IEEJ Energy Journal Vol.9, No.3 2014

Challenges of the German Energy Market and European Efforts to Secure Supplies and Invest in Transmission

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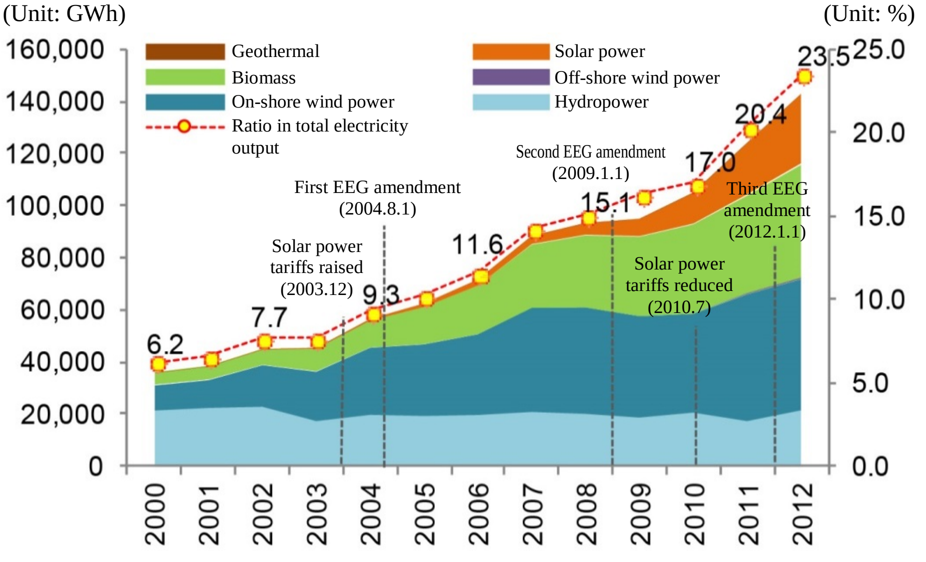
1. Introduction

Germany is currently in the midst of an energy revolution in which the country's generation mix is being changed. The change is being driven by the rapid expansion of renewable energies such as solar power, and the changing cost of power sources.

Determined to break away from nuclear power since the year 2000, the German government established the German Renewable Energy Sources Act (EEG) and launched the Feed-in Tariff (FIT) system in the same year. The system focused on introducing on-shore wind power and biomass when it was initially launched, but the introduction of solar power began to accelerate after the EEG was amended for the second time[1] in 2009, following the first amendment[2] in 2004. The momentum continued despite a cut in the purchase price in 2010, and the share of renewable energies in total electricity output reached 23.5% in 2012 (Fig. 1-1).

Fig. 1-1 Trends in Germany's Renewable Electricity Output and Its Share in Total Electricity Output



Source : BMU

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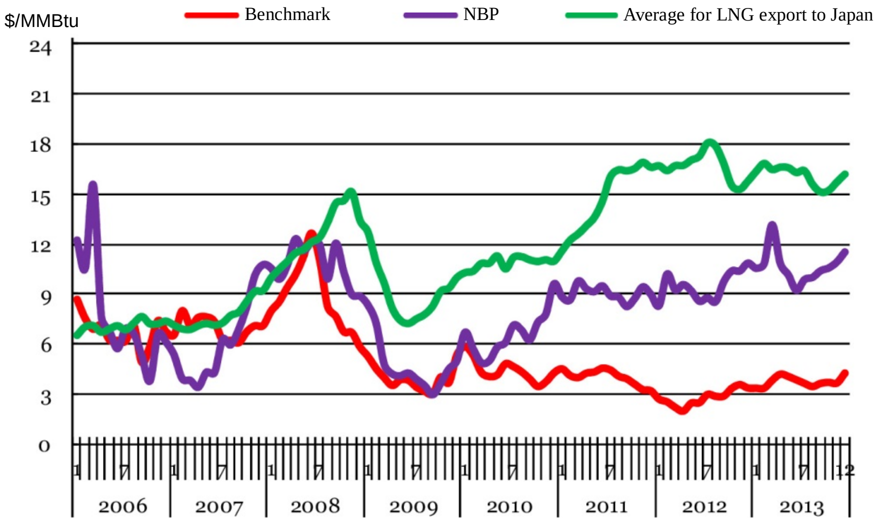
[1] Revision of overall purchase price of solar power
[2] Revision of purchase price per energy source

