Research on the Current Situation of Renewable Energy Exploitation in Typical Countries in the World

Yang Liu *, Jinyue Dou, Jiawen Ye, Mingzhu Li, Liyi Tian and Ming Zeng

State Key Laboratory of Alternate Electrical Power System with Renewable Energy Sources, North China Electric Power University, Beijing, China

*Corresponding author e-mail: liuyang3983@126.com

Abstract. Since the drawbacks of traditional fossil fuels such as pollution and non-renewabiliity become more and more serious, the exploitation and utilization of renewable energy sources achieve more attention. In typical countries such as the Germany and the United States, the exploitation and utilization of renewable energy is relatively early. There are more research and application of energy exploitation approaches in these countries. In a certain period, the exploitation approach of renewable energy is closely related to its exploitation and utilization situation. In this paper, the exploitation and utilization of renewable energy in Germany, the United States and Japan were analyzed, and particularly, the status of their exploitation approaches were stressed reviewed.

Key words. renewable energy, exploitation approach, wind power, photovoltaic power.

1. Introduction
The photovoltaic power generation technology is mainly divided into two categories of large-scale ground-based photovoltaic power plant and roof-top distributed photovoltaic power generation across the world. Large-scale ground-based photovoltaic power plant can make full use of the solar energy resources in the desert area which is rich and relatively stable and can be integrated into the high-voltage power transmission system to provide long-distance load [1,2]. Compared with the previous one, roof-top distributed generation has attracted much attention in recent years due to its flexible installed capacity, low cost and electricity load nearby [3]. In abroad, wind resources have been systematically observed and carried out comprehensive analysis and research in recent years. Wind turbine continues to develop in size, intelligence and reliability. Onshore wind farms have developed to a larger scale with its application environment more diversified, which includes special terrain of hilly and mountainous areas, or some special environment with low temperature and low wind speed. The offshore wind farms are gradually developing into large-scale and deep-sea (water depths greater than 50 meters), with the increase of operation and maintenance equipment specialization [4,5]. With the promotion of Internet of things and big data, the operation and maintenance of wind farms continue to develop along the direction of intelligence and informatization. Therefore, the study of the renewable energy exploitation approaches in typical countries is of great significance.
2. Germany

In transmission, Germany plays the role of indirect energy storage system in the European interconnected power grid. When sunshine and wind power are sufficient, the surplus power is sold to neighbouring countries, while when the wind power and photovoltaic power generation is few in peak demand period, it considers buying electricity from neighbouring countries [6]. On the aspect of power demand side management (DSM), the integrated use of energy storage, heat pumps, smart electricity meters and other technologies can improve load regulation. With the transmission of the European interconnected power grid, Germany achieves an effective consumptive of photovoltaic and wind power generation, which remove the concerns of renewable energy development. On May 15, 2016, solar and wind energy load was 57GW in Germany and its renewable energy supply reach to 45.5GW, of which photovoltaic and wind power supply is 30 GW and 15.5GW each, achieving that 87.6 percent of electricity demand is supplied by renewable energy [7,8]. The proportion of renewable energy in electricity consumption in Germany is shown in Figure 1. As can be seen from the figure, since 2000, the proportion of renewable energy in electricity consumption has been increasing year by year, reaching to 36.1 percent in 2017, nearly six times of that in 2000. The overall development of renewable energy in Germany is fast.

![Figure 1. Proportion of renewable energy of electricity consumption in Germany.](image)

2.1. Photovoltaic power generation

The photovoltaic power plants in Germany can be remotely controlled by the power grid operators to provide ancillary services (such as frequency modulation and voltage control), which can help the photovoltaic power plants improve the stability of the power system. In the future, with the further development of photovoltaic technology in Germany, the PV power plants can also provide reactive power regulation, black start, operation backup and other services. Therefore, Germany is actively adjusting policies and regulations to promote the development and application of system-friendly photovoltaic systems. Distributed solar photovoltaic plants in Germany are mostly located in the south. The industrial factory roof-top distributed photovoltaic project is preferred to be constructed in factories with large roof area, well integration into the grid, large electricity load, clear property rights and good roof structure. Due to the large electricity load, some of the electricity generated by the distributed photovoltaic grid-connected system can be consumed locally. The cooperative mode with the owner usually includes the roof lease mode and the energy performance contracting mode (that is, the tariff discount and the roof free usage mode).

