New Energy System Development: Background, Strategic Recommendations, and Future Prospects (Postprint)

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Date: 2023-08-23T00:00:00+00:00

Abstract

"Accelerating the planning and construction of a new energy system" constitutes a novel formulation and judgment in the report of the 20th National Congress of the Communist Party of China, which charts a new developmental trajectory for China's energy sector and bears significant strategic importance. At this new juncture, this article, based on the current contextual landscape confronting China's energy domain, systematically examines and analyzes the following issues: how to accurately comprehend the core essence of the new energy system, what key construction tasks it encompasses, where critical breakthroughs should be pursued, and which important relationships require elucidation and balanced consideration. It further proposes targeted policy recommendations to provide decision-making references for expediting the planning and construction of China's new energy system.

Full Text

Preamble

ChinaXiv Cooperative Journal
Policy & Management Research
Citation Format: Zhu Y, Xu S M, Ding X H, et al. Background situation, strategic suggestions and future prospects of construction of new energy system. Bulletin of Chinese Academy of Sciences, 2023, 38(8): 1187-1196, doi: 10.16418/j.issn.1000-3045.20230320002.

Zhu Y, Xu S M, Ding X H, et al. Background situation, strategic suggestions and future prospects of construction of new energy system. Bulletin of Chinese Academy of Sciences, 2023, 38(8): 1187-1196, doi: 10.16418/j.issn.1000-3045.20230320002. (in Chinese)

Background Situation, Strategic Suggestions and Future Prospects of New Energy System Construction

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Abstract

"We will speed up the planning and development of a system for new energy sources" represents a new formulation and new judgment in the report of the 20th National Congress of the Communist Party of China, pointing out a new development direction for China's energy industry and bearing important strategic significance. Standing at this new starting point, how should we accurately understand the core essence of the new energy system? What key construction tasks does it encompass? Where should we seek breakthroughs? And what important relationships need to be revealed and balanced? This article systematically analyzes these questions based on the current background situation in China's energy sector and proposes countermeasures and suggestions to provide decision-making reference for accelerating the planning and construction of a new energy system in China.

Keywords: new energy system, energy revolution, modern energy system, integrated energy services
DOI: 10.16418/j.issn.1000-3045.20230320002
CSTR: 32128.14.CASbulletin.20230320002

In his report to the 20th National Congress, General Secretary Xi Jinping proposed "accelerating the planning and construction of a new energy system," representing a new formulation and new judgment for China's energy undertaking. Currently, there is no officially authoritative definition of a new energy system. This article posits that a new energy system is one that primarily relies on clean energy, supplemented by clean and efficient utilization of traditional fossil fuels, with the core mission of promoting a green and low-carbon transformation in both energy development and consumption patterns. It is built upon the foundation of the new power system currently under construction, fully leveraging electricity's platform and hub role in the energy system to effectively safeguard China's energy security, contribute to global climate change governance, and balance the interests of all stakeholders.

To accelerate the construction of a new energy system, we must not only analyze and assess the domestic and international background situation but also develop a relatively accurate understanding and grasp of its concepts and core essence. Although the term "new energy system" has appeared previously, its content was not entirely identical. For instance, Wang Weihan argued that practical exploration and implementation represent the only path to developing a new energy system, but his conception focused more on renewable and distributed energy. He Jiankun viewed the new energy system revolution as the

necessary path to ecological civilization, emphasizing more on energy system transformation and energy revolution. Zhao Ran introduced relevant results from the Chinese Academy of Engineering's major consulting project "Strategic Research on Promoting Energy Production and Consumption Revolution," which mentioned the term but without detailed elaboration.

