will remove problems with manipulation and inconsistencies in data. This provides data of high quality to support the expanded boundaries for collecting data and the refined system of measures that analysis describes in previous sections. Platforms that use cloud systems and standards that apply across all data will remove barriers between

departments and between regions. These systems allow tracking and comparison of energy carbon footprints across regions and across the full process. The result establishes integrated data on energy-carbon emissions that is transparent and credible across the nation. This creates conditions for participation by multiple parties and response in real time in governance relating to energy collaboration. The approach provides a tool of significant power for making policy with precision and for regulation using scientific methods.

5 Conclusion

This paper discusses the main problems existing in the current energy statistical field from three dimensions: data coverage, indicator application and data accuracy. Based on the above problems, this paper proposes three innovative development paths to improve the current energy statistics, namely, extending statistical range, building a perfect indicator system and enhancing technology empowerment. These three improvement paths promote and complement each other, and together construct a complete improvement system. It is hoped that a more accurate, complete and flexible modern statistical system could be built to meet the needs of energy conversion, thereby providing accurate data support for high-quality development and realizing the "dual carbon" targets.

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