Experience and Enlightenment of Energy Transition in Germany

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Abstract. As a leading developed nation of energy transition, Germany has achieved great progress of energy transition by a series of policies such as renewable energy legislation, shutdown of nuclear power stations, phase-out of coal-fired power and starting the carbon emissions trading system. During the process of energy transition, Germany also encountered issues like retarded grid construction, slow progress of carbon emission reduction in mobility sector, excessive subsidy for renewable energy. As a latecomer of green transition, China needs to prudently consider and deliberate Germany's experience and lessons of energy transition.

1. Introduction
Germany is the frontrunner of global energy transition and the leader of renewable energy development. Given the relative shortage of energy resource endowment, Germany sets the reduction of greenhouse gas emission and phase-out of nuclear power as the two major policy targets of its energy transition, takes the renewable energy development and energy efficiency improvement as the two core objectives and major paths, and adopts a number of incentive and subsidy policies to proactively advance the market-oriented reform and infrastructure construction of power market, boost science and technology innovation, energy conservation and emission reduction, and take a lead in green, low-carbon and smart energy transition[1-3].

Many scholars at home and abroad have studied and analyzed the main paths of Germany’s energy transition, and universally deemed the vigorous development of renewable energy as the key path. In the literature[4], the German option is based on two perceptions that firstly from the perspective of sustainable social development, the renewable energy serves as a critical guarantee of protecting environment and realizing basic human rights; secondly from the perspective of general cost, the unparallel advantage of renewable energy is highly recognized. In the literature[5], Germany sets renewable energy as the cornerstone of future energy production that will guarantee the reliable, economically feasible and environmentally-friendly energy supply, and turn the country into the most energy-saving and greenest economy in the world. In the literature[6], Germany’s great efforts in energy transition driven by renewable energy are for three major targets, i.e. the environmental target of response to climate change and phase-out of nuclear power, the economic target of creating new industry, more job opportunities and better export and trade, and the security target of reducing energy import and realizing diversified energy supply.

Over the years China also actively promoted energy transition in order to comply with the global trend of energy transition and tackle with the domestic issues like structural imbalance of energy supply and demand and the ecological and environmental degradation[7]. Since China and Germany have lots of similarities in resource endowment and energy structure, China may take reference of the
experience and lessons of German energy transition. The paper probes into the present status, policies and strategic path of energy transition in Germany, sorts out and summarizes the issues in the process of energy transition, and gives advice to China's energy transition.

2. Present status and policy support of energy transition in Germany

By the end of 2019, Germany's total installed capacity of renewable energy registered 122.5GW with a year-on-year increase of 4.7%, which included 60.9GW of wind power installed capacity, 49.2GW of PV power capacity, 4.8GW of hydropower capacity and 8.2GW of biomass power capacity. In 2019, the total carbon emission of Germany was about 811 million tons with a decrease of over 50 million tons compared with a year ago and a significant drop of about 35% from 1990 so that the country gets closer to the target of emission reduction by 2020. Such emission reduction should be attributed to the power generation sector. Owing to the upsurge of carbon credit price in the European Carbon Emission Trading System in 2019, Germany's renewable energy output including wind, solar, hydro and biomass power had a year-on-year increase of 5%, and at the same time the output generated by traditional fossil energy like lignite and hard coal declined significantly. However in the sectors of construction and mobility, the increasing consumption of petroleum and natural gas resulted in rise of carbon emission that to some extent offset the emission reduction efforts at the power generation side.

2.1. Renewable energy policy

The renewable legislation system in Germany is with the "Renewable Energy Law" as the core for sound and sustainable development of renewable energy[8], which is featured with separate legislations for different application segments (electricity, mobility and heat production). After the implementation of renewable energy incentive policy with fixed feed-in-tariff, and the FiT reduction mechanism based on newly added capacity, Germany now fully implements the renewable energy power bidding system that promotes the market-oriented development of power generation by renewable energy in a comprehensive manner.

2.2. Nuclear power shutdown policy

The Fukushima Event in 2011 culminated in the German public's fear and exclusion of nuclear power. To go with people's voice, German environmental minister announced to shut down all the domestic nuclear plants before 2022. Hence Germany becomes the first industrialized country to give up nuclear power. According to the schedule of phasing out nuclear power, the seven nuclear power plants temporarily shut down after the Fukushima accident that were put into operation before 1980 will be permanently shut down. The remaining ten nuclear power plants in Germany will all be closed by 2021.

2.3. Coal-fired power phase-out policy

German Chancellor Angela Merkel promised at the World Economic Forum 2019 in Davos that Germany would gradually phase out the coal-fired power and uplift the share of renewable energy in power generation mix from presently 38% to 65% by 2030. After 21 days of intense negotiation, the German Coal Exit Committee officially announced on Jan. 26, 2019 that a consensus on the timetable to phase out coal-fired power plants has been reached, and all the power plants will be shut down no later than 2038.

2.4. Carbon emission trading mechanism

In 2019, the German federal government adopted the main contents of climate protection plan 2030 and the relevant climate protection act so as to further reduce the emission of greenhouse gas detrimental to the climate. An important measure is to introduce CO₂ emission trading mechanism in heat production and transportation sectors. These two sectors were previously not included in the European Carbon Emission Trading system that Germany is a member state, and this time is involved in the national emission trading system. The system will be launched in 2021 to sell emission credits
to the enterprises selling gasoline, diesel, gas, coal and the earnings are utilized as subsidies to electric tariff, public travel, etc.