Following the 20th National Congress proposal to "build a new energy system," national energy authorities, energy practitioners, and energy scholars have attached great importance to this concept. Yuan Jiahai believes that the complex and volatile international political and economic situation since 2022 has led to tight global energy supply, and accelerating the planning and construction of a new energy system can enable leapfrog development of new energy. Chen Hongbo argues that building a new energy system holds important strategic significance for China in responding to domestic and international risks and challenges and building a modern powerful country. Hao Yu considers the new energy system a solid barrier for ensuring national energy security, a foundational project for achieving carbon peaking and carbon neutrality, an important foothold for actively participating in global climate change governance, and effective support for promoting high-quality development. At the March 2023 National Two Sessions, the Government Work Report once again proposed "accelerating the construction of a new energy system," and delegates and committee members from the energy industry engaged in vigorous discussions around the planning and construction of the new energy system.

Tang Guangfu believes that on the path of energy transformation, six key tasks need to be effectively advanced, including rapidly developing and increasing the proportion of wind and solar resources, steadily advancing power source structure transformation, strengthening oil and gas exploration and production, improving large-scale long-distance power transmission and grid flexible mutual aid capabilities, building an electricity-centered terminal energy consumption pattern, and strengthening interconnectivity among multiple energy sources. These viewpoints offer opinions and suggestions on planning and constructing the new energy system from perspectives of internal and external environments, strategic significance, source-grid-load-storage, digitalization, and energy transformation. However, existing research lacks systematic exposition of the new energy system, insufficient review and 梳理 of its background situation, and inadequate analysis and judgment of its future tasks.

This article will focus on exploring: What are the domestic and international background situations and pressures facing the new energy system? What key tasks will its construction face, and which should be prioritized? The new energy system was proposed seven months later than the modern energy system—how should their relationship be considered? What is the relationship between the new energy system and the energy revolution, carbon peaking and carbon neutrality goals, as well as new energy business types and business models such as integrated energy services and virtual power plants? These are fundamental questions that need to be answered in planning and constructing the new energy

system, and they are also important issues requiring continuous demonstration and discussion in the coming period.

1. Background Situation Facing New Energy System Construction

1.1 International Background Situation

The current international situation is complex and volatile, creating considerable uncertainty for human society. The Russia-Ukraine conflict, which erupted in February 2022 and continues to this day, has had a representative impact on the global energy system, including WTI crude oil prices . This conflict has not only exposed numerous deficiencies in the current global energy system but also exerted far-reaching influence on its evolutionary trajectory. This article presents specific changes in the international energy situation following the Russia-Ukraine conflict from five aspects .

The Russia-Ukraine conflict is a microcosm of the impact on the global energy governance system and a manifestation of the regression of global energy governance capacity against the backdrop of deglobalization. Since the China-U.S. trade friction in 2018, the term "decoupling" has gradually spread to the clean energy sector. For example, in 2021, the United States and the European Union extended the scope of prohibited imports from Xinjiang-produced cotton to Xinjiang-produced photovoltaic components under the so-called pretext of "forced labor." The power politics logic of the U.S. and EU is reflected in the global energy governance system as high vigilance and suppression of China's rising momentum in the current global energy pattern, distorting normal global energy industry product and technology cooperation into the "China threat theory," and employing every possible means to maintain their own advantageous positions and seek their own interests. How to promote the return of rationality and "depoliticization" in the global energy governance system and resist or even reverse the trend of regression in global energy governance capacity deserves full examination and in-depth consideration in the process of building the new energy system.

1.2 Domestic Background Situation

Since the 18th National Congress of the Communist Party of China, China has achieved remarkable results in energy conservation and consumption reduction. By the end of 2021, clean energy consumption had increased by approximately 11%, coal consumption had decreased by approximately 12.5%, wind and solar power installed capacity had grown by approximately 12 times, new energy power generation had exceeded 1 trillion kilowatt-hours for the first time, energy consumption per unit of GDP had decreased by approximately 26.4%, carbon dioxide emissions per unit of GDP had decreased by approximately 34.4%, water consumption per unit of GDP had decreased by approximately 45%, and major resource productivity had increased by approximately 58% . However, China's

energy sector still faces enormous pressure, particularly evident in the following three aspects.

