Transition to Renewable Energy Society in Germany and the U.K.
― Historical paths to FIP and CfD Introduction and Implications for Japan ―

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Summary

Renewable energy is attracting attention from the decarbonization trends and the viewpoint of resilience against the COVID-19 disaster. In line with this recognition, this paper considers how best to realize the transition to a society where renewable energy is widespread. Taking up the power sector of Germany and the United Kingdom that have historically depended heavily on fossil fuels, this paper analyzes how the two countries have tried to achieve the transition from a fossil-based system to a renewable-based system for the power sector. The analysis mainly focused on EU and domestic policies, political party trends, and the Parliament discussions.

Interestingly, Germany and the United Kingdom have followed widely different policy paths to their common renewable energy promotion goal. Germany has frequently implemented fine-tuned legislative measures since its initial development of renewable energy promotion systems, adjusting feed-in tariffs and their gradual reduction rates by renewable energy type, capacity range, and activation year. In contrast, the United Kingdom has used market functions as much as possible from the beginning for the cost-efficient promotion of renewable energy.

While following different paths to renewable energy promotion, the two countries commonly experienced twists and turns for handling renewable energy's relations with other energy sources such as coal and nuclear. Also, they continued efforts to advocate national visions and long-term targets to implement renewable energy promotion policies. Climate change, energy security, and other higher-ranked policy agendas have also significantly impacted their renewable energy promotion.

Given such analysis, this paper suggests the need for assessing the impacts of other primary energy sources and high-ranked policy agenda. It also points out the significance of long-term targets and coordination after institutional development to realize a renewable energy-oriented society.

As implications from German and the U.K. policy processes for Japan, this paper emphasizes the importance of developing electricity markets, eliminating grid constraints, securing the supply-demand balancing capacity, and demonstrating the long-term targets for 2050 to promote renewable energy as a major power source. This paper also considers calculation methods for premium prices under the Feed-in Premium (FIP) system.

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Introduction

Adopting decarbonization as one of the pillars for economic recovery from the COVID-19 disaster has become a significant trend, especially in Europe. The world seeks to build back better by tackling society-wide challenges like climate change, technological innovation, health, employment, and social gap issues.

In such a situation, renewable energy has attracted attention not only as a low-carbon energy source contributing to decarbonization but also from the perspective of resilience against the COVID-19 disaster. While global electricity demand has plunged into economic stagnation due to the pandemic, renewable energy power generation, mainly from solar photovoltaics and wind, has been growing. In 2020, renewable energy became the only energy source scoring primary energy supply growth[2]. Renewable energy had been viewed as a volatile and costly electricity source. However, given its characteristic position as distributed energy and its cost-competitiveness enhanced through technological development, renewable energy has increasingly been recognized as safer and cheaper than conventional electricity sources for which massive labor and fuels are required.

With such recognition, it must be worth reconsidering how to realize a society where renewables are widespread. As the future global energy mix's direction has long been discussed, the significance of policies promoting the transition from a fossil-based society to a renewable-based one has widely been recognized. In an EU Strategy for Energy System Integration released in July 2020, Europe indicated a policy at the EU level to gradually shape a new integrated energy system, *i.e.*, "the energy system as a whole, across multiple energy carriers, infrastructures, and consumption sectors, by creating stronger links between them with the objective of delivering low-carbon, reliable and resource-efficient energy services, at the least possible cost for society"[3]. In Japan, the cabinet decided on the Fifth Strategic Energy Plan in July 2018, adopting a policy of diffusing renewable energy as a primary electricity source for the first time. Since then, institutional designs have been discussed to diffuse renewables as a cost-competitive and long-term stable electricity source.

Based on such trends, this paper reviews the transition from a fossil-based system to a renewable-based one in the power sector, where renewables were actively promoted ahead of other sectors such as heat and transport. In the field of political science, the question of how technologies and institutions that had been locked in society would make a transition to new ones has actively been researched. Some researchers have broken down transition processes into phases and analyzed phase-to-phase changes[4]. Others have considered transition processes by focusing on political trends triggered by

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[2] Y. Ninomiya "2020-21 Renewable Energy Trends: How Would Covid-19 Impact Renewable Energy?" 435th Forum on Research Works, IEEJ, 7/14/2020, IEA "Renewables 2020 – Analysis and forecast to 2025", November 2020.

[3] "Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Powering a climate-neutral economy: An EU Strategy for Energy System Integration," COM(2020)299 final, 8th of July 2020., p.2.

[4] Earlier studies regarding the theme of this paper include Geels et al., "The Socio-Technical Dynamics of Low-Carbon Transitions", *Joule* 1, November 15, 2017, pp.463-479; Verbong, Geert and Loorbach, Derk eds., *Governing the Energy*

external shocks impacting existing systems[5]. Studies on transitions paid attention to the timings when specific policies were taken and clarify processes in which existing systems or institutions transitioned to new ones.

This paper conducts a comparative analysis of German and U.K. cases based on such framework of transition studies. Both countries had historically depended heavily on fossil fuels but have dramatically expanded renewables' presence in the power sector since the 1990s. In Germany, renewables' share of total power generation dramatically increased from 3.5% in 1990 to 39.9% in 2019 and a record 55.8% in the first half of 2020[6]. In the United Kingdom, renewables' share of the power mix soared from only 2.7% in 2000 to 37.1% in 2019. It has reached 47% in the first quarter of 2020. Among EU countries that have promoted cross-border renewable electricity trading through the international grid, the two countries have achieved remarkable renewable expansion[7]. Their power sector's transition from heavy dependence on fossil fuels is worthy of attention.

To analyze how the German and U.K. power sector has promoted transition to renewables, this paper chronologically tracks the two countries' renewable energy policies while keeping trends for other energy sources in sight. It attempts to three-dimensionally identify transition processes by discussing specific policy choices and their background, including EU and domestic policies, political party trends, and Parliamentary discussions. Based on the comparative analysis, implications for Japan to realize a renewable energy-oriented economic society will be considered.

Transition: Reality, Illusion or Necessity? (Routledge, 2012); Grin, John, Rotmans, Jan and Schot, Johan., *Transitions to Sustainable Development: New Directions in the Study of Long Term Transformative Change* (Routledge, 2010); and Loorbach, Derk, *Transition Management: New Mode of Governance for Sustainable Development* (International Books, 2007)

[5] Aklin, Michaël and Urpelainen, Johannes, *Renewables: The Politics of a Global Energy Transition* (The MIT Press, 2018).

[6] Data for 1990 and 2019 are from IRENA, "Renewable Energy Statistics," 2020. Data for the first half of 2020 are from a story in the Nikkei Sangyo Shimbun newspaper dated July 21, 2020, citing a release from Germany's Fraunhofer Society.

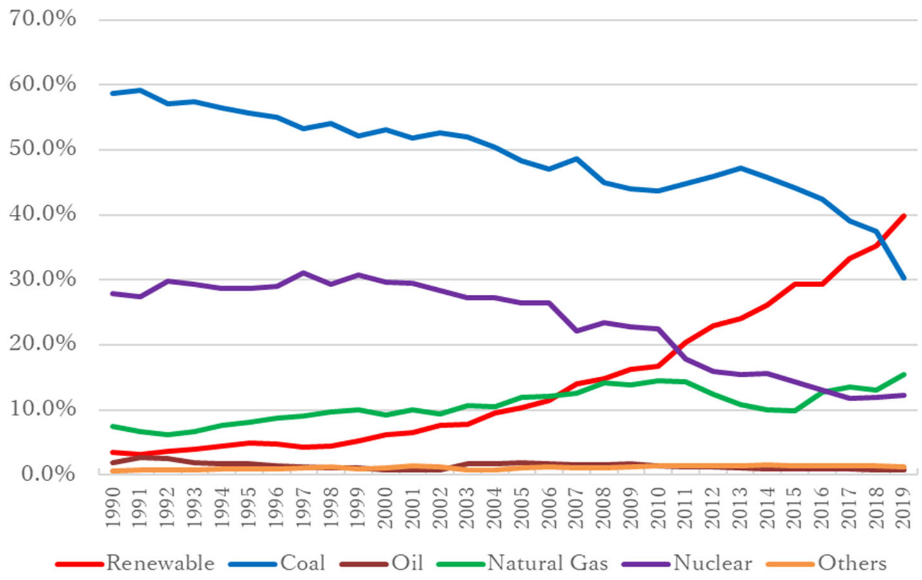
[7] Renewable energy data in the power sector in EU countries are from Agora Energiewende, "The European Power Sector in 2019: Up-to-Date Analysis on the Electricity Transition." According to the report, renewables accounted for 34.6% of total EU power generation in 2019. In Sweden and Austria endowed with rich hydro resources, renewables capture more than 70% of total power generation. Hydro has long been a mainstay power source in these countries. Denmark has boosted its renewable share to around 70% by expanding wind power generation.

1. German institutional building process for renewable energy expansion

Germany has taken the initiative in energy transition for decarbonization, greatly expanding renewable energy's share of the power sector. How has Germany, which has historically depended heavily on fossil fuels, developed renewables in the power sector? This section reviews Germany's power supply and demand trends, tracks its renewable energy expansion policy process from the 1990s, and analyzes its policies.

1-1. German power supply and demand trends

As a country endowed with rich coal resources, Germany has depended heavily on coal for developing manufacturing since the 19th century. Poor with non-coal energy resources, the country has relied on imports for most oil and natural gas supply. When cheap oil began to be imported into Germany in the 1960s, its primary energy supply source shifted from coal to oil. However, the first oil crisis in 1973 led Germany to transition back to coal and give policy protection to the coal industry[8]. As shown in Figure 1-1, coal's share of Germany's total power generation stood at 58.7% in 1990 and remained above 50% until 2004. In 2005, it slipped below the level to 48.2% and 30.3% in 2019[9]. While coal's presence in power generation was still significant, in January 2020, the German government announced plans to phase out coal mines and coal-fired power plants by 2038.



8 Federation of Electric Power Companies of Japan website, "German Energy Policy Trends(「ドイツのエネルギー政策動向」)" (https://www.fepc.or.jp/library/kaigai/kaigai_jigyo/germany/detail/1231559_4782.html)

9 IEA, "World Energy Statistics and Balances 2020." According to the statistics, oil accounted for 0.8% of Germany's total power generation in 2019, natural gas for 15.4%, nuclear for 12.3%, renewables for 39.9% and others for 1.3%.

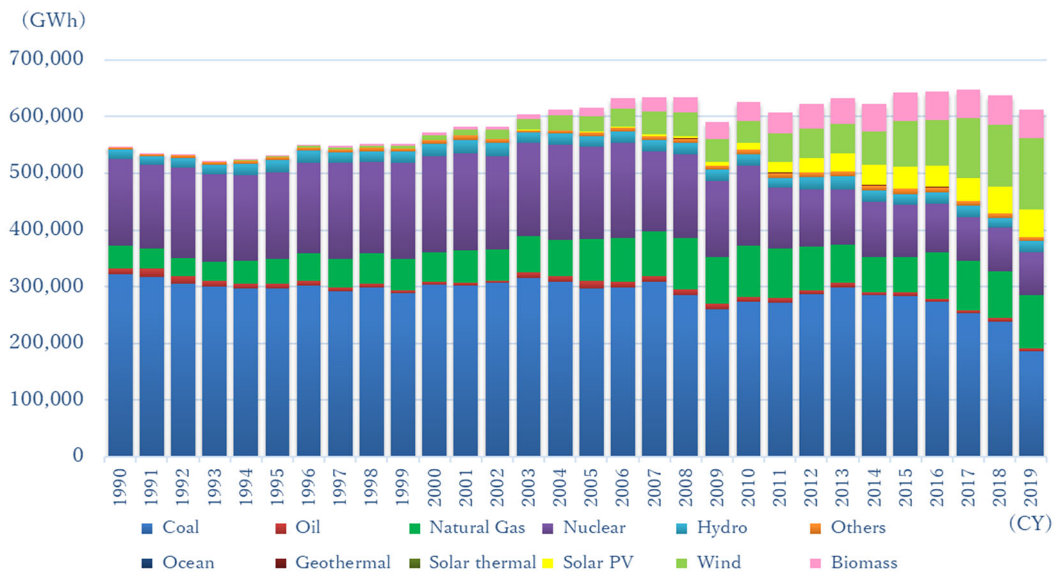


Figure 1-1: (Upper) Each energy source's share of total power generation (%), (Lower) German power mix trends

(Source) Prepared from IEA, "Energy Statistics and Balance 2020"

The German government had already announced a nuclear phaseout policy in 2011. Nuclear had accounted for about 30% of total power generation until the early 2000s as the second-largest power source after coal (Figure 1-1). Under anti-nuclear campaigns that have been buoyant since the 1970s in Germany, a nuclear phaseout law took effect in 2002 to retire nuclear power plants by 2022. Later, the German government revised the schedule to retain nuclear power plants as it had found that renewable energy alone would not be enough to cover the domestic power demand. In response to the March 2011 Fukushima Daiichi nuclear plant accident, however, the German government swung back to the nuclear phaseout policy. In July 2011, Germany took legislative action to restore a nuclear phaseout plan close to the original one, deciding to phase out nuclear plants by 2022. Under such policy, the nuclear share of total power generation almost halved from 22.4% in 2010 to 12.3% in 2019.

As shown in Figure 1-2, renewables' share of the power mix increased substantially from 3.5% in 1990 to 39.9% in 2019. During the same period, renewable power generation output grew about 12-fold from 19,093 TWh to 244,197 TWh. Particularly, wind and solar PV power generation expanded remarkably. Hydro energy had captured most of the total renewable power generation in 1990, while the wind had accounted for only 0.37% of the total, and solar PV for 0.005%. In 2019, however, the share soared to 51.6% for wind and 19.5% for solar PV.