The other cause, the changing cost of power sources, is presumably due largely to the impact of the US's Shale Gas Revolution. With technically recoverable resources of shale gas of as much as 188 trillion m^3 [3] and its highly-developed domestic gas pipeline network, the US is causing the Henry Hub price to remain low at $3–5/MMBTU (Fig. 1-2).

Fig. 1-2 Trends in Gas Prices by Region



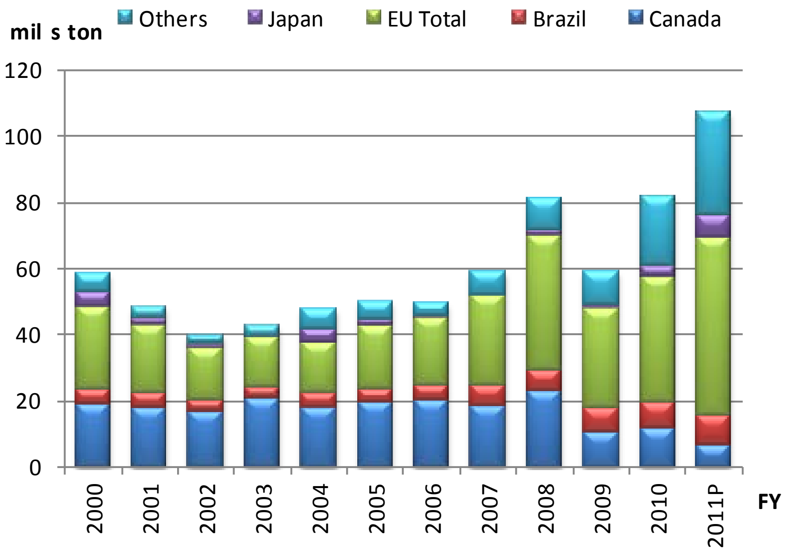
Source : The Institute of Energy Economics, Japan

The expansion of this cheap and low-carbon natural gas has resulted in tighter restrictions on coal-fired thermal power, which has a relatively high environmental burden. In September 2013, the US EPA[4] proposed the first federal emissions regulation bill targeted at new power plants. If approved, the bill will limit the CO_2 emissions of coal-fired thermal power plants to 1,100 pounds (approx. 500 kg) per 1 MWh or less, which will force the plants to introduce the latest technologies (effectively, CCS).

With a target of reducing CO_2 emissions by 17% from 2005 levels by 2020, the Obama administration is set to strengthen regulations on power plants, which produce roughly a third of the country's CO_2 emissions. This tighter environmental regulation is causing most of the coal to leave the US for Europe (Fig. 1-3).

[3] The world's explorable reserves of conventional natural gas are 181 trillion m^3 as of the end of 2009.
[4] Environmental Protection Agency