2.1 Insufficient Oil and Gas Reserves and High External Dependence The distribution of global fossil energy reserves is uneven. Consulting British Petroleum's *Statistical Review of World Energy* released in recent years reveals that countries ranking high in oil reserves include Russia, Saudi Arabia, Iran, Iraq, Kuwait, the UAE, Venezuela, Canada, and the United States. Countries ranking high in natural gas reserves include Russia, Iran, Qatar, Saudi Arabia, the UAE, Turkmenistan, and the United States. Countries ranking high in coal reserves include Russia, the United States, China, India, Australia, and Germany. China has relatively abundant coal reserves but relatively scarce oil reserves. Although proven natural gas reserves have increased in recent years, they have not changed the status of relative scarcity.

Without breakthrough technologies in the oil and gas sector, China's resource endowment of being rich in coal but poor in oil and gas determines that crude oil production was approximately 199 million tons in 2021 and returned to 200 million tons in 2022, but it is difficult to achieve substantial increases. Natural gas production exceeded 205 billion cubic meters in 2021 and 217 billion cubic meters in 2022, but its growth cannot keep pace with the rapid growth in consumption. China's crude oil external dependence exceeded 50% in 2009 and has continued to rise, breaking through 60% in 2015, 70% in 2019, and remaining at a high level of 71% in 2021 and 2022 despite two consecutive years of decline. Before 2006, China's natural gas production and consumption were basically self-sufficient. However, since 2007, China's natural gas external dependence has also been in a continuous upward trajectory—exceeding 20% in 2011, 30% in 2013, and 40% in 2018, maintaining a high level of 40% in 2022. The current situation of scarce oil and gas reserves, coupled with the continuous growth in energy production and consumption demand, has resulted in China's long-standing high external dependence on traditional fossil energy, seriously affecting energy supply security.

2.2 Dual Tasks of Carbon Emission Reduction and High-Quality Development Data analysis based on multiple research reports released by the Ministry of Ecology and Environment and other institutions in recent years shows that since 2015, global carbon emissions have exceeded 30 billion tons annually and remained stable with slight increases, with China accounting for over 30%, the United States approximately 14%, and India approximately 7%. Other top-ranking countries include Russia, Japan, Germany, and South Korea. To achieve the "dual carbon" goals of carbon peaking by 2030 and carbon neutrality by 2060, China faces enormous pressure for carbon emission reduction.

Under the requirements of high-quality development, shortcomings in energy supply and people's livelihood energy use need to be addressed, the energy use gap between eastern and western regions and between urban and rural areas

needs to be narrowed, and energy quality in poor and remote areas needs to be improved. How to enhance energy security to meet the sustainable development of the economy and society, and how to focus on the contradiction between the people's growing needs for a better life and unbalanced and inadequate development, require full understanding and accurate grasp.

2.3 Opportunities and Challenges in Breaking Global Energy Rules and the International Energy Pattern For many years, China has lagged behind Western developed countries in the exploration, research and development, and strategic layout of traditional fossil energy, resulting in long-term passive adaptation to global energy governance rules (such as fossil energy trade rules) and global environmental governance rules. Countries and organizations rich in fossil energy resources, represented by Russia, the United States, and OPEC, hope to maintain the world's traditional energy pattern and maximize their own economic interests and influence. However, not only China, but also energy-scarce yet economically developed European countries such as the United Kingdom and Germany have deeply realized the unfavorable situation of being constrained by others in energy. Therefore, relevant countries are actively developing new energy and high technologies.