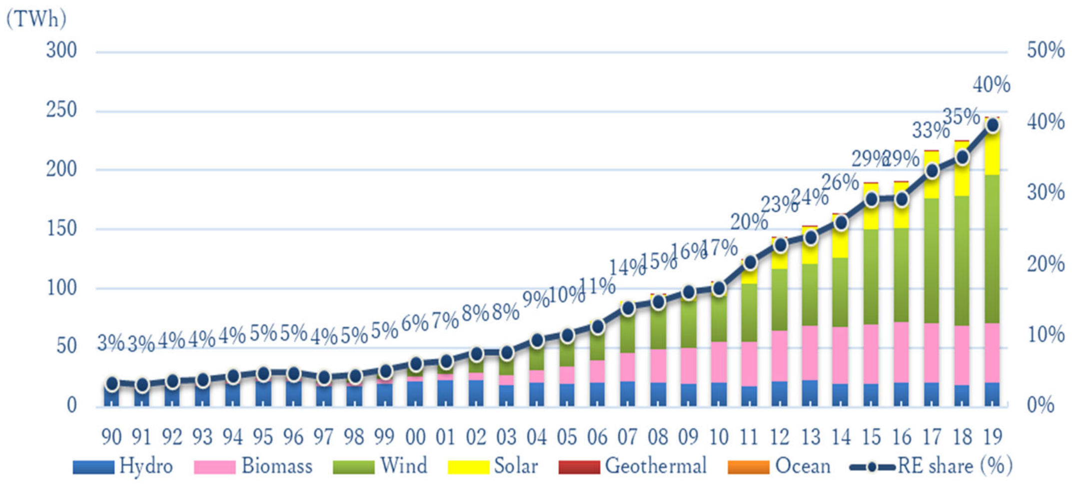


Figure 1-2: Renewables' share of total German power generation (1990-2019)

(Source: Prepared from IEA, "Energy Statistics and Balance 2020")

Based on the above power supply and demand trends, the following analyzes Germany's policy process to expand renewable energy.

1-2. FIT system creation and evolution

1-2-1. Launching institutional building for renewable energy diffusion

Germany fully launched institutional building for renewable energy diffusion under the Federal Electricity Feed Law (StrEG) that came into effect in 1991. The law required power suppliers to purchase electricity generated from hydro, wind, solar energy, waste gas, sludge gas, and "agriculture or forestry products or biological residue[10]" at rates set as percentages of electricity retail prices in their respective business territories[11].

The law was enacted to help achieve a target adopted by the German Bundestag for cutting greenhouse gas emissions by 30% by 2005 in response to growing interests in the global warming issue[12].

[10] This item was revised into "biomass" through the second amendment to the StrEG. This section describes the StrEG, the Renewable Energy Sources Law (EEG), and the EEG 2004 based on T. Watanabe, "German Renewable Energy Sources Law," *Foreign Legislation, no.225,* August 2005, National Diet Library, pp. 61-86.
（渡邊斉志「ドイツの再生可能エネルギー法」『外国の立法』no. 225、2005. 8、国立国会図書館）

[11] Purchase prices were set at 90% of average electricity retail prices for solar PV and wind electricity and 65-75% of such prices for hydro and biomass electricity according to capacity sizes. The ceiling on purchases was put at 5% of each power supplier's local power supply. Electricity from 5 MW or larger facilities among hydro, waste gas, and sludge gas power generators are not subjected to the purchase requirement. T. Watanabe, "German Renewable Energy Sources Law," p. 62, as cited above. （渡邊「ドイツの再生可能エネルギー法」p. 62）

[12] K. Oshima, "Germany's Experiences with Renewable Energy Diffusion – Feed-in Tariff System Framework and Realities," *Journal of Ritsumeikan Social Sciences and Humanities,* Vol. 88, pp. 65-91
（大島堅一「再生可能エネルギー普及に関するドイツの経験ー電力買い取り補償制の枠組みと実際ー」『立命

The main support measures for renewable energy were limited to research and development subsidies until the enactment. Then, however, the need was widely recognized for institutional building for promoting renewable energy in place of coal and nuclear energy[13]. It was because the anti-nuclear campaigns since the 1970s gained momentum on the 1986 Chernobyl nuclear plant accident, and global warming was widely seen as a severe challenge in Germany. The Christian Democratic Union of Germany (CDU) and the Christian Social Union in Bavaria (CSU) under the Kohl administration allied with the Green Party and the Social Democratic Party of Germany (SPD), as well as the European Association for Renewable Energies (Eurosolar) founded in 1988, to pass the StrEG through the Bundestag[14]. As a result of such multi-party cooperation, the law was unanimously approved in 1991[15].

The law was amended in 1994 and 1998 before the Renewable Energy Sources Law (EEG) was enacted in April 2000 to reform renewable energy policies thoroughly.

1-2-2. Institutional building for renewable energy diffusion under EEG

The EEG Law can be considered an extension of the StrEG Law because of their common purpose of renewable energy diffusion. However, the EEG differed from the StrEG in the following points. First, the EEG set a numerical target in response to the European Union's renewable energy target. The target called for doubling renewables' share of total energy supply in Germany from 2.6% in 2000 by 2010[16].

Second, the EEG took the initiative in creating the Feed-in Tariff system as a framework for promoting investment in renewable power. As noted above, the StrEG set renewable power purchase prices by some percentages of electricity retail prices, meaning that renewable power purchase prices would fluctuate in line with electricity retail prices, which resulted in failing to secure business predictability for renewable power generators. The EEG guaranteed renewable power purchases at fixed prices to allow renewable power generators to predict their future cash flow, which also encouraged newcomers to invest in renewable power generation.

Third, power suppliers' requirement term to purchase renewable power was set to last for 20 years. It aimed to encourage renewable power generators to increase business efficiency and prevent their profitability from declining over the long term. Forth, as renewables subject to the FIT system, geothermal energy and coal mine firedamp gas were added to wind, solar PV, hydro, waste gas, sludge gas, and biomass. Then, a power output ceiling was set for each renewable power source. Feed-in tariffs, or prices for renewable power purchases, were finely set based on the characteristics and degrees of diffusion for renewable power sources. Thus, the EEG set the numerical target and clarified the FIT

館大学人文科学研究所紀要』88 号、pp. 65−91）

13 Aklin and Urpelainen, *op.cit.*, pp.146-157.

14 *Ibid.*

15 *Ibid.*

16 T. Watanabe, "German Renewable Energy Sources Law," p. 63（渡邊「ドイツの再生可能エネルギー法」）

system introduction by indicating the system's details to build a framework for accelerating renewable energy diffusion.

In such institutional building, the Social Democratic Party of Germany (SPD) became the largest political party through the 1998 general elections. It formed a coalition with the Green Party promoting climate change measures, renewable energy diffusion, energy efficiency improvement, and other policies related to sustainable development. The Green Party participated in a coalition government for the first time in German history. The SPD-Green coalition immediately tackled the nuclear phaseout and the acceleration of renewable energy diffusion. In 2001, it decided on a nuclear phaseout law, providing that existing nuclear power plants would be closed by 2022, with new nuclear plant construction being banned.

Another background for the EEG included the so-called Aachen model launched in 1995 in a German town close to the borders with Belgium and the Netherlands[17]. Under the model, a public water and energy corporation offered to purchase solar PV electricity over 20 years and wind electricity over 15 years at higher prices than market levels while levying a 1% surcharge on electricity rates to raise financial resources for the purchase[18]. The model, which is similar to the FIT system, led to new investment in renewable power generation capacity and became a harbinger system for diffusing renewable energy.

The EEG was implemented in a full-blown manner from 2001. While renewable energy diffusion trends and the suitability of feed-in tariff levels were verified as needed, the law was amended several times[19]. In July 2002, the ceiling capacity for the solar PV electricity purchasing obligation was raised from 350 MW to 1,000 MW in response to smooth solar PV diffusion. It eliminated solar PV power generators' concern that they could lose FIT compensation in the future, encouraging investment in new solar PV power generation projects. In July 2003, preferential treatment for large-lot users[20] was adopted, halving a surcharge for their purchases above 100 GWh. The measure was based on a view that the surcharge for renewable energy diffusion should not seriously affect business operations. In January 2004, an EEG amendment focusing on solar PV expansion was passed. It set feed-in tariffs for solar PV

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[17] K. Ishikura "Analysis on Germany's Renewable Energy Feed-in Tariff System and Price Transitions," *Hitotsubashi Economics, 7 (1) pp. 33-64, 2013*
（石倉研「ドイツにおける再生可能エネルギー買取の制度と価格の変遷に関する考察」『一橋経済学』7(1)、pp. 33-64、2013）

[18] K. Yamauchi "Aachen Model Encouraging Solar PV Power Generation Diffusion" 2002 (http://www.genergy.jp/downloads/aachen_model.pdf)
（山内浩一「太陽光発電施設普及を促すアーヘンモデルとは」2002 年）

[19] T. Watanabe, "German Renewable Energy Sources Law" （渡邊「ドイツの再生可能エネルギー法」）

[20] Large-lot users are enterprises that consumed more than 100 GWh in electricity on average and paid power charges equivalent to more than 20% of gross added value in the past 12 months. See T. Watanabe, "German Renewable Energy Sources Law," p.64 (渡邉「ドイツの再生可能エネルギー法」p. 64)

capacity brackets and repealed the solar PV electricity purchasing obligation ceiling.

1-2-3. Setting medium to long-term targets for renewable energy diffusion and evolving the FIT system

In August 2004, the EEG2004[21] was enacted to amend the EEG comprehensively. The EEG2004 reflected an EU directive (EU2001 renewable energy directive)[22] seeking to diffuse renewable energy in the internal electricity market. First, EEG2004 targeted boosting renewables' share of total electricity supply to 12.5% by 2010 and 20% by 2020. The 2010 target share was the same as the EU2001 renewable energy directive. Second, the EEG2004 obliged power transmission and distribution companies to purchase renewable energy electricity and grid operators to connect renewable energy to the grid preferentially[23]. The obligation was regulated in Article 7 (grid system issues) of the EU2001 renewable energy directive.

The EEG2004 also reset feed-in tariffs by renewable energy source and capacity size. Besides, it expanded the scope of large-lot users subject to the preferential surcharge measure introduced under the EEG to ease surcharge burdens on a broader range of enterprises[24].

In this way, the EEG2004 built on the framework and targets for renewable energy support, reflecting the EU2001 target, to enhance Germany's existing measures. Also, it set its own renewable energy diffusion target for 2020 to promote renewable energy diffusion from the medium to long-term viewpoint.

In 2009, the EEG2004 was substantially amended[25] to raise the target for renewables' share of total electricity supply for 2020 from 20% to 30%. A report submitted to the Bundestag in 2007 stated that the renewable share reached 11.6% in 2006 and was expected to top 13% in 2007. It indicated that

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[21] Gesetz zur Neuregelung des Rechts der Erneuerbaren Energien im Strombereich (BGBl. I 2004 S.1918) (A law to establish a new renewable energy law for the power sector) as translated in T. Watanabe, "German Renewable Energy Sources Law" 渡邊「ドイツの再生可能エネルギー法」 p.69-86. The EEG2004 is a substantially revised version of the traditional EEG, replacing the traditional EEG.

[22] Directive 2001/77/EC of the European Parliament and the Council of 27 September 2001 on the promotion of electricity produced from renewable energy sources in the internal electricity market. The directive calls for setting renewable power diffusion targets and taking renewable energy support measures including green certificates, investment assistance, tax exemption or reduction, tax refund, and direct price maintenance. It also seeks to utilize the guarantee of origin of electricity produced from renewable energy sources and create a framework for grid managment including the preferential connection of renewable power sources to the grid.

[23] Details of the EEG2004 are based on its translation in T. Watanabe, "German Renewable Energy Sources Law" (渡邊「ドイツの再生可能エネルギー法」) p. 69-86.

[24] The burdens were eased on enterprises that consume more than 10 GW in electricity annually and pay electricity charges equivalent to more than 15% of gross added value. See T. Watanabe, "German Renewable Energy Sources Law" (渡邊「ドイツの再生可能エネルギー法」) p. 66.

[25] For EEG2004 and EEG2009, see K. Yamaguchi "German Energy and Climate Change Countermeasure Legislation (2) – 2009 Renewable Energy Law," *Foreign Legislation, No.241,* September 2009, National Diet Library, pp. 101-132 (山口和人「ドイツのエネルギー及び気候変動対策立法(2) −2009 年再生可能エネルギー法」『外国の立法』no. 241、2009. 9、国立国会図書館、pp. 101-132)

the target for 2010 in the EEG2004 would be achieved three years ahead of schedule[26]. In March 2007, the European Council, then chaired by Germany, decided on a binding target of 20% for renewables' share of total EU energy consumption in 2020[27]. Based on the new EU target, the EEG2009 raised the renewable share target for 2020 to 30%.

The EEG2009 also unified FIT purchase periods for all renewable energy power generation facilities (other than large hydroelectric power plants) into 20 years (15 years for large hydroelectric power plants) from the start of operation at power generation facilities, and specified conditions of direct electricity sales for renewable power generators[28]. Furthermore, it provided feed-in tariffs by power source, gradual reduction rates, and other details[29]. Given that the fuel costs for biomass power generation were rising though the remarkable growth in the generation was observed in Germany, the EEG2009 lowered the annual reduction rate of feed-in tariff from 1.5% in the EEG2004 to 1.0% for biomass power generation. As for solar PV power generation that rapidly diffused (see Figure 1-3), the EEG2009 raised the feed-in tariff's annual reduction rate because solar PV power generation costs were substantially falling on technological development.

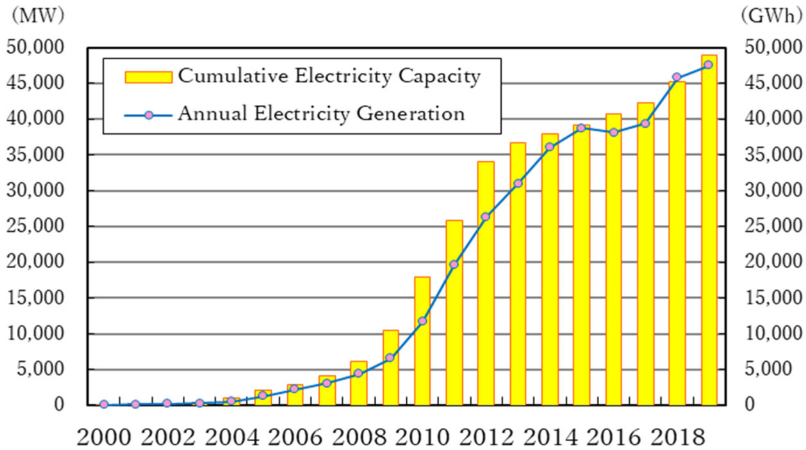

Figure 1-3: Solar PV power generation trends in Germany (2000-2019)
(Sources: Cumulative electricity capacity data are from IRENA, "Renewable Energy Statistics 2020," and annual electricity generation data from IEA, "World Energy Statistics and Balance 2020."

