Analysis of Energy Efficiency Level of Typical Countries

Junhai Wang¹, Jianbing Yin¹, Lin Chen¹, Zhiyuan Chen¹, Yingfei Gong¹ and Qingkun Tan²,*

¹State Grid HangZhou Power Supply Company, Hangzhou 310000, Zhejiang Province, China;
²State Grid Energy Research Institute Co., LTD., Beijing Changping 102209, China.
*Corresponding author email: tanqingkun@163.com

Abstract. The current global energy transition is in a period of acceleration, and the transition process of various countries shows certain characteristics of differentiation. Based on the analysis of the development direction of the energy transition, this paper proposes covering energy structure and energy efficiency. On this basis, a comparative analysis of the energy transition situations of major countries such as China, the European Union, Germany, and Japan was carried out, and then conclusions and enlightenments for my country's energy transition were put forward.

1. Introduction
Energy is an important basic material for human survival and development, as well as the driving force and foundation for social and economic operations. Countries around the world regard energy production and consumption as important strategic issues related to national development. Improving the energy efficiency of the whole society is an important way to ensure the security of energy supply and promote the long-term economic and social development. At present, my country's energy utilization efficiency is generally low. In 2018, my country's unit GDP energy consumption was as high as 0.52 tons of standard coal per 10,000 yuan, more than twice the average of developed countries in Europe and America, 2.7 times of Japan, and 1.5 times of the world average. At the same time, my country's energy consumption is highly concentrated in cities, and China's total urban energy consumption accounts for 85% of the country's total energy consumption. Especially in the large-scale urban agglomerations represented by the Yangtze River Delta, the Pearl River Delta, and the Beijing-Tianjin-Hebei Region, cities are the most important energy-consuming entities, and their energy-saving levels are directly related to the improvement of national energy efficiency.

Current research on national energy transition mainly focuses on transition goals and policy combing [1-2], focusing more on indicators such as energy structure, energy efficiency, energy self-sufficiency, foreign dependence, and gas emissions [3], as well as key areas for transition. However, from the perspective of the research objects, the existing studies mostly focus on the time series data analysis of a specific country or region [4], or make a horizontal comparison of multiple countries or regions under the same time section [5], taking into account multiple countries or regions. From the perspective of research content, existing research has focused more on energy structure analysis, including the evolutionary trend of fossil energy and clean energy in primary energy [6], and the final energy consumption structure [7-8].

This article mainly summarizes the energy consumption status and energy efficiency measures of the European Union, Germany and Japan. Summarize its main experience and provide suggestions for the smooth development of China's energy efficiency management work. Building a comprehensive urban energy efficiency evaluation index system with Chinese characteristics according to local
conditions is of vital importance to further promoting the optimization of my country's energy structure, industrial structure transformation and long-term green development.

2. Situation Analysis

2.1 Analysis of the Status Quo of EU Energy Efficiency

2.1.1 Status of Energy Utilization in EU

From the perspective of total energy consumption, the changes in total primary energy consumption in the EU from 2010 to 2018 are shown in Figure 1. It shows a downward trend as a whole, reflecting the EU's effectiveness in energy saving and energy efficiency improvement. Among them, the EU's total primary energy consumption in 2018 was 1685 million tons of oil equivalent. From 2010 to 2018, the total amount of primary energy in the EU was relatively stable, and the growth rate fluctuated within 5%.

![Figure 1. 2010-2018 EU total primary energy consumption (data source: BP data)](image)

2.1.2 EU energy Efficiency Measures

(1) Legal order

The content of EU energy efficiency laws is very comprehensive, covering almost all sectors and levels. The EU's energy efficiency directives and standards are relatively comprehensive in the fields of transportation energy conservation, industry, and construction. The EU Eco-Design Directive stipulates standards for products or facilities including hot water, boilers, televisions, chargers, office automation equipment, air-conditioning office lighting, street lighting, etc.

(2) Energy efficiency management mechanism

The energy efficiency labeling system is an information label for labeling the energy consumption of energy-consuming products, providing consumers with energy consumption consultations, and indicating product energy efficiency grades and other performance indicators. The energy consumption of household appliances in the European Union accounts for a relatively high proportion of total energy consumption.

(3) Voluntary Energy Conservation Agreement

In the EU, voluntary energy conservation agreements are self-regulatory industry agreements jointly promoted by the government and industry. The EU has signed an agreement with the "EU consumer electrical appliance manufacturers" to reduce the standby power consumption of consumer electrical appliances such as televisions, and washing machines, as well as electric motors, household electric
storage water heaters, dishwashers, and external Voluntary agreements for the reduction of energy use of power supplies.

2.2 Analysis of German Energy Status

2.2.1 Status of Energy Utilization in Germany

From the perspective of total energy consumption, the changes in total primary energy consumption in Germany from 2010 to 2018 are shown in Figure 2. It has shown a downward trend as a whole, reflecting German's effectiveness in energy saving and energy efficiency improvement. Among them, the total primary energy consumption in Germany in 2018 was 323.89 million tons of oil equivalent. From the perspective of energy consumption in Germany, the overall total energy consumption in Germany has shown a downward trend.

![Figure 2](image)

**Figure 2.** 2010-2018 German total primary energy consumption (data source: BP data)

2.2.2 Germany Energy Efficiency Measures

The German government mainly implements the energy transition through top-down laws, policies, technology research and development, and incentive mechanisms. In 2010, it proposed that Germany should develop renewable energy as its core by 2050 to improve energy efficiency and reduce energy consumption. The main measures of Germany's energy transition are as follows:

1. Perfect legal system

   The German Renewable Energy Law and Regulation System is a set of preferential and federal regulation systems that promote the development of renewable energy with the Renewable Energy Law as the core. It mainly presents three main characteristics: one is to separately legislate for different application fields such as electricity, transportation, and heating.