In 2016, photovoltaic power generation accounted for 5.9 percent of the annual electricity consumption in Germany, which was 38.3TWh. As of the first half of 2017, the installed capacity of PV power in Germany was 42GW and the total number of photovoltaic power plants in Germany was 1.5 million. As early as 2015, the installed units of domestic photovoltaic power generation in
Germany had reached 1.5 million. When the weather is sunny, instantaneous photovoltaic generation can supply about 40 percent to 50 percent of the electricity demand. As of 2013, compared to Bulgaria, Spain and other countries, where large ground-based centralized photovoltaic power plants account for more than 80 percent of photovoltaic power installed capacity, the installed capacity of roof-top distributed photovoltaic power accounts for nearly 80 percent represented by Germany, Switzerland and Austria. Specifically, for Germany, the percentage of residential, commercial and industrial roof-top distributed photovoltaic plants is 12 percent, 53 percent and 10 percent respectively, while the large ground-based plants account for only 25 percent. In 2016, the total amount of carbon dioxide emission reductions reached 22 million tons due to photovoltaic generation in Germany, explaining the remarkable development of renewable energy industry. The new installed capacity of photovoltaic in Germany is shown in figure 2. It can be seen from the figure that the newly installed capacity of photovoltaic power in Germany reaches peak during 2010 to 2012 and then drops sharply after 2012. Figure 3 shows the overall photovoltaic installed capacity in Germany in the past five years. In general, the commercial use accounts for a large proportion in Germany.

![Figure 2. New photovoltaic power installed capacity in Germany (MW).](image)

![Figure 3. Photovoltaic power installed capacity in Germany (MW).](image)

### 2.2. Wind power

From the 90s of last century, Germany actively promoted the development of renewable energy such as wind power. At present, Germany has become one of the largest wind power markets in the world and its wind power equipment manufacturing is in the leading position in the world. In 2016, the total installed capacity reached 194.53GW in Germany, including 4.13GW of offshore wind power and
44.80GW of onshore wind power. Compared with 2015, onshore wind power increased 3.55GW and offshore wind power increased 0.70GW. According to the latest study by the Fraunhofer Institute for Wind Energy and Energy Systems Technology (IWES) under the German Wind Energy Association, about 2 percent land in Germany can be used for wind power development. After over two decades’ development, wind power has become an important part in the German electricity market. By 2022, Germany plans to shut down all nuclear power plants, compress thermal power capacity, vigorously develop wind, solar and bio-energy and transform new smart grids. By 2020, renewable energy will account for more than 30 percent of the electricity consumption.

At present, the total installed capacity of wind power in Germany ranks the third across the world. The installed capacity of onshore wind farms is usually smaller, which are connected to distribution network of 6 kV to 36 kV or 110 kV, mainly locally consumed. In the offshore wind equipment manufacturing industry, only the Siemens occupies over 80 percent of the European market share. At present, offshore wind power accounts for 16.5 percent of German wind power. In 2016, the German government passed the Renewable Energy Law reform draft, which proposed that stipulating the upper limit of wind power generation capacity in order to reduce overcapacity, stopping the fixed subsidies for new wind power plants, phasing out subsidies for green electricity grid-connected prices, and limiting the expansion of onshore wind power. In recent years, Germany has made many policy adjustments to limit the development pace of wind power to coordinate with smart grids and energy storage technologies. In September, 2017, according to Federal Grid Administration, the German grid regulator, Germany will add more than 1 million kilowatts of onshore wind power installed capacity, equivalent to a new nuclear power plant. The German government plans to have the installed capacity of more than 6.5 million kilowatts by 2020 and 15 million kilowatts by 2030.