[26] K. Yamaguchi "German Energy and Climate Change Countermeasure Legislation (2) – 2009 Renewable Energy Law," *Foreign Legislation, No.241,* September 2009, National Diet Library, p. 103 (山口和人「ドイツのエネルギー及び気候変動対策立法(2)－2009 年再生可能エネルギー法」, p.103)

[27] "Brussels European Council 8/9 March 2007 Presidency Conclusions," Council of the European Union, 7224/1/07 REV1, Brussels, 2 May 2007.

[28] For the EEG2009, see K. Yamaguchi "German Energy and Climate Change Countermeasure Legislation (2) – 2009 Renewable Energy Law," pp. 107-132 (山口和人「ドイツのエネルギー及び気候変動対策立法(2)－2009 年再生可能エネルギー法」pp. 107-132). Article 17 of the law provides for conditions on direct sales, stating that power generators can sell electricity generated from their facilities to third parties in each month if they report such sales for a month to power distributors before the start of the previous month.

[29] To promote efficient renewable energy investment, feed-in tariffs were set to decline at fixed annual rates. For solar PV, the annual rate of decline in the feed-in tariff was set at 9%, higher than for other renewable electricity sources, because of falling costs.

1-3. Market premium system introduction (EEG2012)

1-3-1. Energy transition policy

As mentioned above, renewable energy diffusion under relevant policies has been a critical policy challenge for Germany to address climate change and promote energy transition in German society[30]. Some 50% of renewable energy facilities installed by 2010 were owned by the private sector[31], and numerous citizens were hoping for an energy transition towards a society that does not depend on fossil fuels or nuclear energy[32]. Meanwhile, the German government was concerned about growing costs for supporting renewable energy diffusion and thought that renewable energy alone would have difficulties meeting electricity demand growth while recognizing the importance of energy transition [33]. As noted in section 1-2-2, the SPD-Green coalition decided on a nuclear phaseout law, providing that existing nuclear power plants would be closed by 2022. However, a new coalition government between the Christian Democratic Union of Germany/Christian Social Union in Bavaria (CDU/CSU) and the Free Democratic Party (FDP), which was formed through the September 2009 general election, thought that the nuclear phaseout schedule would raise the risk of power shortages.

In September 2010, the Merkel cabinet of the coalition government announced an energy transition program called “Energiewende,” vowing to transform energy supply in Germany thoroughly[34]. It indicated a policy of using nuclear power generation until developing renewable power supply infrastructure. And the program extended the operating life for 8 years for nuclear power plants launched by 1980 and for 14 years for those found later[35]. It also demonstrated a path of renewable energy diffusion by indicating the target to increase renewables’ share of power supply to 35% by 2020, 40-45% by 2025, 55-60% by 2035, and at least 80% by 2050[36].

However, in response to the March 2011 Fukushima Daiichi nuclear power plant accident, the government had no choice but to revise the program substantially. In June 2010, it decided to cancel the previous year’s extension of the nuclear plant operating life and restore the policy of terminating nuclear

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30 For EEG2009 amendment history and the EEG2012, see T. Watanabe, “German Renewable Energy Sources Law” (渡辺「ドイツの 2012 年再生可能エネルギー法」).

31 Yildiz, Özgür, “Financing Renewable Energy Infrastructures Via Financial Citizen Participation – The case of Germany,” *Renewable Energy* 68, 2014, pp.677-685.

32 Aklin and Urpelainen, *op.cit.*, p.184.

33 *Ibid.*, pp.184-185.

34 Agora Energiewende “Energiewende and Economy (「エネルギーヴェンデと経済」) May 29, 2015 (https://sekitan.jp/wp-content/uploads/2015/06/Part1_Christoph_JP_final.pdf)。

35 F. Watanabe, “Germany Accelerates Nuclear Phaseout,” Foreign Legislation, May 2011, National Diet Library（渡辺富久子「【ドイツ】脱原発が加速」『外国の立法』2011. 5、国立国会図書館）

36 Agora Energiewende “Energiewende and Economy (「エネルギーヴェンデと経済」) May 29, 2015 (https://sekitan.jp/wp-content/uploads/2015/06/Part1_Christoph_JP_final.pdf)。
(Agora Energiewende「エネルギーヴェンデと経済」)

power generation by 2022[37]. Based on the decision, the government recognized the need to accelerate renewable energy diffusion further to cover nuclear plants' closure. From July 2011, it launched efforts to amend the EEG2009 substantially[38].

1-3-2. Integrating renewable electricity into the market

In January 2012, Germany implemented the EEG2012 to accelerate renewable energy diffusion. The law specified targets for renewables’ share of power supply through 2050 in line with the energy transition program and called for integrating renewable power into the power supply system[39]. It also revised feed-in tariffs and their reduction rates and included detailed conditions for integrating renewable power into the power market. While renewable power supply expanded under the FIT system, Germany recognized the need to reduce FIT surcharges' burden on consumers and improve renewable power’s market competitiveness, beginning to seek the integration of renewable power into the power market.

The EEG2009 had already provided conditions for direct sales of renewable power in the market, but the EEG2012 featured an independent chapter (Chapter 3a) for details of direct sales and market premiums[40]. First, direct sales of renewable power were divided into three categories – (i) direct sales designed to charge market premiums, (ii) direct sales designed to reduce electric power suppliers’ surcharges, and (iii) other direct sales. Renewable power generators were allowed to choose FIT compensation or direct sales and change their direct sales categories.

A market premium is a difference between the average market price and the compensation amount paid as claimed under the FIT system (standard value)[41]. Renewable energy power generators who directly sell renewable power in the market can claim a market premium from grid operators for actual electricity sales in the market and must report the latest monthly market sales volume to grid operators by the 10th day of the following month. A mechanism was introduced to retrospectively calculate a market premium for each calendar month in line with the fourth supplementary provision of the EEG2012. As for biomass power generation, electricity from 750-kW or more extensive facilities

[37] K. Koyama, “Germany Revises Nuclear Power Generation Phaseout, Deciding to Extend Operating Life” Institute of Energy Economics, Japan, September 9, 2010 (小山堅「ドイツ、原子力発電フェーズアウト計画を見直し、稼働延長方針を決定」日本エネルギー経済研究所、2010 年 9 月 9 日）(https://eneken.ieej.or.jp/data/3326.pdf）; F. Watanabe, “Germany Accelerates Nuclear Phaseout,” *Foreign Legislation*, May 2011, National Diet Library (渡辺富久子「【ドイツ】脱原発が加速」『外国の立法』2011.5、国立国会図書館）

[38] T. Watanabe, “German 2012 Renewable Energy Sources Law” (渡邊「ドイツの 2012 再生可能エネルギー法」) p. 80.

[39] For EEG2012, see T. Watanabe, “German 2012 Renewable Energy Sources Law” (渡邊「ドイツの 2012 再生可能エネルギー法」)

[40] For direct sales provided in the EEG2012, see T. Watanabe, “German 2012 Renewable Energy Sources Law” (渡邊「ドイツの 2012 再生可能エネルギー法」)

[41] Details of the market premiums are provided in Articles 33g and 33h and the fourth supplementary provision of the EEG2012. For conceptual diagrams of the FIT and FIP systems, see “Comparative conceptual diagrams of renewable energy support measures” at the end of this paper.

launched on January 1, 2014, or later was subjected not to fixed tariff purchases but to direct sales. Biogas-fired power generators that can generate power in line with power demand fluctuations were allowed to claim a flexibility premium in addition to a market premium if they increase capacity and directly sell electricity in the market.

In this way, the EEG2012 further specified the direct sales system created under the EEG2009 and introduced market and flexibility premiums to develop a framework for integrating renewable power into the power market. Renewable power was expected to gradually be integrated into the power market as renewable energy power generators accumulate experiences. The generators take advantage of the direct sales system to gain a more significant profit than FIT compensation by selling electricity when electricity demand and prices are high.

1-4. FIP system introduction (EEG2014)

1-4-1. From protection to competition

The integration of renewable energy into the power market accelerated along with the political transition. After the federal parliamentary election in September, Germany transitioned to a grand coalition between the CDU/CSU and the SPD in December 2013. The new coalition government changed the agency in charge of renewable energy and promoted the amendment of the renewable energy sources law[42].

As renewables' share of total power generation reached 24% in Germany when the new government was inaugurated in 2013 (Figure 1-2), the need was recognized for a transition from the policy protection stage to the competitive diffusion of renewables. How to hold down the FIT surcharge growing in line with renewable energy diffusion was viewed as an urgent challenge. The unit surcharge rose from 1.16 euro cents/kWh in 2008 to 3.59 euro cents/kWh in 2012, to 5.28 euro cents/kWh in 2013, and 6.24 euro cents/kWh in 2014 (Figure 1-5). In 2014, the total surcharge reached 23.8 billion euros[43]. Until then, FIT compensation for solar PV power generation was lowered to hold down the surcharge growth. However, this measure failed to prevent the surcharge from rising and left power charges, including the surcharge, to increase year by year.

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[42] For EEG2009 amendment history and the EEG2014, see F. Watanabe, "Enactment of Germany's 2014 Renewable Energy Sources Law," *Foreign Legislation*, *No.262*, December 2014, National Diet Library, pp. 72-109 (渡辺富久子「ドイツにおける 2014 年再生可能エネルギー法の制定」『外国の立法』no. 262、2014. 12、国会図書館、pp. 72−109)

[43] F. Watanabe, "Enactment of Germany's 2014 Renewable Energy Sources Law,"（渡辺「ドイツにおける 2014 年再生可能エネルギー法の制定」), p.76

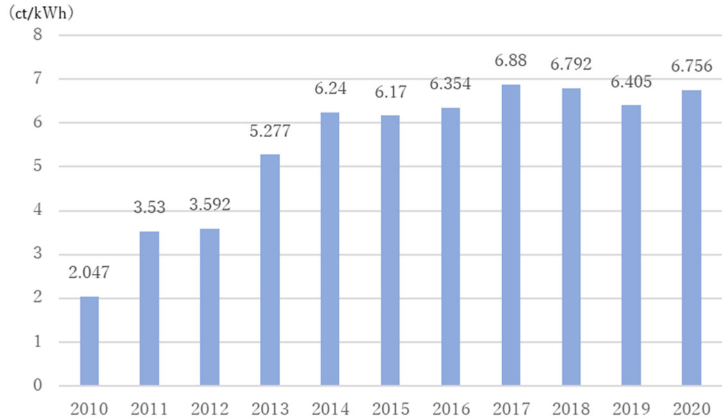

Figure 1-5: German FIT surcharge trends (2010-2020)

Source: Prepared from the German grid operator information platform website (EntwicklungderEEG-Umlage) (https://www.netztransparenz.de/EEG/EEG-Umlagen-Uebersicht)

Furthermore, the European Commission issued the Guidelines on State Aid for Environmental Protection and Energy 2014-2020[44], urging EU members to take relevant national measures[45].

The guidelines indicated conditions and standards for subsidization measures in the energy and environment fields to maintain an adequate competitive environment within the European Union. Whether renewable energy support systems under the German StrEG and EEG would be state subsidies banned under EU law had long been an issue mainly in the European Court of Justice[46]. Under such circumstances, the Guidelines on State Aid for Environmental Protection and Energy positioned support measures for renewable electricity as the adequate policy to achieve renewable energy diffusion targets set by the European Union and its members[47]. They also suggested that renewable electricity should be competitive in the grid between 2020 and 2030, and those existing policies of relieving renewable electricity of responsibilities for balancing power supply with demand be phased out. Then, the guidelines required that new renewable energy diffusion support measures be implemented in or after January 2016 to add a feed-in premium to market prices for renewable power generators selling electricity directly to

44 European Commission, "Communication from the Commission, Guidelines on State Aid for Environmental Protection and Energy 2014-2020 (2014/C 200/01)." The guidelines replaced those in 2008 on state subsidies for environmental protection, covering not only environmental protection but also renewable energy, energy efficiency, cogeneration, carbon capture and storage, and other matters.

45 Kahles, Markus, and Pause, Fabian, "The Influence of European State Aid Law on the Design of Support Schemes for Electricity from Renewable Energy Sources in Germany and Other Member States" in *The European Dimension of Germany's Energy Transition – Opportunities and Conflicts*, ed. Erik Gawel et al. (Springer, 2019) pp.67-82.

46 The position of state subsidies in EU law, regulatory requirements, and an outline of the energy and environment guidelines are based on Central Research Institute of Electric Power Industry, Survey Report on "Trends and Challenges Regarding Renewable Energy Diffusion Policy and Renewables' Integration into Power Market in Europe" (「欧州における再生可能エネルギー普及政策と電力市場統合に関する動向と課題」調査報告): Y15022, May 2016.

47 Approaches on state subsidies for renewable energy support measures are given by EC (2014/C 200/01) 3.3, Aid to energy from renewable sources (107).

the market[48]. They also required that projects for new support measures to be taken in or after January 2017 be subjected to specific, transparent, and non-discriminatory competitive auctions unless the number of power sources subject to these measures is limited or strategic auctions are expected.

1-4-2. Enactment of EEG2014 renewable energy expansion law

In response to the EU guidelines and FIT surcharge growth, Germany established the EEG2014 renewable energy expansion law to amend the EEG2012 in August 2014 substantially[49].

The EEG2014 called for raising renewables' share of total electricity consumption continuously and cost-efficiently to 80% or more by 2050, setting the target share at 40-45% for 2025 and 55-60% for 2035. Under these targets, the EEG2014 cited the integration of renewable electricity into the market and the subsequent promotion of renewable electricity's direct sales in the power market as principles. It attracted attention as a sign that Germany transitioned from a traditional renewable energy policy focusing on FIT compensation provisions to a new one pursuing market transactions in renewable electricity.

Specifically, the EEG2014 subjected 500-kW or smaller renewable power generation facilities launched by December 31, 2015, and 100-kW or smaller ones found on or after January 1, 2016, to FIT compensation and required other facilities to sell electricity in the market directly. It also provided that renewable electricity generators engaging in direct electricity sales in the market would be responsible for balancing supply with demand.

Renewable electricity generators were authorized to claim a market premium from grid operators regarding electricity that was subjected to direct sales in the market, supplied to the market, and purchased by third parties. Market premium amounts were planned to be calculated every month, with a standard amount (euro cent/kWh) set for each renewable energy source for computing market premium and compensation amounts. The standard amount was set to gradually fall in line with a diffusion target for each renewable energy source[50].