2. Establish a standard system for ultra-low energy consumption buildings

   German ultra-low energy buildings are buildings whose energy consumption is 30% or more than 50% higher than the current national standards. They are the country's future energy efficiency improvement goals. There are corresponding regulations on the energy consumption limits of ultra-low energy buildings.

2.3 Analysis of Japan Energy Status

2.3.1 Status of Energy Utilization in Japan

From the perspective of total energy consumption, the changes in total primary energy consumption in
Japan from 2010 to 2018 are shown in Figure 3 below. It has shown a downward trend as a whole, reflecting Japan's effectiveness in energy conservation and energy efficiency improvement. Among them, Japan's total primary energy consumption in 2018 was 454.1 million tons of oil equivalent.

![Figure 3. 2010-2018 Japan total primary energy consumption (data source: BP data)](image)

### 2.3.2 Japan Energy Efficiency Measures

Japan is lacking fossil energy, so it has always attached great importance to energy conservation and energy efficiency management. In order to improve energy efficiency and reduce the excessive dependence of economic growth on energy, since the first world oil crisis, Japan has issued a series of laws and regulations to build a complete regulatory system. Typical policies and measures are as follows.

1. **Energy efficiency management legal system**
   
   The Japanese government has established and continuously improved the legal system for energy conservation and energy efficiency. The system consists of three types of laws: the first is the basic law represented by the "Law on the Rationalization of Energy Use"; the second is the comprehensive law represented by the "Resources Effective Utilization Promotion Law"; the third is it is a law for a certain type or a certain product represented by the Home Appliance Recycling Law and the Food Recycling Law. These laws are both interrelated and have their own emphasis.

2. **Energy manager**

   Japanese "energy manager" refers to senior technical personnel engaged in energy management after being trained and tested by a government-led energy-saving professional service organization, and obtained energy management qualifications. There are currently about 6000 energy managers in Japan. They are mainly responsible for the energy planning and management of the corresponding enterprises and places, and they need to submit relevant reports to the government on a regular basis.

### 3. Conclusions

1. **Formulate and improve energy efficiency management policies and laws**

   In terms of energy efficiency policies, one is the need to propose individualized and targeted plans and programs for different fields. For example, the energy consumption in the residential field is mainly concentrated in cooling, heating, and lighting. Therefore, policies need to focus on building insulation measures. And the use of high-efficiency electrical appliances. In the industrial and commercial fields, on the one hand, it is necessary to strictly supervise the energy use, energy efficiency and greenhouse gas emissions of various enterprises through mandatory reporting and other measures. Therefore, while formulating energy efficiency policies, it is also necessary to actively
support energy efficiency start-ups to create a complete industrial chain and ecosystem.

(2) Complete energy efficiency labeling and standard system

The EU is a country that has implemented energy efficiency labeling and energy efficiency standard systems relatively early. At the same time, vigorously promoting energy efficiency labeling and standard systems is one of the EU's main policy tools to improve energy efficiency. The European Union has very detailed directives and specific regulations on marking, and with the development of society, it is constantly improving relevant directives and markings.

(3) Carry out energy optimization in urban communities

China should learn from the German experience and pay attention to the renewal and transformation of urban communities. First, integrate the goals of energy optimization and low-carbon transformation into the community, and implement them through specific measures; secondly, integrate a holistic perspective into China’s community renewal, formulate a comprehensive development plan, conduct unified planning guidance, and integrate multiple In terms of energy transformation measures, strengthen the monitoring and management after implementation, and strengthen the continuity of planning; finally, improve the legal and policy guarantee for community energy optimization. And rely on technological innovation and technological progress to promote the optimization and upgrading of the energy structure and drive the city's low-carbon transformation.

4. Acknowledgments

This paper is supported by State Grid HangZhou Power Supply Company Management Consulting Project (Grant No: SGZJHZ00FZWT2001200). The authors declare that there is no conflict of interest regarding the publication of this paper.

5. References

[1] Li Liu, Lei Xu. Energy-Saving Technical Measures of German Low-Energy Buildings. Applied Mechanics and Materials, 2014, 2972(S07).
[2] Wang Jialong, Wu Jingyi. Thermodynamic characteristics of mixed effect absorption chiller powered by dual heating source. Journal of Engineering Thermophysics,2015,36(11): 2334-2338.
[3] Di Somma M, Yan B, Bianco N, et al. Operation optimization of a distributed energy system considering energy costs and exergy efficiency. Energy Conversion and Management,2015,103: 739-751.
[4] Ozgener O, Ozgener L. Exergy and reliability analysis of wind turbine systems: A case study. Renewable and Sustainable Energy Reviews,2007,11(8): 1811-1826.
[5] Bayrak F, Abu-Hamdeh N, Alnefaie K A, et al. A review on energy analysis of solar electricity production. Renewable and Sustainable Energy Reviews,2017,74: 755-770.
[6] Thomas Preggern, Joachim Nitsch, Tobias Naegler. Long-term scenarios and strategies for the deployment of renewable energies in Germany. Energy Policy, 2013, (59): 350-360.
[7] Scott Victor Valentine, Benjamin K. Sovacool. Energy transitions and mass publics: Manipulating public perception and ideological entrenched in Japanese nuclear power policy. Renewable and Sustainable Energy Reviews, 2019, 101, 295–304.
[8] BP. BP Statistical Review of World Energy 2019[R]. 2019.