3. The United States

3.1. Photovoltaic power generation

According to statistics, the expansion and application of photovoltaic power generation in the United States do not need government policies to be the main driving force any more. 83 percent of the PV installed capacity in 2013 stemmed from companies to meet renewable energy quotas regulated by the government [9]. This proportion has been declining year by year, with 57 percent in 2015 and 50 percent in 2016, and in 2017, only 27 percent of the installed capacity is estimated to be driven by the quota system. As of September 2017, in the 24GW of installed capacity under construction, 24 percent are driven by the renewable energy quota system, 35 percent are procured by power companies and 12 percent are purchased by residents and communities. In addition, 29 percent are procurement contract under the open market competition guidelines encouraged by the Public Utility Regulatory Policies Act (PURPA) [10].

In the exploitation of centralized photovoltaic power plants, the cost of large-scale centralized photovoltaic power generation dropped 64 percent from 2008 to 2015[11]. At present, there are mainly three centralized photovoltaic power plants in the United States. First, the sun I and II, which is located in Rosamundo, California with installed capacity of 579MWAC and was completed in June 2015. Second, Topaz Photovoltaic Power Station, which is located in San Luis Obispo County, California, with installed capacity of 550MW and is the third largest photovoltaic power plant in the world. Third, the desert solar photovoltaic power plant, which is located in the Mojave Desert in California desert center, with an installed capacity of 550MWAC and an annual generation of 1287GWh.

In the area of distributed photovoltaics, the United States has also introduced many supportive measures in recent years to promote the exploitation of small-scale power generation facilities on the customer side such as wind power, photovoltaic and domestic fuel cells. One of the contributing factors in the achievement is the marked decline in the cost of installing PV modules, which has dropped more than 70 percent in the past decade. Another reason for the increase is the Renewable Energy Investment Tax Relief policy, which provides a 30 percent tax rebate on both commercial and
individual residential PV installations. By the end of 2015, the investment tax relief extends to 2019, and tax rates will be gradually reduced in 2021. Another reason is that there are 43 states and Washington, DC adopting a net-metering tariff, which means that users with renewable energy power generation facilities can deduct the amount of electricity delivered to the grid from their electricity bills and calculate only net consumption. When there is still surplus power after deduction, the remaining electricity will be passed to the next month, that is, the mechanism of offsetting the power consumption by the generation. Figure 4 shows the installed capacity of photovoltaic power in the United States in the past five years. It can be seen that the installed capacity of photovoltaic power in the United States shows an overall increasing trend year by year. The major reason is that the installed capacity of public utilities grows remarkably. The photovoltaic power installed capacity in 2017 is about 4 times of that in 2013, among which commercial use accounts the least and grows slowly.

![Figure 4. Photovoltaic power installed capacity in the United States.](image)

3.2. Wind power
From 2008 to 2015, the cost of renewable energy power generation dropped sharply in the United States, especially the wind power generation cost decreased by 41 percent. Due to the unbalanced distribution of wind resources and load centers in the United States, large-scale wind farms are mostly developed instead of small-scale wind power and electricity is delivered through transmission networks to load centers. However, distributed wind energy has also achieved a great development in recent years. In 2016, the total installed capacity of utility-scale wind power in America is over 82 GW, which can meet the 6.2 percent of the terminal demand. Forty states and Puerto Rico are operating utility-scale wind projects. Wind power installed capacity in Texas is more than 20 GW, ranking first in the United States. The newest utility-scale wind power is grid-connected in North Carolina early in 2017. In 2017, the total installed capacity of wind power is 89,077 MW, covering 41 states. The generation of these wind farms is sufficient to meet the demands of about 26 million local households. Overall, in 2017, the United States adds 7,017 MW of wind power, attracting 11 billion dollars' private investment. The capacity of wind farms under construction or under exploitation is 28,668 MW, increasing 34 percent over that in 2016.