The EEG2014 also came up with a policy of transitioning to a system for determining subsidies through auctions by 2017. In response to drops in solar PV and wind power generation costs, it recognized that solar PV and wind power could compete with other non-renewable power sources even without policy support and that competitive auctions should allow compensation amounts to decline. The

[48] However, FIT system support is admitted for less-than-500-kW power generation facilities or demonstration projects, excluding wind power generation facilities subject to 3 MW or 3-unit capacity. See EC (2014/C 200/01), 3.3 Aid to energy from renewable sources (125). For a conceptual diagram of the FIP system, see "Comparative conceptual diagrams of renewable energy support measures" at the end of this paper.

[49] For Details of the EEG2014, see F. Watanabe, "Enactment of Germany's 2014 Renewable Energy Sources Law"（渡辺「ドイツにおける 2014 年再生可能エネルギー法の制定」）pp.81-109

[50] The standard amount was set to fall every year for hydro, geothermal, and offshore wind facilities, every quarter for biomass and onshore wind facilities, and every month for solar PV facilities.

EEG2014 sought to accumulate experiences in which auctions are used for determining compensation amounts for rooftop solar PV power generation projects before auctions are introduced on a full-fledged basis.

In addition to the above-mentioned provisions for integrating renewable electricity into the market and direct sales of renewable electricity in the power market, the EEG2014 included revised provisions for cutting or eliminating the FIT surcharge on large-lot electricity users and private consumers of renewable electricity to hold down surcharge growth[51]. These provisions expanded the scope of those responsible for paying the surcharge to reduce the consumer's surcharge burden.

In this way, the EEG2014 attempted to transition from the traditional FIT system to the Feed-in Premium system to promote direct sales of renewable electricity in the power market and provide the market premium. It also called for introducing auctions, indicating a path to determining compensation levels based on competition principles. The EEG2014 thus demonstrated that Germany transitioned from a protective policy for renewables to a new policy of promoting the integration of renewable electricity into the market under a competitive environment. It represents the base for Germany's current renewable energy promotion policy.

1-5. Auction system introduction (EEG2017)

In line with the EEG2014 policy of testing auctions for onshore solar PV power generation projects, test auctions were conducted in 2015 for 500 MW in capacity, in 2016 for 400 MW, and in 2017 for 300 MW. Successful bids slipped below compensation amounts and average successful bid prices dropped gradually. Based on such results, Germany enacted the EEG2017 in January 2017 to amend the EEG2014 and fully introduce the auction system.

The EEG2017 set the target for renewables' share of total electricity consumption at 40-45% for 2025 and 80% or more for 2050[52], which were the same as EEG2014. It also specified annual new capacity installation targets for wind, solar PV, and biomass power generation. It then provided for the introduction of the auction system and renewable energy diffusion, keeping step with grid development.

Regarding how to design the auction system, the EEG2017 called for giving all actors fair opportunities, conducting highly competitive auctions to minimize renewable energy support costs, and setting auction capacity sizes to prevent installed capacity sizes from exceeding or slipping below the

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[51] The 219 sectors subject to surcharge burden cuts were selected as those that intensively consume electricity and could lose international competitiveness by paying the ordinary surcharge. They are listed in the fourth supplementary provision of the EEG2014. The list corresponds to the Guidelines on State Aid for Environmental Protection and Energy. (F. Watanabe, "Enactment of Germany's 2014 Renewable Energy Sources Law"（渡辺「ドイツにおける 2014 年再生可能エネルギー法の制定」）)

[52] F. Watanabe, "German 2017 Renewable Energy Sources Law," *Foreign Legislation*, January 2017, Research and Legislative Reference Bureau, National Diet Library（渡辺富久子「【ドイツ】2017 年再生可能エネルギー法」『外国の立法』(2017. 1)、国立国会図書館調査及び立法考査局）

EEG2017 targets[53].

Under these policies, new facilities of wind, solar PV, and biomass power generation were subjected to auctions. However, less-than-750-kW wind and solar PV facilities and less-than-150-kW biomass facilities were excluded from auctions with consideration given to administrative costs and small power generators. Other renewable energy facilities, including hydro and geothermal plants, were also excluded from auctions and left subject to support under the FIT or FIP system. Furthermore, under transitional measures, onshore and offshore wind facilities meeting some requirements were excluded from auctions[54]. The auction system is being phased into cost-efficiently diffuse renewable power generation through such trials.

1-6. Analysis of German institutional building processes

This section has reviewed how the German power sector has tried to transition to a system where renewable energy is widespread. Germany launched institutional building for renewable energy diffusion as historical German movements against nuclear power generation gained momentum on the 1986 Chernobyl nuclear plant accident and global warming started to be considered a key policy challenge. Under such a background, political parties shared the view that renewable energy power generation should be promoted to replace nuclear and coal-fired power generation, leading to the enactment of the Federal Electricity Feed Law (StrEG) in 1991.

Germany has promoted renewable energy diffusion on a full scale since the Renewable Energy Sources Law (EEG) was enacted in 2000 to introduce the FIT system and institutionalize a framework for stepping up investment in renewable energy power generation. Under the FIT system, the German government has taken fine-tuned legislative actions in line with renewable energy technology advancement and diffusion, adjusting feed-in tariffs and their gradual reduction rates by renewable energy source, capacity bracket, and year of starting operation.

Since the 2011 Fukushima Daiichi nuclear power plant accident, Germany has accelerated renewable energy diffusion and led the country to reaffirm its nuclear phaseout policy. It has recognized the need to reduce the FIT surcharge and improve renewable electricity's market competitiveness to further diffuse renewable energy, seeking to integrate renewable electricity into the power market. The EEG2012 introduced an option to directly sell renewable electricity to the market and receive a market premium.

A new administration that came into being in 2013 changed the agency in charge of renewable energy and substantially amended the renewable energy law to institutionalize renewable electricity

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[53] Tokio Marine & Nichido Risk Consulting Co. "FY2018 Research Report on Projects Contributing to Rationalizing Energy Use in Emerging Market Economies (Survey on Overseas Renewable Energy Trends) (for release)" March 2019, p. 112（東京海上日動リスクコンサルティング「平成 30 年度新興国におけるエネルギー使用合理化等に資する事業（海外における再生可能エネルギー等動向調査）調査報告書（公表用）」2019 年 3 月、p. 112）

[54] *Ibid*., p.95. Conditions for participation in auctions based on the EEG2017 are detailed in this research report.

integration into the power market explicitly. During this period, the European Commission issued the Guidelines on State Aid for Environmental Protection and Energy 2014-2020, indicating that renewable electricity should be competitive in the grid and that the existing policy of relieving renewable electricity generators of the responsibility for balancing supply with demand should be phased out. To institutionalize such approaches into the domestic policy, the German government came up with integrating renewable electricity into the market and the relevant promotion of direct sales of renewable electricity to the power market. It indicated a turning point from the renewable energy protection policy under the FIT system to a new policy of developing a competitive environment for renewable electricity. Then, Germany fully introduced the FIP system.

As mentioned above, Germany has persistently implemented fine-tuned policies to diffuse renewable electricity in the power sector amid the tremendous energy transition challenge. Germany has frequently amended the renewable energy law during the policy process, specifying long-term renewable energy diffusion targets and conditions for support to each renewable energy source. This resulted in providing business operators and investors with a framework to invest in renewable energy projects confidently. By establishing such a framework from the beginning of institutional building and continuing to make adjustments in response to emerging challenges, Germany has dramatically diffused renewable energy.

Although green political forces have historically been influential in Germany, not only green parties but also multi-party alliances and coalitions have promoted renewable energy policies during the past policy process. Domestic initiatives have been combined with domestic responses to EU directives to lead Germany’s renewable energy policies to transition to a new phase. Backed by domestic and external initiatives, Germany is achieving a transition to a society in which renewable energy is widespread.

2. U.K. institutional building process for renewable energy expansion

How has the United Kingdom attempted to transition to a society where renewable energy has been promoted after historically depending heavily on fossil fuels along with Germany? This section reviews the United Kingdom's power supply and demand trends, tracks its renewable energy expansion policy process from institutional building launched in the 1990s, and analyzes its policies.

2-1. U.K. power supply and demand trends

The United Kingdom has been rich with coal resources and has promoted oil and natural gas development in the North Sea since the 1960s, depending on fossil fuels for most of its energy supply. In the 1990s, however, the country rapidly expanded gas-fired power generation by taking advantage of the North Sea oil field amid power industry deregulation while keeping away from additional investment in coal-fired power generation[55]. Oil and natural gas production peaked in the North Sea in the second half of the 1990s and saw a gradual production decline due to the depletion of resources later. In 2004, the United Kingdom became a net energy importer[56].

As energy choices became complicated in this way, the United Kingdom began to give policy priority to climate change. Coal-fired power plants operating during the 2000s in the country were inefficient subcritical ones that started operation in the 1960s or 1970s. Many of them failed to meet EU environmental standards regarding air pollutants[57]. Feeling a sense of crisis about such a situation, the U.K. government formulated the Climate Change Act in 2008, setting a target of cutting greenhouse gas emissions by 80% from 1990 until 2050. While promoting institutional building for climate change countermeasures, the government positioned nuclear power generation, which had been viewed as one of the promising energy options, as a major energy source contributing to both stable energy supply and climate change countermeasures[58]. It came up with a policy of promoting nuclear power generation in January 2008. Under the policy, nuclear power plants have been maintained as an electricity source covering about 20% of total power generation in the United Kingdom (Figure 2-1).

The U.K. power mix amid such trends indicates that coal's share of total power generation has remarkably changed. The coal share stood at as high as 65% in 1990, peaked at 65.8% in 1991, and plunged to 34.8% in 2001. It roughly remained above 30% until 2014 but has rapidly fallen since the then U.K. energy and climate change minister in November 2015 vowed to close all coal-fired power

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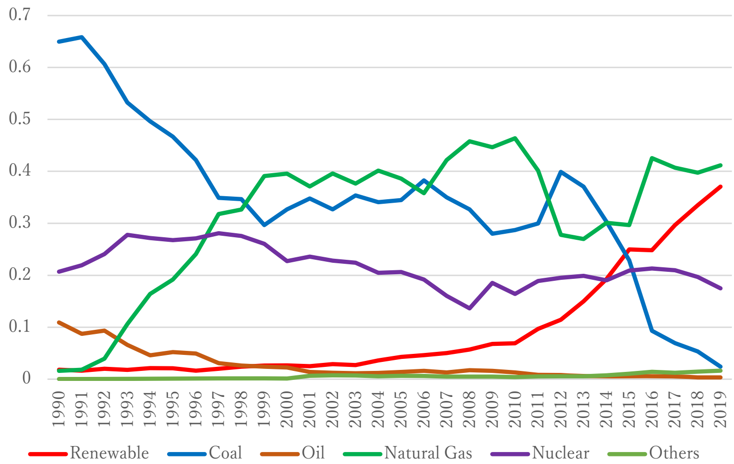
[55] Y. Ito "EU Decarbonization Policy Background and Realities," IEEJ, August 2017
（https://eneken.ieej.or.jp/data/7504.pdf）
（伊藤葉子「EU における"脱炭素"の政策的背景と実情」日本エネルギー経済研究所、2017 年 8 月）
[56] Federation of Electric Power Companies of Japan, "U.K. Energy Policy Trends"
（https://www.fepc.or.jp/library/kaigai/kaigai_jigyo/britain/detail/1231567_4785.html）
（電気事業連合会、「イギリスのエネルギー政策動向」）
[57] Y. Ito "EU Decarbonization Policy Background and Realities," IEEJ, August 2017
（伊藤葉子「EU における"脱炭素"の政策的背景と実情」2017 年）
[58] UK Department of Trade and Industry, "The Energy Challenge: Energy Review Report 2006," July 2006.

plants by 2025[59]. In 2019, the coal share stood at only 2.4%[60]. The United Kingdom was the first major European country to clarify a target for closing all coal-fired power plants, followed by France and Portugal in 2016, by the Netherlands and Italy in 2017, and by Germany in 2020. The U.K. government has indicated the coal phaseout policy and measures to give priority to natural gas-fired power plants, enhance offshore wind power generation, and promote a transition to a smart energy system[61].



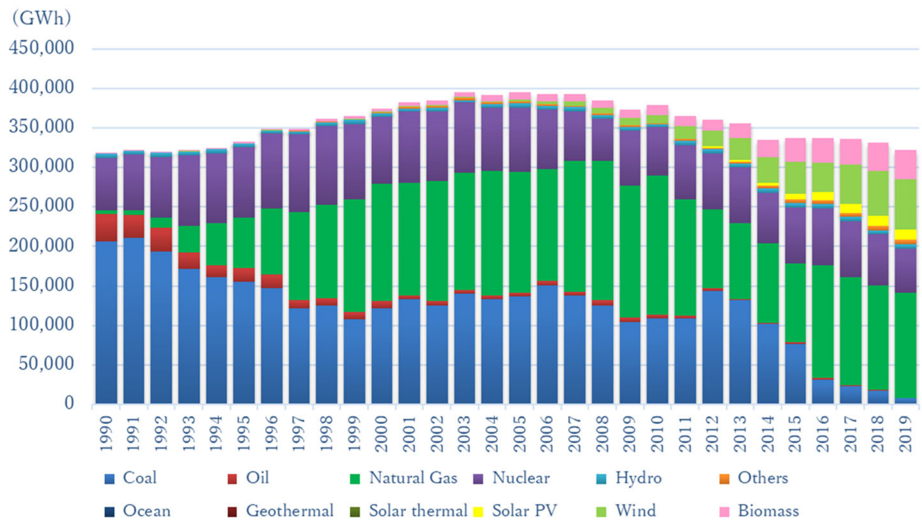


Figure 2-1: (Upper) Each energy source's share of total power generation (%), (Lower) the U.K. power mix trends (GWh)

(Source: Prepared from IEA, "Energy Statistics and Balance 2020")

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[59] GOV.UK, Press release published November 18, 2015, "New Direction for UK energy policy" (https://www/gov.uk/government/news/new-direction-for-uk-energy-policy)

[60] IEA, "World Energy Statistics and Balances 2020" According to the IEA statistics, oil accounted for 0.3% of the U.K. power mix in 2019, natural gas for 41.1%, nuclear for 17.5%, renewable energy for 37.1%, and others for 1.6%.

[61] GOV.UK, Press release published November 18, 2015, "New Direction for UK energy policy"

Renewables' share of total U.K. power generation expanded from only 2.7% in 2000 to 37.1% in 2019 (Figure 2-2). Renewable power generation grew about 12-fold from 9,970 TWh to 119,334 TWh. Notably, wind power generation posted a remarkable increase, boosting its share of renewable power generation from 0.15% in 1990 to 9.5% in 2000 and 53.7% in 2019. The biomass share increased from 10.2% in 1990 to 30.6% in 2019 and the solar PV share from almost zero to 10.6%.