Taking China as an example, since the 18th National Congress of the Communist Party of China, remarkable achievements in the energy revolution have been accompanied by China's new energy development, represented by wind and photovoltaic power generation, entering the world's first echelon. Technological innovation levels in energy sectors such as ultra-high voltage and smart grids have also been significantly improved, providing opportunities and possibilities for breaking traditional fossil energy trade rules and reconstructing the international energy pattern. However, Western developed countries will obviously not stand idly by and allow China's new energy industry to develop rapidly. From the EU's "photovoltaic anti-dumping and anti-subsidy" investigations a decade ago to the United States' prohibition of importing photovoltaic components produced in China under various pretexts, the many practices of Western developed countries to suppress China's new energy industry development are frequently reported. Moreover, China's export products are mostly at the mid-to-low end of the global industrial chain, and the current situation of an industry structure that is overly heavy and energy consumption that is relatively high has not changed, with carbon emission factors generally higher than the EU average. The United States, the United Kingdom, and Japan are currently studying the imposition of carbon border taxes, and it will be difficult for China's export products to gain advantages in this regard. China faces the risk of falling into a passive situation, and the pressure to break global energy rules and reconstruct the international energy pattern remains significant.

3. Recommendations for New Energy System Construction

3.1 Clarify Priority Tasks in New Energy System Construction

The report of the 20th National Congress of the Communist Party of China and the 2023 National Two Sessions proposed accelerating the planning and construction of a new energy system. However, we should not view the new energy system in isolation but must fully integrate it with its domestic and international background situation. Against the backdrop of deeply advancing the energy revolution, high-quality energy development, and carbon peaking and carbon neutrality goals, the new energy system will inevitably face many key construction tasks, making prioritization crucial. Based on recent practical experience, this article recommends prioritizing foundational work such as institutional mechanism innovation and standard system establishment as priority tasks in building the new energy system.

3.1.1 Prioritize Institutional Mechanism Innovation The sixth meeting of the Central Financial and Economic Affairs Leadership Group proposed "promoting energy institutional revolution" and "restoring energy commodity attributes, constructing an effective competitive market structure and market system, and forming a mechanism where energy prices are mainly determined by the market." Institutional mechanism innovation should be one of the priority tasks of the new energy system. In terms of specific measures, this article recommends focusing on planning and pricing aspects.

In planning, it is recommended to coordinate current energy planning across different dimensions. Although various energy sources including wind, solar, hydro, nuclear, and thermal have already issued different dimensional energy development plans, it is necessary to promptly review and avoid potential overlaps or even conflicts among these plans. For example, coordination should be improved between comprehensive energy planning and specialized energy planning for wind, solar, hydro, nuclear, thermal, and hydrogen; between short-term and medium-to-long-term energy planning; and between global and regional energy planning, to ensure that energy plans across different dimensions demonstrate systematicity, integrity, and synergy.

In pricing, it is recommended to fully consider and reflect key factors such as energy costs, contribution magnitude, and time-specific value of various energy types. For example, under the increasingly prominent "dual high and dual peak" characteristics, new energy grid integration and consumption, as well as costs across all aspects of the power system's source-grid-load-storage chain, are gradually increasing. Moreover, the reverse distribution of new energy resources and demand leads to high costs for both centralized development and long-distance transmission. It is recommended to clarify the marginal scope of government pricing, price ceilings, and average prices, allowing prices to reflect benefit distribution and coordination as much as possible, and ensuring that prices of various energy types remain within reasonable ranges.

3.1.2 Prioritize Standard System Improvement In October 2022, the National Energy Administration issued the *Energy Carbon Peaking and Carbon Neutrality Standardization Enhancement Action Plan*, with the goal of "initially establishing a relatively complete energy standard system that can strongly support and guide the green and low-carbon transformation of energy by 2025." This early planning approach offers valuable lessons for new energy system construction. Similar to institutional mechanisms, the standard system also belongs to foundational institutional work, making the priority development of standard system improvement work highly significant. Therefore, standard system improvement should also be one of the priority tasks of the new energy system. In terms of specific measures, this article recommends focusing on three key areas.

In wind-solar-hydro-nuclear-thermal standardization, it is recommended to establish and improve technical standards for wind power adapted to different application scenarios such as deserts, Gobi, and offshore areas; photovoltaic technical standards adapted to residential, distributed, and centralized application scenarios; hydropower technical standards adapted to different types such as high-head and large-capacity hydropower; as well as technical standards for geothermal and nuclear energy. These standards should cover utilization standards, recycling standards, safety standards, and post-evaluation standards.