In the aspect of distributed wind power application, the United States is one of the fastest developing countries. The main factors for its rapid development are as follows: firstly, distributed wind power generation projects are strongly supported throughout the country. Secondly, the United States promised that in 2020 greenhouse gas emissions will drop 17 percent compared to that of 2005 and 20 percent of electricity demand will be supplied by wind power in 2030. Thirdly, distributed wind power projects vary in size from small units of 50 kW to large grid-connected units, so it is necessary to meet requirements of different users with fixed price. Fourthly, exploitation process of distributed wind farm is simple and its cycle from the assessment to commercial operation is short. Lastly, distributed wind farm can directly access the power grid through local distribution network.
4. Japan

Japan is a major energy consuming country. Due to its geographical constraints and scarce resource, most of its energy supply depends on imports. The external dependency of crude oil, natural gas and coal is 99.6 percent, 96.1 percent and 93.9 percent respectively. Because of the advantages of high energy independence, low cost and non-carbon emission, it has been regarded as an important autonomous energy source by the country and accounted for 30.8 percent of its entire power structure in 2010. However, after the Fukushima nuclear accident in 2011, Japan was forced to increase its thermal power generation to make up for the shortage of electricity supply caused by the shut-down of nuclear power plants. Therefore, the import and consumption of fossil energy sources increased. Since then Japan has actively adjusted its energy security strategy and began to focus on the development of renewable energy sources and accelerate its utilization and promotion [12].

4.1. Photovoltaic power generation

According to the development policy of the government, the proportion of renewable energy power generation in the power structure will increase from the current 12 percent to 22 percent to 24 percent by 2030. In Japan, the development of PV industry is much faster than any other renewable energy. The solar industry in the country has rapidly grow in 2012, stimulated by Japan's high subsidies for solar energy. However, with the annual reduction of solar energy purchase price in Japan, the trend of market recession is obvious. Affected by the shrinking domestic demand in 2016, the Japanese photovoltaic market has been in recession for seven quarters, with the related enterprises successively bankrupt. In 2016, solar power generation provided 4.3 percent of the country's electricity, accounting for about 30 percent of the total renewable energy power generation.

In terms of distributed photovoltaic power generation, Japan proposed the Zero Energy Home(ZEH) project in 2010 and began to offer support fund in 2012. Standard ZEH should include Photovoltaic power generation system, house shading, high-efficiency thermal insulation layer, high-efficiency lighting LED, energy-saving air conditioning, energy-saving ventilation fans, water supply equipment, thermal insulation windows, batteries and so on. Energy saving of the entire system must reach more than 20 percent, and renewable energy is covered 100 percent. There is also a concept close to ZEH that renewable energy can provide more than 75 percent of required energy. Japan's Sekisui Chemical Co., Ltd. surveyed 3545 residential users, among the new homeowners admitted in 2013, only 34 percent, 1202 households, were non-ZEH systems, whose annual electricity consumption was over 3460kWh. 49 percent of the households consumed more electricity, causing energy provided by ZEH system insufficient, and the grid power delivery is 13495 kWh. There are 589 households accounting for17 percent achieving complete zero energy consumption. At present, the proportion of ZEH families is increasing year by year.

In terms of centralized photovoltaic power generation, Japan is currently the world's most widely used country of floating photovoltaic station. Compared with the conventional onshore photovoltaic power generation project, the construction cost of floating photovoltaic station of the same scale is much higher. But for countries like Japan which have scarce land resources, it is one of the few options available. Although the initial construction cost is high, studies show that the efficiency of floating photovoltaic station is about 11 percent higher than that of onshore station due to the evaporation and cooling of water, and its returns are higher in later period, to some extent, reducing the overall project construction costs. In addition, the water project naturally has a higher seismic capacity against Japan's active geological environment. Figure 5 shows the photovoltaic power installed capacity in Japan In 2017, which has reached 50GW. Commercial use occupies a larger proportion, accounting for about 60 percent, while that of residential and public utilities are similar.
4.2. Wind power
In the early stage in Japan, wind energy exploitation mainly focused on onshore wind power. However, since 2012, Japan began to gather information for the commercialization of offshore wind power in Choshi and Kitakyushu coastal areas, including weather conditions and power generation. Combining these information and overseas experience, Japan established a new tariff for offshore wind power electricity in 2014 to promote the its development.