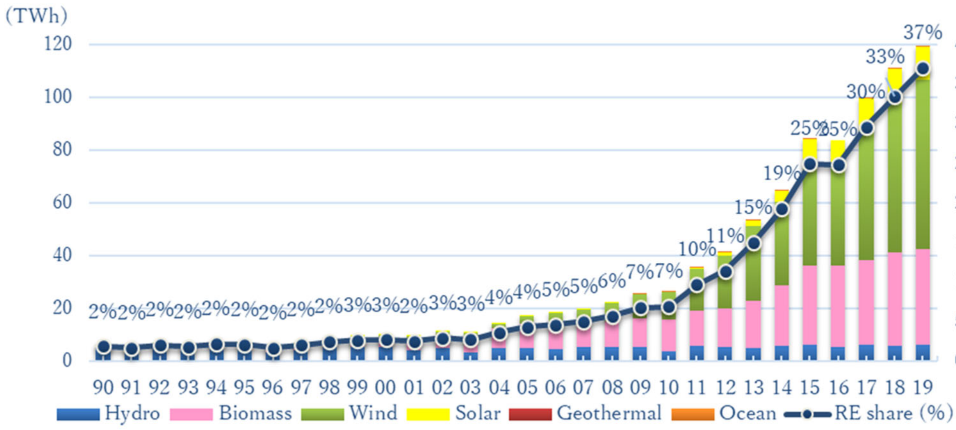

Figure 2-2: Renewables' share of total U.K. power generation (1990-2019)
(Source: Prepared from IEA, "Energy Statistics and Balance 2020")

Based on the above power supply and demand trends, the following analyzes the United Kingdom's policy process to expand renewable energy.

2-2. Renewables Obligation system introduction

2-2-1. Launching institutional building for renewable energy diffusion

The United Kingdom privatized its power sector under the Electricity Act 1989 enacted under the Thatcher administration, completing the power sector's deregulation ahead of any other country in the world. It had driven the global power system deregulation since 1990, giving priority to the realization of a deregulated power market. As U.K. policy priority for climate change increased; however, the country revised its policy and began to think that it should build institutions to provide incentives for investment in renewable energy projects instead of leaving market forces to work fully. It was also required to achieve renewable energy diffusion targets under the EU directive to promote electricity produced from renewable energy sources in the internal electricity market (EU2001 renewable energy directive) formulated by the European Council in 2001.

Then, the United Kingdom launched institutional building for renewable energy diffusion nearly 10 years later than Germany. The Utility Act 2000 was put into force in 2000. It introduced the

Renewables Obligation (RO) system[62] that placed an obligation on power generators to source some proportion of their electricity from renewable sources. In April 2002, the Renewables Obligation Order [Statutory Instrument 2002 No.914] was issued to clarify and fully implement the system.

The "Energy White Paper: Our energy future -- Creating a low carbon economy" published in February 2003 set out the following four targets[63]. First, carbon dioxide emissions should be cut by 60% from 1990 by 2050 to contribute to climate change countermeasures. Second, energy supply stability should be maintained in preparation for the depletion of domestic resources. Third, domestic and overseas competitive markets should be promoted to sustain economic growth and improve productivity. Fourth, sufficient heating should be secured for all households at fair prices.

Renewables were expected to play a vital role in accomplishing these targets. For example, the white paper noted that renewables should cover 30-40% of total power generation by 2050 to achieve the first target[64].

In January 2000, the U.K. government announced a target of increasing renewables' share of total power generation to 10% by 2010. This target was imposed on the United Kingdom under the EU2001 renewable energy directive[65]. Then, the United Kingdom featured a lower renewable energy diffusion rate than other major European countries. According to the white paper, renewables, excluding large-capacity hydro and waste-fired power plants, accounted for only 1.3% of total power generation in the United Kingdom in 2000, against 16.7% in Denmark, 4% in the Netherlands, 3.2% in Germany, and 3.4% in Spain[66]. The United Kingdom was required to install about 10,000 MW in new renewable power generation capacity by 2010 to accomplish the renewable share target for the year[67]. Then, the RO system was introduced to accelerate renewable energy diffusion.

2-2-2. RO system

The RO system obliges electricity suppliers to source a proportion of electricity sales from renewable sources at prices that would not be too burdensome for consumers[68]. Electricity suppliers

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[62] The Renewables Obligation was introduced to replace the Non-fossil Fuel Obligations (NFFO) provided in Article 32 of the Electricity Act 1989. The NFFO system obliged public electricity suppliers to purchase electricity from renewable power generators and sell renewable electricity at fixed prices under 15-year contracts (Ofgem (Office of Gas and Electricity Markets), "The Renewables Obligation: Ofgem's first annual report," February 2004, p.8). This system was initially designed to diffuse renewables. Later, however, it was interpreted as a financial system to maintain nuclear power generation (H. Nagayama, "U.K. Renewable Energy Policy," p.110; K. Ueda & K. Yamaka, "International Comparison of Renewable Energy Policies," Kyoto University Press, 2017) （長山浩章「イギリスの再生可能エネルギー政策」p. 110、植田和弘、山家公雄編『再生可能エネルギー政策の国際比較』京都大学学術出版社、2017 年）

[63] U.K. Department of Trade and Industry, "Energy White Paper: Our energy future -- Creating a low carbon economy" CM5761, February 24, 2003.

[64] *Ibid*., p.44.

[65] Country-by-country targets were specified in Directive (2001/77/EC), *op.cit*., Annex. The target for Germany was 12.5% as mentioned above.

[66] Department of Trade and Industry, "Energy White Paper: Our energy future -- Creating a low carbon economy", *op.cit*., p.45.

[67] *Ibid.*

[68] New & Renewable Energy Group, New Energies & International Cooperation Unit, Institute of Energy Economics,

receive annual RO orders, or renewable electricity sales quotas, from the government at least six months before every business year starts[69]. Accredited renewable electricity generators report power generation volume to the Office of Gas and Electricity Markets (Ofgem) every month and acquire relevant Renewables Obligation Certificates (ROCs). Ofgem administers the RO system by issuing ROCs and accrediting generating stations capable of generating electricity from eligible renewable energy sources, monitoring compliance with RO orders' requirements, and calculating and receiving the buy-out price[70].

Electricity suppliers are required to purchase ROCs amounting to renewable electricity sales quotas and pass ROC purchasing costs on to electricity charges. In this way, renewable electricity generators can sell electricity at higher prices than wholesale electricity prices by selling ROCs issued by Ofgem to electricity suppliers. Renewable electricity generators have an incentive to receive a premium on wholesale electricity prices. Electricity suppliers can demonstrate their compliance with their sales obligations by presenting ROCs to Ofgem[71].

If electricity suppliers fail to procure sufficient ROCs, they are deemed to have met their obligations by paying about 33 pounds per 1,000 kWh shortfall as the buy-out price to Ofgem. Buy-out price payments are used for Ofgem operation. Surplus payments are paid back to electricity suppliers according to how many ROCs they have presented[72].

Renewables subject to the RO system are solar PV, wind, tidal energy, geothermal energy, biomass, hydro, waste, landfill gas, and sewerage gas. When the RO system was initiated, a ROC per 1 MWh was issued for all renewables. Under a statutory instrument implemented in April 2009, more ROCs were issued for priority renewables than for others under banding.

In 2009, for example, the number of ROCs per MWh was raised to two for offshore wind, solar PV, tidal, and wave energy power generators, while being unchanged at one for onshore wind and fossil/biomass mix generators[73]. From 2013 to 2015, the number was left unchanged at two for offshore wind generators but cut to 0.9 for onshore wind generators and 1.7 for solar PV plants[74]. In this way, priority was given to technologies under development or critical areas, with aid levels diversified.

Japan, “U.K.: Accelerating CfD introduction to hold down renewable subsidy growth” January 2016（日本エネルギー経済研究所 新エネルギー・国際協力支援ユニット 新エネルギーグループ「英国：CFD 制度の導入時期を早め、再エネ補助金増大の抑制を図る」2016 年 1 月 （https://eneken.ieej.or.jp/data/6528.pdf））

[69] The RO system is described based on the Policy Paper by the U.K. Department of Energy & Climate Change; the Annual Report by Ofgem; and M. Yamaguchi “U.K. Power Market Reform and Implications for Japan’s Renewable Energy Policy” July 28, 2014, a study published at the Society for Environmental Economics and Policy Studies in 2014 (山口光恒「イギリスの電力市場改革と日本の再エネ政策への示唆」2014 年 7 月 28 日、2014 年環境経済政策学会発表論文)

[70] Ofgem, “Guidance for generators that receive or would like to receive support under the Renewables Obligation (RO) system,” April 2019.

[71] Department of Energy & Climate Change (DECC), “Policy Paper: 2010 to 2015 government policy: low carbon technologies” updated May 8, 2015.

[72] Ofgem website (https://www.ofgem.gov.uk/environmental-programmes/ro/about-ro)

[73] DECC, “UK Renewable Energy Roadmap Update 2013,” November 2013, p.30.

[74] *Ibid.*

Under the RO system, renewable power generation increased year by year. Notably, wind power generation posted remarkable growth. From 534 MW in 2002 when the RO system was launched, cumulative installed wind power generation capacity soared to 933 MW in 2004 and 5,421 MW in 2010, increasing more than 10-fold under the RO system[75] (Figure 2-3). Remarkably, cumulative installed offshore wind capacity expanded dramatically from 4 MW in 2002 to 1,342 MW in 2010[76].

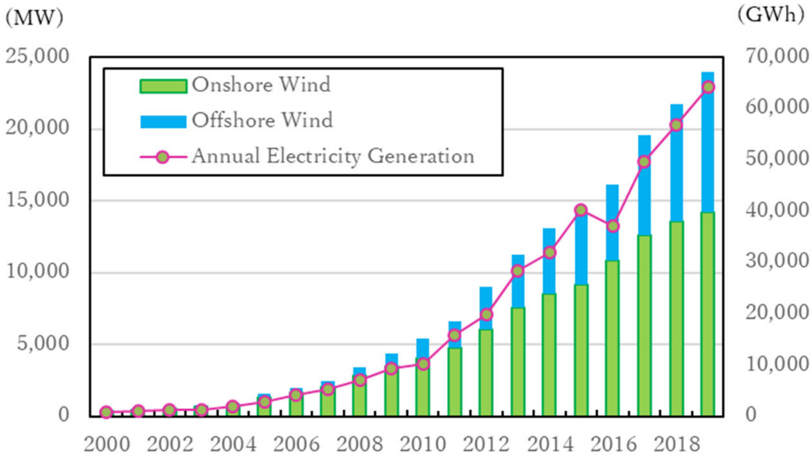

Figure 2-3: the U.K. installed wind power generation capacity trends (Left scale for cumulative installed capacity and the right scale for annual power generation)
(Sources: Prepared from IRENA, "Renewable Energy Statistics 2020," and IEA, "World Energy Statistics and Balances 2020"

2-2-3. Phasing out the RO system

In 2011, renewable electricity's share of total electricity supply in the United Kingdom reached 10% for the first time, with renewable power generation totaling 35 TWh. This meant that the country achieved a target announced in January 2000, one year behind schedule. In this way, the RO system to take advantage of RO orders for promoting renewables brought about some achievement in the United Kingdom.

Given that ROCs tradable under the RO system were left to be priced through negotiations between electricity suppliers and renewable power generators and according to the changing supply-demand balance, it was difficult for renewable power generators to make future business plans. Particularly, RO system procedures were cumbersome for small-capacity power generators, preventing small-capacity facilities from spreading. Furthermore, the United Kingdom lacked fine-tuned support measures for each renewable technology, as seen in Germany[77]. Due to these problems, the U.K.

[75] Data from IRENA, "Renewable Energy Statistics 2020"
[76] *Ibid.*
[77] M. Yamaguchi "U.K. Power Market Reform and Implications for Japan's Renewable Energy Policy" July 28, 2014, a study published at the Society for Environmental Economics and Policy Studies in 2014 (山口光恒「イギリスの電力市場改革と日本の再エネ政策への示唆」） p.13

government decided to exclude new renewable power generation facilities built on or after March 31, 2017, from the RO system while leaving the existing facilities subjected to the system until 2037[78].

While the problems forced the RO system to be phased out, the United Kingdom was required to introduce additional measures to increase renewables' share of final energy consumption from less than 2% in 2009 to 15% by 2020 under the EU2009 renewable energy directive[79]. Then, it introduced the FIT system as a new renewable energy promotion measure.

2-3. FIT system introduction

2-3-1. Discussions towards FIT system introduction

Before introducing the Feed-in Tariff (FIT) system, the then Labor administration created the Renewables Advisory Board and implemented a consultation on a renewable energy strategy to verify the direction of renewable energy diffusion. In June 2008, the Renewables Advisory Board published a policy recommendation paper titled "2020 Vision – How the U.K. can meet its target of 15% renewable energy," indicating that renewable energy's share of final energy consumption would be limited to around 6% until 2020 in a reference scenario, although the Renewables Obligation (RO) system contributed to diffusing renewables[80]. The paper recommended that the United Kingdom place renewable energy diffusion initiatives at the heart of its energy policy and promote innovative economic, policy, and social initiatives as a drive to achieve the target of 15% renewable energy. It then called for introducing a financial aid measure to allow investors to become confident that the renewable energy market would support new renewable energy investment. A report titled "Consultation on the Renewable Energy Strategy," released in June 2008 after such consultation, pointed out the significance of grid network enhancement and new renewable energy technology development and the need for positive support for small-scale renewable power generators[81].

2-3-2. Launching the FIT system

Based on such discussions, the United Kingdom decided to introduce the FIT system under the Energy Act 2008 in November 2008. The system was put into operation under an April 2010 statutory instrument (No. 678). Under the title "Feed-in tariffs for small-scale generation of electricity," Section 41, Chapter 32 of the Energy Act 2008 empowers the Secretary of State (for energy and climate change) to establish and operate a system of financial incentives to encourage a small-scale low-carbon generation

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[78] DECC, "Digest United Kingdom Energy Statistics 2019," Chapter 6 Renewable sources of energy, p.125.
[79] Directive (2009/28/EC) *op.cit.*
[80] Renewables Advisory Board, "2020 VISION-How the UK can meet its target of 15% renewable energy," June 2008, p.3.
[81] Regarding the consultation on a renewable energy strategy, I referred to a relevant document released in June 2008 by the Department of Energy and Climate Change under the then Labor administration. (https://www.gov.uk/government/consultations/progressing-our-renewable-energy-strategy)

of electricity[82]. Subjected to the FIT system under the Energy Act from April 2010 were 50 kW or smaller generators powered by solar PV, wind, anaerobic digestion (A.D.) gas, hydro, and micro combined heat and power (CHP), or 50 kW to 5 M.W. generators launched on or after July 15, 2019[83].