In new power system standardization, it is recommended to establish and improve technical standards covering key areas such as new power system planning and design, operation control, security defense, and source-grid-load-storage coordination. Examples include technical standard systems for ultra-high voltage AC, conventional DC, and flexible DC on the source-grid side, as well as technical standards for virtual power plants, electric vehicles, and electricity markets on the load-storage side.

In energy storage and hydrogen energy standardization, it is recommended to establish and improve technical standards covering key areas such as grid connection of energy storage, battery performance, and mandatory safety. For example, technical standard systems for grid connection configuration and two-way interaction should be established. Additionally, technical standards covering key areas such as hydrogen production, storage, transportation, refueling, and diversified application should be established, including technical standard systems for alkaline water electrolysis, solid oxide electrolysis, and pure water electrolysis.

3.2 Deepen Understanding of the Important Concept of New Energy System

3.2.1 Clarify the Relationship Between New Energy System and Modern Energy System A term similar to new energy system is "modern energy system." In March 2022, the National Development and Reform Commission and the National Energy Administration issued the *14th Five-Year Plan for Modern Energy System*, with main development goals involving key indicators such

as energy security, low-carbon transformation, energy efficiency, innovation capability, and service level, all of which are quantified. Based on considerations of the rigor and continuity of energy planning, this article believes that the new energy system and modern energy system share similarities in connotation, characteristics, and background situation, but differ in proposal time and key indicators. Therefore, new energy system construction can be further refined and sublimated with reference to modern energy system construction .

3.2.2 Clarify the Relationship with Energy Revolution and "Dual Carbon" Goals In recent years, China's energy revolution has continuously advanced in depth, achieving a series of remarkable accomplishments in its energy undertaking. The "dual carbon" goal, as one of the specific strategic goals of China's energy development, has prompted industries such as power grids, construction, and steel to research and issue relevant action plans or implementation roadmaps. A large body of literature has conducted extensive academic research around the energy revolution and carbon peaking and carbon neutrality. This article believes that both the energy revolution and the new energy system are important energy strategies in China and are closely related to each other. As a specific strategic goal of China's energy development, "dual carbon" is also one of the specific strategic goals in the process of new energy system construction. In the process of building the new energy system, it is recommended to focus on whether the future new energy system can meet socio-economic development needs, satisfy the people's growing needs for a better life, and align with the strategic expectations of the energy revolution.

3.2.3 Clarify the Relationship with New Energy Business Types and Business Models Such as Integrated Energy Services and Virtual Power Plants Building a new energy system cannot be separated from planning and consideration of background situation and key tasks. Drawing on the planning approach of the modern energy system, China intends to continuously deepen the "delegate power, improve regulation, and upgrade services" policy in the energy sector, stimulate the vitality of energy market entities, and cultivate and strengthen emerging market entities such as integrated energy service providers and electric energy storage enterprises. It is believed that the new energy system, which shares similar background situations and connotation characteristics with the modern energy system, will also bring new opportunities to new energy business types and business models including integrated energy services and virtual power plants. For example, the rapid development of non-fossil energy brings opportunities for distributed clean energy service businesses, and integrated energy services, virtual power plants, and other new energy business types and business models will also benefit from the construction process of the new energy system.

4. Future Prospects

4.1 In-Depth Promotion of Low-Carbon Energy Transformation, with Carbon Emissions and Energy External Dependence Expected to Decrease and Energy Security to Strengthen