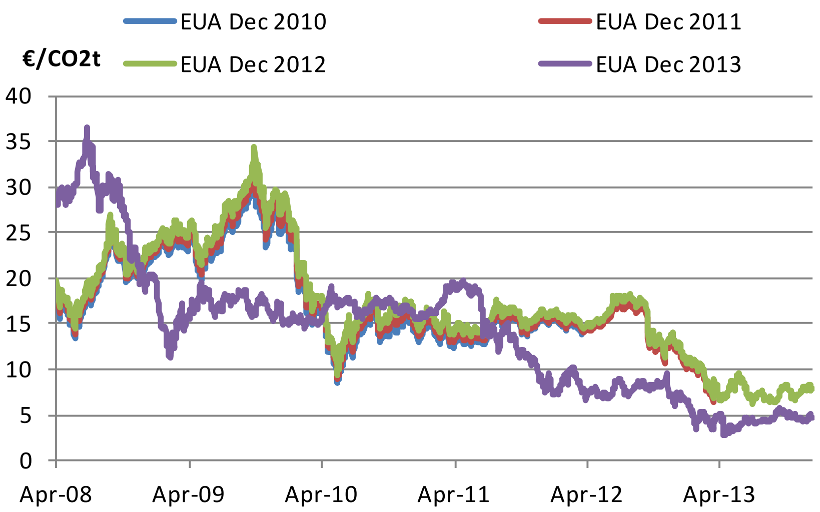
Fig. 1-3 Trends in US Coal Exports by Destination



Source : EIA

Meanwhile, in Europe, the emissions credit price (EUR) has been low since 2008 (Fig. 1-4) due to the prolonged recession. This has made it possible to achieve the emissions target even when burning coal, which has a high environmental burden, and has raised the utilization factor of coal-thermal power stations.

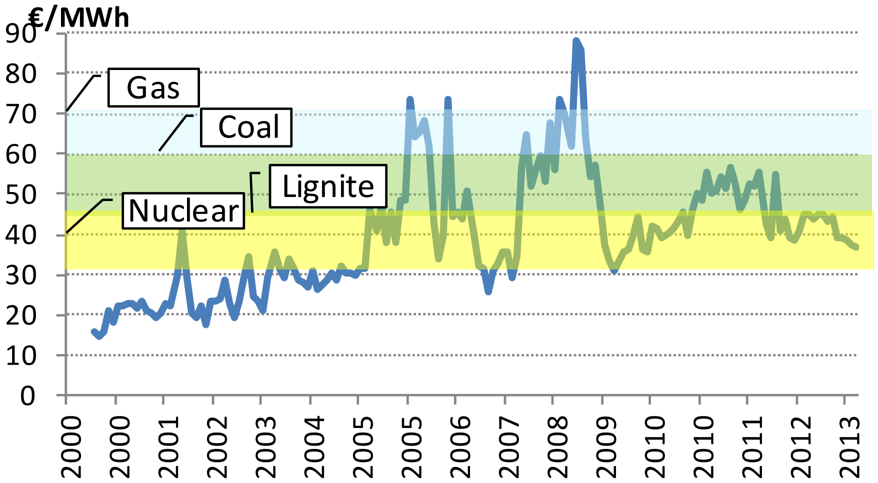
Fig. 1-4 Trends in EU-ETS Futures Prices



Source : Point carbon

The expansion of renewable energies has also significantly affected the electricity wholesale market. In Germany, under the EEG law, renewable energies began to pour into the EEX[5] market as renewable electricity is connected preferentially to the grid. The wholesale electricity price (futures), which was 40–60€/MWh from 2009, has been falling since 2012 to below the marginal cost of natural gas-fired thermal power and even that of coal and lignite-fired thermal power (Fig. 1-5).

Fig. 1-5 Trends in EEX Futures Market Prices and Marginal Cost by Electricity Source