The U.K. FIT system is designed for licensed electricity suppliers to purchase electricity from small-scale renewable electricity generators at fixed tariffs. Under the system, renewable electricity generators receive generation tariff payments for every kWh generated and export tariff payments for surplus electricity sold[84]. This means that renewable electricity generators can receive payments at fixed tariffs according to total power generation even if they consume electricity on their own without selling it to the grid and can sell surplus electricity at guaranteed tariffs. Small-scale private electricity generators can receive generation and export tariffs and benefit from bill savings by consuming electricity they generate to cut electricity purchases[85].

Generation tariffs are finely fixed by capacity and year of starting operation for each renewable energy technology[86]. Generation tariffs are indexed to the Retail Price Index and revised annually in principle[87]. Tariffs are fixed at levels expected to achieve a return of 5-8% on the investment for facilities in desirable locations[88]. Renewable electricity generators can choose to sell electricity at guaranteed export tariffs or market prices. As well as generation tariffs, export tariffs are indexed to the Retail Price Index and adjusted annually[89].

2-3-1. Adjustments under the FIT system

When the FIT system was introduced, the government indicated a policy of keeping generation tariffs unchanged until 2013 before revising them every five years. In less than one year after the introduction, however, it came up with a plan to revise them[90]. This was because far-more-than-expected facilities, especially solar PV generators, were registered for the FIT system, with their power generation exceeding predicted levels. Furthermore, large-scale solar PV power generation with 0.25-5.0 MW

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[82] The Energy Act 2008 provides for renewable energy diffusion and carbon capture and storage methods and how to decommission nuclear, renewable energy, and other power plants. Regarding details of the act, see U.K. government's legislation information site (http://www.legislation.gov.uk/ukpga/2008/32/part/2.)
[83] Ofgem website (https://www.ofgem.gov.uk/environmental-programmes/fit/about-fit-system/) Generators with 50 kW or smaller capacity were excluded from the RO system and covered by the FIT system. Generators with capacity between 50 kW and 5 MW were allowed to choose to remain subject to the RO system or transition to the FIT system. Generators with capacity of more than 5 MW remained subject to the RO system.
[84] DECC, "Digest United Kingdom Energy Statistics 2019", *op.cit.*, p.125.
[85] Electricity generators are required to install electricity meters for receiving support for their own consumption in principle and pay for the installation.
[86] Details of tariffs from April 2010 are available on Ofgem's website (https://www.ofgem.gov.uk/environmental-programmes/fit/fit-tariff-rates/).
[87] *Ibid.* Tariffs from April 1, 2020, to March 31, 2021, were revised on March 31, 2020.
[88] DECC, "Feed in Tariffs: Government's Response to the Summer 2009 Consultation," February 2010, p.6.
[89] Details of tariffs are available on Ofgem's website (https://www.ofgem.gov.uk/environmental-programmes/fit/fit-tariff-rates/).
[90] DECC, "Feed-in Tariffs System: Summary of Responses to the Fast-Track Consultation and Government Response," June 9, 2011.

generators increased faster than predicted[91]. The rapid increase in large-scale solar PV generation prompted the FIT budget to be spent fast and threatened to exert pressure on budget spending on other renewables[92]. The results did not necessarily meet the FIT system's objective of diffusing small-scale renewable electricity generation. In August 2011, the government substantially revised generation tariffs for 50 kW or larger solar PV generators and biomass (A.D.) facilities to improve cost efficiency[93]. Even since the revision, however, generation tariffs and capacity brackets have been revised several times per year.

In this way, solar PV, which had failed to diffuse under the RO system, rapidly spread after the FIT system introduction thanks to prompt adjustments responding to progress in the diffusion under the system (Figure 2-4). Cumulative installed solar PV capacity was limited to 4 MW in 2002 when the RO system was introduced, to 8 MW in 2004, and 95 MW in 2010. After the FIT system introduction, however, such capacity expanded more than 10-fold during 2011[94] and continued robust expansion later.

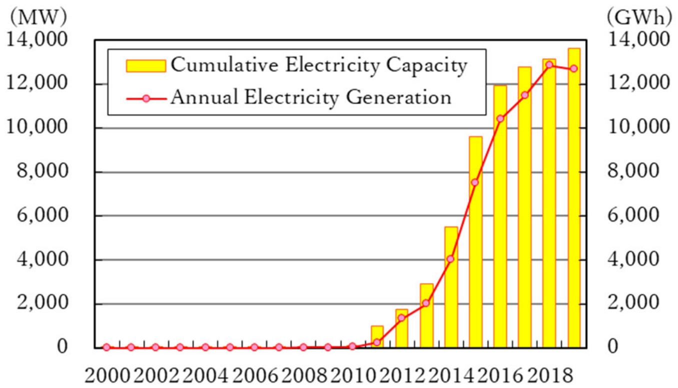

Figure 2-4: the U.K. solar PV capacity trends (left scale for cumulative installed capacity, right scale for annual power generation)

(Sources: Prepared from IRENA, "Renewable Energy Statistics 2020" and IEA, "World Energy Statistics and Balances 2020"

2-4. FIT-CfD system introduction

2-4-1. Electricity market reform

As mentioned above, the FIT system launched in 2010 accelerated renewable energy diffusion in the United Kingdom by promoting solar PV generation that had failed to grow under the RO system. However, the U.K. government recognized that more innovative measures would be required to further

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[91] *Ibid.*, p.5.
[92] *Ibid.*
[93] *Ibid.*, p.6. The generation tariff was substantially lowered to 19.0 pounds/kWh for 50-150 kW facilities, 15.0 pounds/kWh for 150-250 kW facilities, and 8.5 pounds/kWh for 0.25-5.0 MW facilities and ground installed ones.
[94] Cumulative installed capacity data are from IRENA, "Renewable Energy Statistics 2020."

push climate change countermeasures as a policy priority and achieve a target of increasing renewables' share of final energy consumption to 15% by 2020 under the EU renewable energy directive.

In July 2011, Chris Huhne, the then secretary of state for energy and climate change, presented the Parliament with a policy paper titled "Planning our electric future: A white paper for secure, affordable and low-carbon electricity[95]." According to the paper, 20 GW or a quarter of total installed power generation capacity was planned to be retired due to aging and other problems within 10 years, requiring the country to urgently take measures to secure a stable power supply[96]. Then, there was a target of cutting carbon dioxide emissions by 80% from 1990 until 2050. It was recognized that the power sector would have to dramatically promote decarbonization by 2030[97]. Furthermore, total U.K. power demand was expected to double by 2050, with prices rising, as the transport and heat sectors are electrified further.

Following consultation in December 2010, the policy paper came up with an electricity market reform to address the situation. The U.K. government recognized that new low-carbon generators often had to overcome relatively high barriers to market entry and that market illiquidity made it more difficult for a low-carbon generation to compete with fossil fuels and impeded market access[98]. It was estimated that up to 110 billion pounds would have to be invested in electricity generation and transmission by 2020 to simultaneously achieve the low-carbon economy and stable electricity supply objectives[99]. The government acknowledged that the electricity market would have to be reformed to attract the necessary investment and cost-effectively achieve the objectives.

Under the recognition, the primary objectives of the electricity market reform were (1) to ensure the future security of electricity supply, (2) to drive the decarbonization of electricity generation, and (3) to minimize costs to the consumer. The government set out four measures to realize these objectives[100]. The first measure called for "long-term contracts for both low-carbon energy and capacity, the second for institutional arrangements to support this contracting approach, the third for continued grandfathering, supporting the principle of no retrospective change to low-carbon policy incentives, within a clear and rational planning cycle, and the fourth for ensuring a liquid market that allows existing energy companies and new entrants to compete on fair terms". These measures were designed to form a market environment to secure long-term business predictability and attract proactive investment in low-carbon projects.

2-4-2. Discussions on FIP and FIT-CfD systems

For the first measure for the electricity market reform, the policy paper proposed the Feed-in

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[95] DECC, "Planning our electric future: a white paper for secure, affordable and low-carbon electricity," July 2011.
[96] *Ibid.* pp.5-6.
[97] *Ibid.*
[98] *Ibid.*
[99] *Ibid.*
[100] For the four measures, see *Ibid.*, p.7.

Tariffs with Contracts for Difference (FIT-CfD) system. The system was one of the key issues in the December 2010 consultation. At issue was whether the FIT-CfD system or the FIP system should be introduced[101]. As the FIP system was similar to the RO system in that electricity generators would receive some payments in addition to electricity sales income from the electricity wholesale market, renewable electricity generators supported the FIP system that they saw as understandable for investors and suitable for smooth implementation. Meanwhile, the FIT-CfD system was widely viewed as a framework to cost-efficiently promote the low-carbon generation, despite concern that the system would be too complex to implement.

After hearing such opinions from various stakeholders, the U.K. government concluded that the FIT-CfD system was more desirable. The FIT-CfD system was viewed as more suitable for minimizing electricity price fluctuation risks over the long term and promoting investment in low-carbon electricity sources. The system was packaged with (1) the capacity market, (2) the carbon price floor, and (3) the emissions performance standard to cost-effectively achieve a low-carbon society and stable electricity supply. Renewable energy diffusion for a low-carbon economy would naturally increase intermittent power sources vulnerable to weather changes, threatening to destabilize the power supply. To address this problem, the U.K. government combined renewable energy diffusion measures with the effective utilization of highly adjustable fossil-fired power generation. Simultaneously, as the capacity to cover supply shortages was secured through the capacity market, the emission performance standard per installed capacity and the carbon price floor was set for new fossil-fired power plants to promote low-carbon electricity.

2-4-3. Parliamentary discussions on the FIT-CfD system

Edward Davey, appointed as the new secretary of state for energy and climate change in February 2012, announced a draft energy bill[102] taking over the institutional design in May 2012. The draft bill was considered by a group of lawmakers from the House of Commons Energy and Climate Change Committee and the House of Lords.

Regarding the FIT-CfD system, one of the key issues was what kind of scheme should be used to execute payments between electricity generators and suppliers to contribute to forming an investment environment that would be stable over the long term[103]. The Department of Energy and Climate Change

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[101] For discussions on the CfD and FIP systems in the consultation, see *Ibid*, pp.17-22. For a conceptual diagram of the FIT-CfD system, see "Comparative conceptual diagrams of renewable energy support measures" at the end of this paper.

[102] "Draft Energy Bill," Presented to Parliament by the Secretary of State for Energy and Climate Change by Command of Her Majesty, May 2012, CM8362. When the draft bill was announced, the Department of Energy and Climate Change released a policy paper titled "Electricity market reform: policy overview," detailing the draft institutional design. (https://www.gov.uk/government/publications/electricity-market-reform-policy-overview)

[103] Minutes of deliberations on the Draft Energy Bill at the House of Commons Energy and Climate Change Committee are available at the U.K. Parliamentary Archives. For deliberations on the CfD, see "Draft Energy Bill: Pre-legislative Scrutiny- Energy and Climate Change Contents, 3. Contracts for Difference" (https://publications.parliament.uk/pa/cm201213/cmselect/cmenergy/275/27506.htm) in the Archives

(DECC) proposed a scheme called the "Multiparty Payment" model. The model, inspired by the existing imbalance system, called for assigning Elexon, a National Grid subsidiary that served as a Balancing and Settlement Code Company (BSCCo) and accumulated experiences with calculating and settling imbalance costs, to undertake FIT-CfD payment services[104]. The model assumed that Elexon would mediate interactive payments under the individual contracts for the difference between electricity generators and suppliers. DECC thought that combining regular payment to electricity generators with suppliers' establishment of collateral to hold down default risks would be effective for minimizing the credit risk, or the risk that contractors could fail to collect credits due to their trading partners' financial deterioration. It is believed that Elexon, well versed in complex computation and settlement services, should be used for realizing the model.

The House of Commons Energy and Climate Change Committee criticized that the DECC-proposed Multiparty Payment model would hold electricity suppliers finally responsible for payments and fail to eliminate credit risk concerns or form a solid base for investment[105]. Then, it proposed the Alternative (central, single) Counterparty model[106].

The alternative model called for creating a credible CfD Counterparty Body that alone would conclude contracts for difference with electricity generators. Under the model, the CfD Counterparty Body would undertake electricity suppliers' payments to electricity generators and clearing services and be controlled by the government and National Grid. It attempted to develop an environment in which electricity generators would conclude contracts only with the government-backed body to eliminate credit risks taken by electricity generators and attract investment at lower finance costs.

The House of Commons Energy and Climate Change Committee strongly recommended the government to adopt the Alternative (central, single) Counterparty Model, while noting that whether the model could unduly work to the disadvantage of small electricity suppliers should be sufficiently considered.

2-4-4. U.K. government response to the parliamentary proposal

In response to the parliamentary proposal, DECC discussed FIT-CfD designs, including the Multiparty Payment model and the Alternative (central, single) Counterparty model, with relevant actors such as grid operators and electricity generators[107]. In November 2012, it adopted the Alternative (central, single) Counterparty model for payments and a limited company owned by the government as the CfD

(https://publications.parliament.uk/pa/cm201213/cmselect/cmenergy/275/27502.htm).

[104] For the DECC-proposed model, see DECC, "Electricity market reform: policy overview, Annex B, Feed-in tariff with contracts for difference: draft proposal framework," May 2012, p.68-72.

[105] See "Draft Energy Bill: Pre-legislative Scrutiny- Energy and Climate Change Contents, 3. Contracts for Difference" in the abovementioned U.K. Parliamentary Archives.

[106] For details of the Alternative (central, single) Counterparty Model, see "Draft Energy Bill: Pre-legislative Scrutiny- Energy and Climate Change Contents, 3. Contracts for Difference" in the abovementioned U.K. Parliamentary Archives.

[107] DECC, "Electricity Market Reform (EMR): Alternative Payment Model for Contract for Difference" (undated).