2.5. Energy efficiency policy

After the First Oil Crisis, Germany started to establish and improve the energy efficiency legislation and regulatory system. The present energy efficiency policy regime mainly consists of EU's energy efficiency directive, German energy transition plan and a series of supportive policies and measures that mainly include three types of rules and regulations, i.e. EU's energy efficiency directive and other directives, the laws and regulations enacted by the federal parliament on energy and building energy efficiency, and the energy efficiency plans released and implemented by DENA. By the end of 2019, German federal government adopted the EffSTRA 2050 that regulates the energy efficiency targets by 2030, and summarized to compile a new version of energy efficiency plans that include many key measures to be taken by the Government of Germany.

3. Germany's path of energy transition strategy

German Federal Parliament sets 3E as its supreme guiding principles of energy transition namely Energy Security, Energy Efficiency and Energy Sustainability, under which the EffSTRA 2050 was developed by focusing on an environmental friendly, safe and affordable energy supply system and establishes the medium- and long-term energy development philosophy.

As the joint initiative of both federal and regional governments, the Energiewende (energy transition) management involves the governments at all levels, some ministries and public administrative agencies, and the whole business community and society so that the federal level and regional level are closely interlinked[9]. The sound institutional system, endless science and technology innovation, perfect regulatory guarantee and broad public engagement are the four key measures to achieve the energy transition targets in Germany.

4. Issues incurred in Germany's energy transition

Although developing fast, Germany's renewable energy industry also incur several issues. A key issue is the subsidy for renewable energy uplifts the energy consumption cost of the whole society and imposes extra burden on people's livelihood[10]. By far there is no uniform standard to measure the cost of energy transition but the most direct cost is the subsidy to renewable energy. The German retail tariff includes the elements of wholesale tariff, grid connection charge, VAT, carbon tax, renewable energy surcharge. The renewable energy surcharge is to reimburse the gap between FiT of power generated by renewable energy and the wholesale tariff on the market, which is shared by all German residents. German started to collect the surcharge of less than 1 Euro cent per kWh around 2000 but it rose to 6.3 Euro cent per kWh in 2015.

By far Germany is the EU member state with the highest electricity tariff that is nearly 50% higher than the EU's average level. The renewable energy surcharge accounts for 20%, and plus various taxes the electric power turns out to be the most taxed consumables except tobacco, gasoline and liquor. A few poor households even suffer power service interruption as they cannot afford it, which brings heavier economic and social burdens on the green transition. In the public opinions polls, since May 2019 voters take the climate and energy system transition as the most critical issue faced by Germany, even above the issues of immigration/melting (ranking second) and pension (ranking third).

As the scale of various renewable energy and power further expands, the future cumulative cost of renewable energy transition will be astonishing. Shown by a research conducted by Germany Fraunhofer Institute for Solar Systems in 2015, if by 2050 Germany will cut down carbon emission by 80% compared with 1990, the cumulative cost of such energy transition will amount to 5.34 trillion Euros provided that the zero carbon price and fossil fuel price are stable, and given the improbable zero carbon price in the future, the actual cost could be even higher.
5. Enlightenment of Germany's energy transition

Through more than two decades of exploration and practice, Germany's green transition strategy has taken shape, and starts to play a significant role in safeguarding its energy supply, creating green industry, economic growth and job opportunities, and expanding international influence. However, Germany also encounters several issues in energy transition that may serve as reference for China's energy transition.

Firstly we should consummate the pricing mechanism and gives full play to the role of market in resource allocation. Andreas Kuhlmann, CEO of DENA once pointed out the biggest mistake in Germany's energy transition is the lengthy time span and slow exit pace of PV power subsidy that brings heavy burden on the transition process. In fact, China's renewable energy development also incurs the same problem that the stimulus of high subsidy leads to the unscheduled development of wind and solar power beyond planning and expectation, and results in widening gap of renewable energy subsidy, difficulty of renewable energy consumption and digestion, waste of investment and other issues. As the generating cost of wind and solar power keeps declining, China should properly introduce the market competition system of Germany, and realize grid parity and sustainability of renewable energy by a market-oriented approach.

Secondly we should enhance our awareness of energy conservation and environmental protection, and attract more all people engaging in green transition. Citizens are both the initiators and supporters of grass-root energy transition. Germany organizes more than 400 information advisory agencies dedicated to energy and energy efficiency. They make use of all kinds of media to educate the mass people how to improve the utilization rate of renewable energy in heat production, power supply, mobility, food, etc.; the public benefits are guaranteed that the households and farms properly utilizing solar energy can get governmental allowance. China has a mammoth population and high energy consumption per capita. Therefore, stronger awareness of energy conservation and environmental protection by all people and higher enthusiasm about renewable energy utilization will yield infinite boosting effect upon the green energy transition in China.

6. Conclusion

Based on the analysis of the status quo of the development of energy transition in Germany, this paper systematically summarizes the evolution process and strategic trends of German energy transition policies, and fully absorbs the experience and lessons of German renewable energy development. In light of the national conditions, suggestions on promoting the development of China's renewable energy and energy transition were put forward, providing support for the formulation of China's energy transition strategy and development roadmap.

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