Accelerating the green and low-carbon transformation of energy has been ongoing in China for over a decade and has achieved remarkable results. In recent years, multiple documents issued by the National Development and Reform Commission and the National Energy Administration have further quantified specific development goals for the coming years. Looking ahead to the construction process of the new energy system, the green and low-carbon transformation of energy will continue to be promoted in depth. As quantifiable assessment targets, total carbon emissions and carbon emissions per unit of GDP have already been given specific timelines, and work to reduce carbon emissions is expected to be strengthened. With the rapid development of non-fossil energy and the steady increase in non-fossil energy power generation installed capacity, as well as the improvement in electrification levels brought about by national and societal attention to electrification work, various measures will promote the increase in non-fossil energy consumption proportion and the proportion of electricity in terminal energy use. The situation of high external dependence on fossil energy is expected to be significantly improved. The *Outline of the 14th Five-Year Plan for National Economic and Social Development and Long-Range Objectives Through 2035* proposes "enhancing domestic energy supply guarantee levels" and "strengthening energy's continuous and stable supply and risk management capabilities." With the increase in non-fossil energy consumption proportion and the decrease in fossil energy external dependence, China's energy security is expected to be strengthened through multiple measures.

4.2 Scientific and Technological Innovation Capacity Expected to Strengthen, with Current Energy Pattern and Governance System Expected to Break Through and New Pattern and New Track Expected to be Created

Over the past decade, China's new energy industry, represented by wind and photovoltaic power, has achieved rapid development, and the technical equipment level in related fields has also made considerable progress. A batch of key technologies across the entire industrial chain in energy fields such as energy storage, hydrogen energy, new-generation nuclear energy, and carbon capture, utilization, and storage (CCUS) have received high attention and focused 攻关. Looking ahead to the construction process of the new energy system, China's energy scientific and technological innovation capacity is expected to continue receiving attention and strengthening. With the dual decline in fossil energy consumption proportion and fossil energy external dependence, China's energy industry, which has long been passively adapting to and constrained by the current global energy governance system, is expected to break through and create a new pattern and new track through the energy revolution and

new energy. China's international energy discourse power is also expected to truly move from passive to active, from integration to leadership, for example, by participating in international standardization governance, encouraging representative domestic energy enterprises to actively participate in clean energy international standardization formulation, and promoting the translation of Chinese standards. To date, China's work practices in global international standard organizations such as the International Organization for Standardization (ISO), International Electrotechnical Commission (IEC), and International Telecommunication Union (ITU) serve as excellent examples.

4.3 Accelerated Construction of New Power System, with Security Controllability, Flexibility and Efficiency, and Friendly Interaction Capabilities Expected to be Strengthened

In March 2021, the Party Central Committee proposed building a new power system with new energy as the mainstay. The new power system is an important component of the new energy system and carries the glorious mission of energy transformation. The strong uncertainty and weak controllable output characteristics of renewable energy—"no wind in extreme heat, no light during evening peaks, no light when clouds come, and dry rivers in winter"—have continuously increased the difficulty of ensuring power system supply. The continuous increase in new energy power generation installed capacity proportion, vehicle-to-grid (V2G) interaction, distributed energy, energy storage, and other interactive energy equipment proportions has continuously increased the risk of declining rotational inertia and insufficient frequency and voltage regulation capacity in the power system. The massive and widespread access of new technologies and new products across all aspects of source-grid-load-storage has continuously increased the difficulty of power system resource regulation, scheduling, and interactive response. Fortunately, these difficulties and challenges have become major scientific and technological 攻关 objects in the basic theories and technical equipment innovation fields of the new power system and have achieved phased results. Looking ahead, we believe that with the in-depth advancement of building the new power system, the security controllability, flexibility and efficiency, and friendly interaction capabilities of the new energy system are expected to be enhanced.

"Accelerating the planning and construction of a new energy system" has scientifically planned the objectives, tasks, and major policies for China's energy sector development in the next five years and even longer periods, further pointing out the way forward for China's energy undertaking. Looking ahead, the report of the 20th National Congress and the 2023 National Two Sessions have painted a magnificent blueprint for a bright future. Under the guidance of the grand goal of "accelerating the planning and construction of a new energy system," China's energy undertaking in the new era will forge ahead with determination and perseverance toward a new stage of high-quality development.

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Notes

West Texas Intermediate (WTI) is a benchmark price in the international oil market and the underlying asset for oil futures contracts on the New York Mercantile Exchange. All crude oil produced in or sold to the United States is priced against light, low-sulfur WTI as the benchmark crude.

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