Counterparty Body[108]. In this way, DECC developed a FIT-CfD framework in which low-carbon electricity generators would conclude contracts for difference with the government-backed CfD Counterparty Body that would mediate payments between electricity generators and suppliers. DECC then believed that the FIT-CfD system would be operated through transparent procedures to win investors' confidence in the system and vitalize investment in low-carbon electricity generation projects[109]. To realize highly transparent procedures, it defined the roles of and relations between the government, the National Grid, and the CfD Counterparty Body[110].

2-4-5. FIT-CfD system

Under the Energy Act 2013, the U.K. government decided to implement the FIT-CfD system designed in this way. The act authorized the secretary of state for energy and climate change to make regulations about contracts for differences to be concluded between low-carbon electricity generators and the CfD Counterparty Body[111]. Based on the act, the secretary of state has set up regulations concerning the FIT-CfD system, designated the CfD Counterparty Body, and formulated CfD application and quota allocation procedures since 2014[112]. In this process, fine-tuned operational adjustments based on realities have been made, including slight revisions to CfD management procedures and a temporary suspension on CfD payments for a period in which electricity sale prices are negative.

Under the FIT-CfD system, renewable electricity generators provide National Grid with information such as project outlines, construction approvals, and operation start dates in the initial phase of their respective projects before concluding contracts for difference, under which they would be given strike prices over 15 years. Under CfD contracts, renewable electricity generators would receive the strike price's excess over a reference price[113] calculated by the average wholesale electricity price or pay the difference in case the reference price exceeds the strike price. The system allows electricity generators to hedge spot price fluctuation risks.

The Electricity Market Reform Delivery Plan released in December 2013 stated that there was a set of factors to consider in setting the strike price, covering technology-specific factors such as capital, operating, and financing costs; market conditions such as wholesale prices; and policy considerations[114]. The plan also published the strike prices by energy source and by operation start year for facilities starting

108 DECC, "Electricity Market Reform: policy overview," November 2012, p.17.
109 *Ibid*., p.21.
110 *Ibid*., pp.21-22.
111 Legislation.gov.uk,"Energy Act 2013" (https://www.legislation.gov.uk/ukpga/2013/32/part/2/chapter/2/enacted)
112 There are numerous regulations including the Contract for Difference (Counterparty Designation) Order 2014 and the Contract for Difference (Definition of Eligible Generator) Order 2014. They are available in the above-cited Legislation.gov.uk archive.
113 The reference price for intermittent renewable electricity sources is based on the wholesale electricity price for each time zone on the day-ahead market and that for baseload electricity sources on the average price set for each season on the futures market (see the above-cited Tokio Marine & Nichido Risk Consulting Co. 2019, p.181)
114 DECC, Policy Paper "Electricity Market Reform Delivery Plan" published December 19, 2013 (https://www.gov.uk/government/publications/electricity-market-reform-delivery-plan)

operation between 2014/15 and 2018/19[115]. The first auctions regarding the strike prices took place in February 2015, resulting in successful bid prices that slipped below the government-set strike prices for solar PV, onshore wind, and offshore wind power generation facilities[116].

Auction results have been steadily accumulated, with successful bid projects registered in the CFD Register managed by Low Carbon Contracts Company[117]. The register specifies project names, project operator names, technology types, contract types, and current strike prices. Under the current U.K. system, auctions have been used to promote renewables at as competitive prices as possible. Information on successful bid projects disclosed timely, indicating that the system has been managed in a highly transparent manner.

2-5. Analysis of U.K. institutional building processes

This section has reviewed how the U.K. power sector has tried to transition to a system where renewable energy is widespread. As well as Germany, the United Kingdom historically featured the dominant presence of fossil fuels. However, the U.K. government prioritized climate change countermeasures alongside stable energy supply, while it became more complex for the country to make energy choices facing the decline of oil and natural gas reserves and outdated inefficient coal-fired power plants from the second half of the 1990s. In breaking away from the economy dependent on fossil fuels, the government first focused on institutional building to diffuse renewable energy. As nuclear power generation was more accepted in the United Kingdom than in Germany, the U.K. government also gave priority to nuclear power generation as one of the low-carbonization initiatives.

Characteristically, the United Kingdom has tried to take advantage of market forces to cost-efficiently diffuse renewable energy from the initial stage of institutional building. Under the RO system introduced in 2002, renewable electricity generators and electricity suppliers traded unpriced ROCs to determine prices. When it was recognized that aid levels should be diversified to support specific renewable technologies under development, the numbers of ROCs per power generation were increased for these renewable technologies, setting a priority order of renewables. Under some government guidelines, the United Kingdom has persistently maintained pricing mechanisms that exploit market forces as much as possible.

Given that the RO system made it difficult for electricity generators to make future business plans and failed to promote the spread of small-capacity renewable power sources because of cumbersome procedures for small-scale electricity generators, the U.K. government introduced the FIT

115 *Ibid.*
116 Institute of Energy Economics, Japan, "U.K.: First auction results under the CfD system" March 2015
(日本エネルギー経済研究所「英国：CfD 制度による第一回オークション結果が発表」2015 年 3 月（https://eneken.ieej.or.jp/data/5995.pdf)
117 CFD Register (https://www.lowcarboncontracts.uk/cfds)

system for small-scale electricity generators in 2010. Under the system, renewables steadily diffused thanks to quick adjustments responding to diffusion trends.

When it was recognized that an innovative reform would be required to achieve the target of increasing renewables' share of final energy consumption to 15% by 2020 under an EU directive, the U.K. government set out a bold electricity market reform. The government took leadership in the reform process, including consultations and a parliamentary debate over whether the FIT-CfD or FIP system should be introduced. Consequently, it decided to introduce the FIT-CfD system as a framework to cost-efficiently promote low-carbon electricity sources. Auctions have been conducted to determine strike prices under the system, indicating the U.K. attitude of taking advantage of market forces as much as possible to cost-efficiently diffuse renewables.

While giving priority to realizing a free market historically, the United Kingdom has made flexible policy adjustments in the process to diffuse renewables. Instead of depending entirely on market forces, the country has persistently pursued how best to cost-efficiently realize an environment offering long-term investment prospects to provide incentives for promoting investment in renewable energy projects. In introducing the FIT-CfD system, it considered the efficient utilization of fossil-fired power generation and adopted a policy of achieving both a low-carbon economy and stable electricity supply. Though launching institutional building for renewable energy diffusion nearly 10 years later than Germany, the United Kingdom has established a system where renewables have been diffusing under the long-held culture of taking advantage of market forces as much as possible.

Conclusion and implications for Japan

1. Implications from German and U.K. policy processes

This paper analyzed how Germany and the United Kingdom diffused renewable energy in the power sector from the viewpoint of institutional building. The following discusses interesting points of their policy processes and their implications.

(1) Impacts of other primary energy sources and priority policy agenda

First, renewable energy policies have received impacts from other major energy sources such as coal and nuclear in both countries. Germany launched institutional building for diffusing renewables in place of nuclear and coal as anti-nuclear movements gained momentum on the 1986 Chernobyl nuclear power plant accident and global warming was increasingly viewed as a severe challenge. When the Fukushima Daiichi nuclear plant accident occurred in 2011, Germany quickly reversed its decision in the previous year to extend the operating life for nuclear power plants, restored an earlier plan to phase out nuclear power generation by 2022, and launched revisions to its renewable energy law to accelerate renewable energy diffusion.

Meanwhile, the United Kingdom has positioned nuclear as an energy source contributing to both stable energy supply and climate change countermeasures and maintained a nuclear promotion policy. Simultaneously, however, it has gradually reduced coal’s share of power generation, becoming the first major European country to announce a target for closing all coal-fired power plants. Behind the coal phaseout policy, climate change countermeasures became a priority policy challenge for the country. Thus, it has promoted policies to diffuse renewables as an energy source to play a vital role in breaking away from the economic dependence on fossil fuels.

In this way, renewable energy policies have been positioned in relation to other primary energy sources and relevant industrial policies in each country. The priority policy agenda including climate change countermeasures and energy security, greatly impacts renewable energy policy promotion, indicating that it is important to assess such policy agenda accurately.

(2) Offering long-term targets

Second, it is remarkable that both countries have continued efforts to set specific long-term targets and national visions for renewable energy diffusion. They have come up with some such targets under the EU directive umbrella and others independent from the umbrella. Both countries have offered long-term targets for 2050 since the second half of the 2010s, taking steps towards a renewable energy society.

By offering long-term targets, governments can encourage enterprises, investors, financial institutions, research institutes, and other various actors to develop bold strategies and new technologies while sharing long-term prospects. This would help any country enhance its competitiveness in the fields, such as storage batteries, hydrogen development, and next-generation renewable energy technologies, in which initiatives beyond existing frameworks or ideas would be required. It would also help invigorate domestic markets and industries and increase chances to take leadership in international cooperation towards decarbonization.

(3) Institutional adjustments

Third, it is noteworthy that institutional building for renewable energy diffusion included continuous adjustments to cope with challenges arising after the introduction of original institutions. Both countries introduced a system that obliged electricity suppliers to adopt renewable electricity as a certain portion of electricity sales. When it was recognized that such a system failed to secure the predictability of business for renewable electricity generators, the two countries introduced the FIT system that employed feed-in-tariff compensation to allow renewable electricity generators to predict their future cash flow. When the need was recognized for reducing costs for the FIT system and integrating renewable electricity into the power market, Germany transitioned to the FIP system and the United Kingdom to the CfD system. Both systems are designed for renewable electricity generators to hedge risks regarding electricity wholesale price fluctuations, securing investment incentives and future business predictability.

In this way, both countries have taken over the helm of policy support for renewable energy diffusion while making adjustments to challenges arising after introducing the original institutions. Adjustments are required for evolving renewables into energy sources that can compete with other electricity sources. Renewable or any other electricity sources cannot be expected to steadily diffuse over the long term unless policies are adequately adjusted in response to challenges arising in the market after the introduction of those policies for diffusing any electricity sources.

2. Towards a renewable energy society

In addition to the abovementioned points, it was confirmed that Germany and the United Kingdom have combined extensive renewable energy support measures, such as priority connection of renewables to the grid, transmission and distribution network development, and electricity market reform, with the FIT or FIP system to diffuse renewable energy.

On the other hand, when we turn our eyes to the trajectory that Japan has followed so far, Japan implemented the Act on the Promotion of New Energy Usage (also known as the New Energy Act) in 1997 and the Act on Special Measures Concerning New Energy Use by Operators of Electric Utilities (also known as the Renewable Portfolio Standard Act) in 2003, proceeding with institutional building for renewable energy diffusion almost at the same time with Germany. Since the Act on Special Measures Concerning Procurement of Electricity from Renewable Energy Sources by Electricity Utilities (also known as the Renewable Energy Act) took effect in 2012, Japan has promoted renewable energy under its Feed-in Tariff system. In 2010, renewables accounted for 9.5% of the power mix, with non-hydro renewables' share limited to 2%. In 2018, the renewables share increased to 17%, and the non-hydro renewables share to 9%. While renewable electricity generation expanded steadily, FIT costs totaled 3.1 trillion yen in 2018, with FIT surcharge aggregating 2.4 trillion yen, indicating that how to ease the surcharge burden on consumers was an urgent challenge[118]. As solar PV generation increased remarkably because of low business entry barriers and shorter lead times for development, Japan was required to address the FIT surcharge growth dependent on solar PV.

In such a situation, the cabinet formulated the Fifth Strategic Energy Plan in July 2018 and called for renewable power generation to evolve into a major long-term stable source of electricity. It also indicated that for growing into a primary electricity source sustaining Japan's energy supply, renewable energy should be independent of the FIT system and become an electricity source that is integrated along with other electricity sources into the power market[119].

Under the FIT system, renewable electricity generators have been guaranteed to have all their generated electricity bought at fixed feed-in tariffs without market trading. This has secured their business predictability and promoted investment in renewable power generation projects. However, it has failed to provide incentives for renewable electricity generators to become conscious of market prices or have their generated electricity integrated along with other electricity into the market. Then, Japan has decided to introduce the market-indexed Feed-in Premium system in April 2022 for allowing renewable energy generators to maintain their business predictability and become conscious of electricity market prices under the Act of Partial Revision of the Electricity Business Act and Other Acts for Establishing Resilient and Sustainable Electricity Supply Systems, which passed the National Diet in June 2020[120]. In this way, Japan aims to implement the FIP system likewise Germany to secure investment incentives for renewable

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118 Ministry of Economy, Trade and Industry "Document 2 for a combination of the 18th meeting of a subcommittee on massive renewable energy diffusion and next-generation networks, Electricity and Gas Industry Committee, Committee on Energy Efficiency and Renewable Energy, and the sixth meeting of a subcommittee on institutional reform to make renewable energy a major electricity source, Strategic Policy Committee, under the Advisory Committee for Natural Resources and Energy," July 22, 2020
（経済産業省「総合エネルギー調査会 省エネルギー・新エネルギー分科会／電力・ガス事業分科会 再生可能エネルギー大量導入・次世代ネットワーク小委員会（第 18 回）基本政策分科会 再生可能エネルギー主力電源化制度改革小委員会（第 6 回）合同会議 資料 2」2020 年 7 月 22 日）

119 Ministry of Economy, Trade and Industry "Third interim report by a subcommittee on massive renewable energy diffusion and next-generation networks, Electricity and Gas Industry Committee, Committee on Energy Efficiency and Renewable Energy, Advisory Committee for Natural Resources and Energy," August 2019
（経済産業省「総合資源エネルギー調査会　省エネルギー・新エネルギー分科会/電力・ガス事業分科会　再生可能エネルギー大量導入・次世代電力ネットワーク小委員会　中間整理（第 3 次）」2019 年 8 月）

120 Ministry of Economy, Trade and Industry "Document 2 for a combination of the 18th meeting of a subcommittee on massive renewable energy diffusion and next-generation networks, Electricity and Gas Industry Committee, Committee on Energy Efficiency and Renewable Energy, and the sixth meeting of a subcommittee on institutional reform to make renewable energy a major electricity source, Strategic Policy Committee, under the Advisory Committee for Natural Resources and Energy," July 22, 2020
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energy generators by providing them with the premium, which is calculated based on the difference between the standard price and the market reference price when they sell electricity in the wholesale electricity market or bilateral trading.

Given that the FIP system is a transitional measure before renewables are integrated with other electricity sources into the market, it is essential to take comprehensive measures for evolving renewables into a primary electricity source while carefully designing the FIP system. The following discusses measures that are viewed as particularly important among those that Japan should tackle, based on German and U.K. experiences.