The offshore wind power projects in Japan generally have a greater generating capacity. The Fukushima Future, which is a floating offshore wind power platform with 2MW generating capacity wind turbines was completed in 2013. In 2015, Japan set a giant windmill with the height of about 188.5 meters in about 20 kilometres off the coast of Fukushima Prefecture, named Fukushima Ventilation, which is the world's largest windmill with a generation capacity of about 7 megawatts. In 2016, the third floating offshore wind turbine, Fukushima Hamamatsu, is completed in Japan, which is equipped with a large-scale wind turbine with a capacity of 5MW to form the largest floating offshore wind farm, of 14MW, in the world, with the Fukushima Future and the Fukushima Fresh.

5. Conclusion
In the photovoltaic field, photovoltaic development in most countries has experienced initial policy support to industry explosion. After scale explosion, its quality and efficiency are raised. Subsidies are used to improve the industry's cost and profit distribution, and to help reduce costs and prepare for the marketization. The different exploitation modes of different countries lead to the different policies. In addition, the geographical situation, resource conditions and exploitation and utilization of renewable energy in different countries are all significant to the choice of the renewable energy exploitation approaches. In the wind power field, foreign countries do not significantly distinguish centralized and distributed wind power development. Generally, it is referred to the conditions of resources, power grids and load to determine the exploitation scale of wind farms, then accessed to appropriate voltage levels. Germany and other European countries have a certain proportion of small-scale wind power, which is accessed into distribution network and consumed locally. Due to the unbalanced distribution of wind resources and load centers in the United States, large-scale wind farms are mostly developed instead of small-scale wind power and electricity is delivered through transmission networks to load centers.

Acknowledgments
This work is supported by the Science and Technology Project of State Grid of China (Technical and Economic Comparative Models of Transnational Transportation and Distributed Generation Local Consumption and Developmental Timing Research of Renewable Energy Base-SGXJJYOOGHS1700020).
References

[1] J. van der Geer, J.A.J. Hanraads, R.A. Lupton. The art of writing a scientific article, Journal of Personality & Social Psychology, 2000, 83: 1456-1468.

[2] Bi Yantao, Wang Dan, Li Chunxin, et al. The status, outlook and enlightenment of global renewable energy, J. International Petroleum Economics, 2016, 24(8): 62-66.

[3] Xu Qiang. Development trend and Prospect of global renewable energy, J. International Economic Cooperation, 2012 (11): 79-82.

[4] Zhang Meng, Zhang Bin. The status and Prospect of the development of renewable energy in the world, J. China Power Enterprise Management, 2014 (10): 42-44.

[5] Miao Hong. Present situation and prospects of global renewable energy, J. World Environment, 2017 (2): 65-67.

[6] Gao Hui, Yang Yan, Rao Libo, et al. Development of global renewable energy, J. International Petroleum Economics, 2016, 24(4): 1-5.

[7] Zou Caimeng, Zhao Qun, Zhang Guosheng, et al. Enemy revolution: From a fossil enemy era to a new enemy era, J. Natural Gas Industry, 2016, 36(1).

[8] Xie Xiaowei, Liang Xiuhong, Liang Bo. A review of photovoltaic power generation in Germany, J. Solar Energy, 2015(2): 6-10.

[9] Hong Lei, Jia Feng, Wu Ke. Status of Development and Application of German Renewable Enemies, J. Journal of Hefei University (Natural Sciences), 2014, 24(3): 78-82.

[10] Qian Bozhang. Status of Development and planning of American Renewable Enemies, J. Solar Energy, 2011(12): 10-12.

[11] Zhang Ke, Liu Shanshan, Zhang Pei, et al. US Renewable Energy Characteristics and Grid Integration Challenges, J. Southern Power System Technology, 2014, 8(4): 101-106.

[12] B Obama. The irreversible momentum of clean energy, J. Science, 2017, 355: aam6284.

[13] Li Jun, Wang Xuchun, Li Xiaozhao. The energy situation and real utilization state of renewable energy in Japan, J. Solar Energy, 2017(12).