(1) Detailed FIP system design

As for the FIP system's detail, how to design a method for calculating a premium price is important. In Japan, the government has indicated that a unit premium price, obtained by subtracting the market reference price from the standard price, would be multiplied by renewable electricity supply volume to compute a premium amount for every certain period[121]. The FIP system is classified into "fixed FIP" in which a fixed premium is added to the market reference price and "floating FIP" in which the premium is calculated as the difference between standard price and market reference price[122]. Japan plans to adopt the "floating FIP" system, which Germany and other European countries also introduced. One of the critical issues for the floating FIP system is how to set the length of the reference period that will determine the frequency at which a market reference price would be changed. If the reference period is as short as 30 minutes or one hour, renewable electricity generators may be able to flexibly absorb market price fluctuations and ensure the FIP standard price. However, this may make the FIP system similar to the FIT system, failing to encourage renewable electricity to be integrated into the market. On the other hand, if the reference period is as long as one year, the premium may be almost fixed to lead renewable electricity generators' income to become vulnerable to short-term market fluctuations, affecting renewable electricity generators' business predictability and investment.

As reviewed by this paper, Germany has set the reference period at one month, and a mechanism has been introduced to retrospectively calculate a market premium for each calendar month

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[121] Ministry of Economy, Trade and Industry "Document 1 for a combination of the 19th meeting of a subcommittee on massive renewable energy diffusion and next-generation networks, Electricity and Gas Industry Committee, Committee on Energy Efficiency and Renewable Energy, and the seventh meeting of a subcommittee on institutional reform to make renewable energy a major electricity source, Strategic Policy Committee, under the Advisory Committee for Natural Resources and Energy," August 31, 2020
（経済産業省「総合エネルギー調査会 省エネルギー・新エネルギー分科会／電力・ガス事業分科会 再生可能エネルギー大量導入・次世代ネットワーク小委員会（第 19 回）基本政策分科会 再生可能エネルギー主力電源化制度改革小委員会（第 7 回）合同会議 資料 1」2020 年 8 月 31 日）

[122] Y. Ito "Transition of Renewable Energy Support Measures – Implications from Domestic and Foreign Cases for Japan's FIT Revision" IEEJ, August 2015
（伊藤葉子「再生可能エネルギー支援策の変遷～国内外の制度事例から得る日本の FIT 見直しへの示唆～」日本エネルギー経済研究所、2015 年 8 月）

in line with the fourth supplementary provision of the EEG2012. This might have been designed to allow renewable electricity generators to become conscious of market price fluctuations to some extent and secure the predictability of investment conditions. While there is an argument for Japan to set the reference period at one month in line with the German case, whether one month would be adequate as Japan's reference period should be considered cautiously, based on the extent of renewable energy diffusion and market development conditions in Japan. On the precondition that renewable electricity generators should make a step forward from protection under the FIT system to independence, policymakers should consider whether price fluctuations within specific periods would prevent excess risks for renewable electricity generators.

Next, I would like to emphasize the following four measures that are considered to be particularly important to be combined with the FIP system design for evolving renewable energy into a primary electricity source.

(2) Developing electricity markets

First, electricity markets should be developed. Currently, in Japan, discussions have been underway in the direction that the markets in which FIP electricity to be traded are the electricity wholesale market, non-fossil value trading market, and supply-demand balancing market[123]. Under the FIP system, renewable electricity generators will be allowed to receive income from trading their generated electricity in relevant markets while being required to shoulder costs for adjusting planned and actual values of their electricity if these values fail to be identical. There is concern that if the penalty on such value imbalance is excessive for renewable electricity generators, they would be discouraged from taking part in markets. In this respect, the hour-ahead market design should be made flexible as much as possible to suppress such imbalance. Market designs and policy processes reviewed in this paper, differ from country to country depending on national conditions and historical contexts and may have to be considered in detail in a separate article. It may be useful to analyze what measures have been taken in Germany or the United Kingdom and what challenges have been recognized as results from specific actions. In Germany and the United Kingdom where hour-ahead market designs are less flexible than in Italy or Spain, for example, it is pointed out that renewable electricity generators could be forced to

[123] Ministry of Economy, Trade and Industry "Document 1 for a combination of the 19th meeting of a subcommittee on massive renewable energy diffusion and next-generation networks, Electricity and Gas Industry Committee, Committee on Energy Efficiency and Renewable Energy, and the seventh meeting of a subcommittee on institutional reform to make renewable energy a major electricity source, Strategic Policy Committee, under the Advisory Committee for Natural Resources and Energy," August 31, 2020
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shoulder imbalance risks to the disadvantage of renewable energy diffusion[124].

(3) Eliminating grid constraints

Next, grid constraints should be eliminated. In Japan, electricity sources connected to the grid are given transmission capacity quotas first under the first-come-first-served rule. It results in forcing renewable and other new electricity sources to remain unconnected to the grid through congested transmission lines until transmission capacity is increased. The elimination of such grid constraints under traditional grid operation rules is one of the significant challenges for promoting renewable energy as a primary electricity source. Japan is now considering the promotion of Japanese connect & management arrangements for the maximum utilization of existing grids, the development of new grids, the revision of power transmission rules, and other measures[125]. As reviewed by this paper, in Europe, the 2001 EU renewable energy directive included grid system issues, providing for priority connection of renewable electricity sources to the grid. This rule has helped to encourage investment in renewable energy but has been insufficient to pursue a renewable energy society. In Germany, for example, a long-pending issue has been the enhancement of transmission capacity connecting the northern region featuring robust wind power development to the southern region with heavy electricity demand. Transmission line construction has remained far behind schedule. So, Germany introduced a grid reserve system as a transitional measure for stable electricity supply in 2012. In Japan, the enhancement of power transmission capacity including the installation of wide-area transmission networks has been recognized as necessary but is expected to cost much time and money. Therefore, Japan needs to promote the enhancement of transmission capacity as much as possible in parallel with the acceleration of the revision of rules for renewable electricity sources' priority connection to the grid and the maximum utilization of existing transmission capacity to eliminate obstacles to renewable energy diffusion.

(4) Securing supply-demand balancing capacity

As intermittent renewable energy such as solar PV and wind diffuses, it is widely recognized that supply-demand balancing capacity should be secured efficiently and effectively[126]. Fossil-fired power generation has so far played a main role in balancing supply with demand. In Germany and the

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124 Presentation by J. Ogasawara at an IEEJ forum on research works
（小笠原潤一（日本エネルギー経済研究所）による研究会発表資料）

125 Ministry of Economy, Trade and Industry "Document 1 for a combination of the 19th meeting of a subcommittee on massive renewable energy diffusion and next-generation networks, Electricity and Gas Industry Committee, Committee on Energy Efficiency and Renewable Energy, and the seventh meeting of a subcommittee on institutional reform to make renewable energy a major electricity source, Strategic Policy Committee, under the Advisory Committee for Natural Resources and Energy," August 31, 2020
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126 *Ibid.*

United Kingdom that have decided to phase out coal-fired power generation towards a decarbonized society, how to secure supply-demand balancing capacity has become an urgent issue. Coal-fired and other conventional power sources have used their kinetic energy or inertia to offset any rapid change in the power supply-demand balance in the event of an unexpected accident. This nature has contributed to stabilizing the power system. While Germany that belongs to the continental grid has no inertia problem, the United Kingdom has proactively introduced devices and mechanisms to provide inertia to absorb fluctuations in the power supply-demand balance. In this way, it must be noted that constraints on renewable energy diffusion in the United Kingdom differ from those in Germany due to the power grid system difference. In the future, in addition to the active utilization of geothermal and biomass power generation, storage batteries and IoT technology-based Virtual Power Plants (VPP) for using distributed power sources would have to be applied as balancing capacity that could maintain inertia. In Japan, fossil-fired and pumped hydropower generation may be used as a balancing capacity for the immediate future. As decarbonization makes further progress, however, demonstration tests and technological development to secure new balancing capacity will become even more critical.

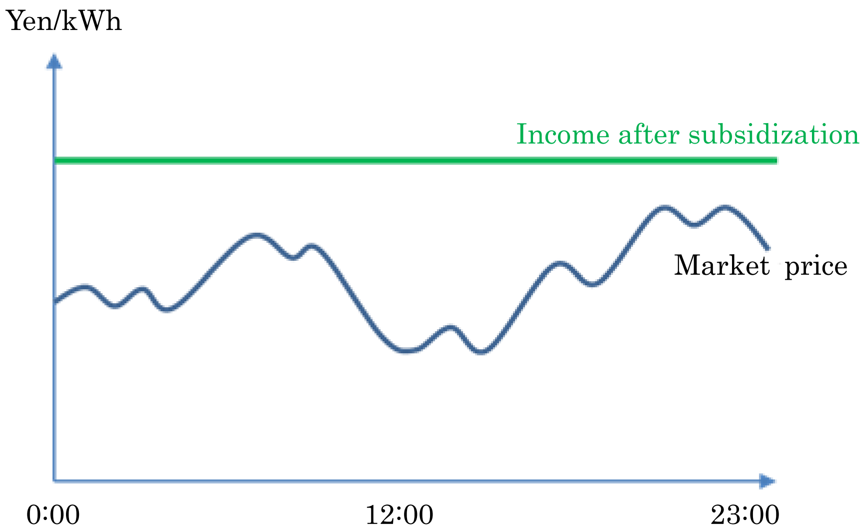
(5) Sharing specific long-term targets

Finally, Japan should demonstrate long-term targets through 2050, leading a wide range of actors to share a path to a society where renewables are widespread. Japan's fifth Strategic Energy Plan has set out an initiative for the more advanced 3E's + S (environmental protection, economic efficiency, energy security plus safety), providing four long-term energy choice guidelines – decarbonization, industrial competitiveness enhancement, diversified energy choices, and innovation of safety through technological and governance innovation. However, it has fallen short of specifying long-term targets and energy mix. While coming up with a policy of developing renewable energy into a major economically independent, decarbonized electricity source, the plan has failed to clarify a path to the development or a specific strategy. To diffuse renewable energy further, Japan will have to develop markets, enhance the grid, and accelerate technological innovation at much cost of time and labor. To sustainably stimulate investment in renewable energy and technical development for a transition to a society where renewables are widespread, Japan should set specific targets beyond 2030 and encourage various actors to take bold actions while sharing a long-term direction.

As indicated by German and U.K. policy processes, renewable energy diffusion has been promoted by renewable energy policies while being shaken by other energy policies and revised occasionally. Although paths to a renewable energy society vary depending on national energy mixes and economic conditions, the two countries' processes for developing systems and market conditions to enhance business predictability provide implications for Japan's institutional designing. It is expected that Japan will take steady steps to diffuse renewable energy under clear paths and institutions.

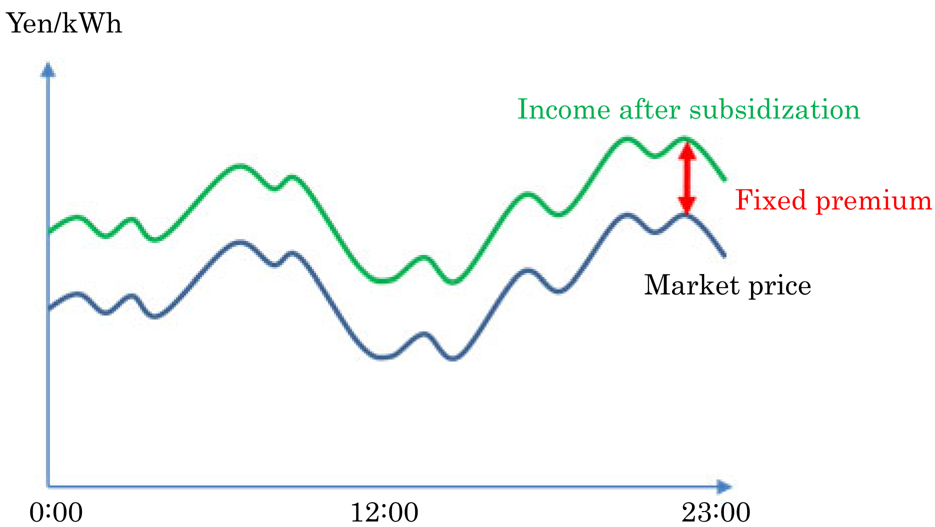
Comparative conceptual diagrams of renewable energy support measures[127]

FIT system



* Feed-in tariffs are fixed irrespective of market prices

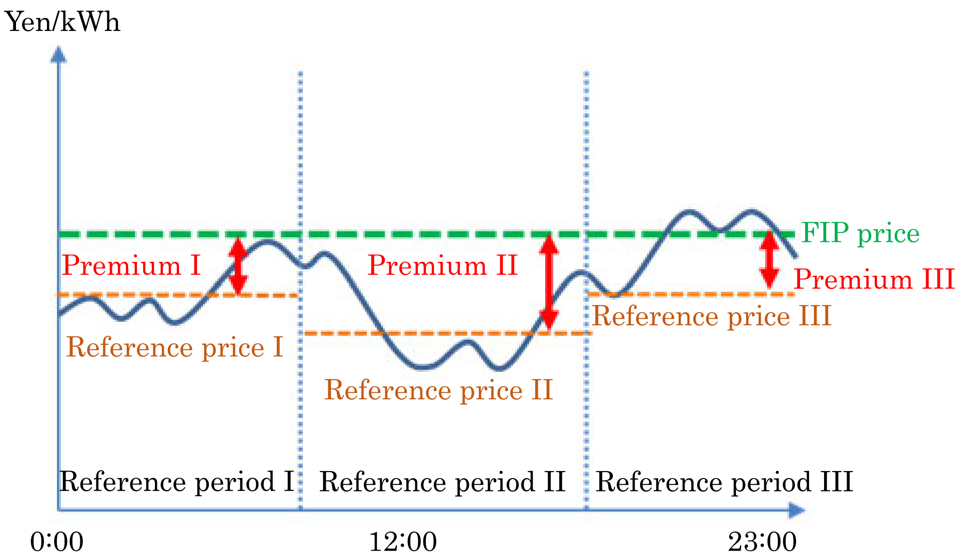
Fixed FIP system



* A fixed premium is put on the market price

[127] *Ibid.* Referred other various documents

Floating FIP system



* The FIP price is fixed over a delivery period.
* The reference price is computed every certain period based on average market prices during a reference period.
* The premium price is computed every certain period according to reference price fluctuations.

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