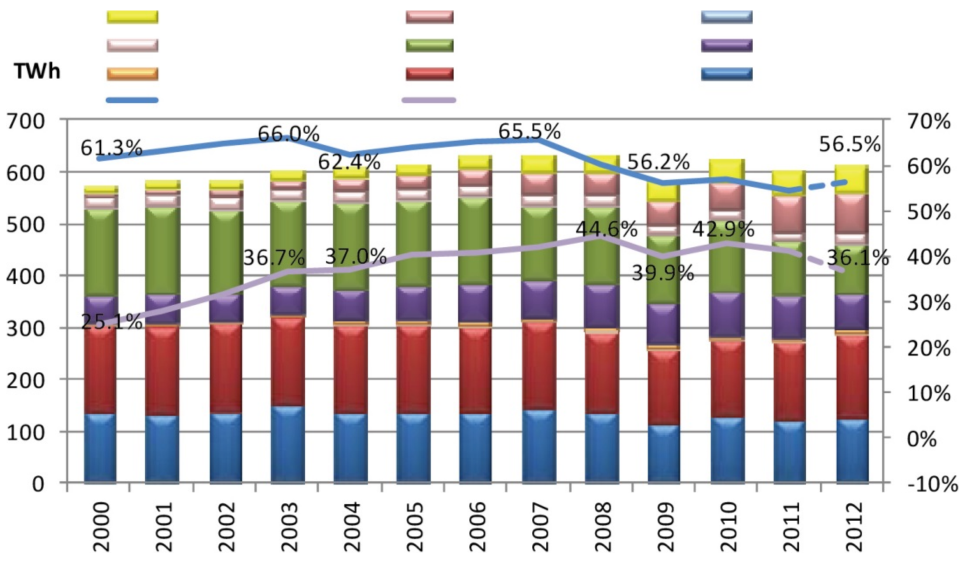
Source : WELT

As a result, the utilization factor remains high for coal/lignite-fired thermal, which only just manages to stay profitable, but is falling for natural gas-fired thermal power which is relatively expensive (Fig. 1-6).

Fig. 1-6 Trends in Germany's Generation Mix and the Utilization Factor of Coal and Natural Gas-Fired Thermal Power Plants

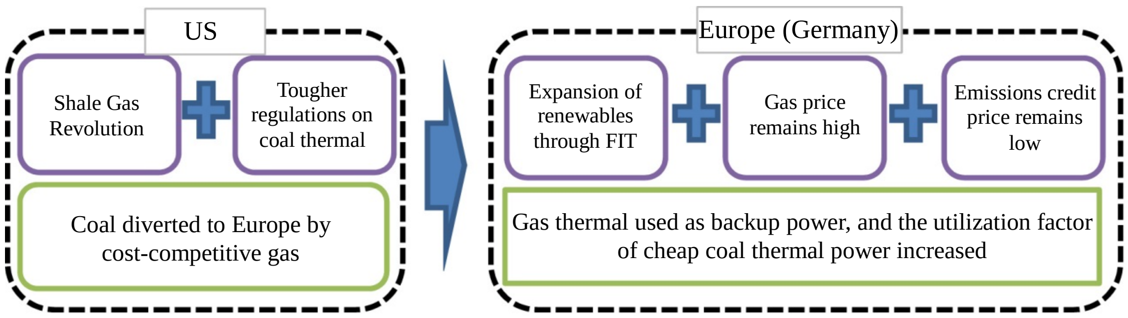
Biomass/waste
Solar power/wind etc.
Geothermal
Hydropower
Nuclear
Natural gas
Oil
Lignite
Coal
Utilization factor for coal
Utilization factor for natural gas

5 European Energy Exchange



Source : IEA, BMWI

Summary of Chapter 1



In summary, the following challenges have arisen with the expansion of renewable energies in Germany:

① Shutdown/decommissioning of natural gas-fired thermal power plants due to the drop in wholesale electricity price
② Establishment of a capacity market due to shortage of backup power sources
③ Investment in transmission lines to solve the uneven distribution of renewable energy sources

These issues will be analyzed in the following chapters.

2. Shutdown/Decommissioning of Natural Gas-Fired Thermal Power Plants due to the Drop in Wholesale Electricity Price

German power companies are shutting down (or decommissioning) gas-fired thermal power plants that are no longer profitable. In August 2013, E.ON announced that it will close power plants totaling 11,000 MW in Europe between 2012 and 2015 (including 6,470 MW of capacity which has already been closed). Malženice Power Station (CCGT) in Slovakia, launched in January 2011, was forced to shut down after operating for only 5,600 hours in two and a half years, despite the initial plan to operate for 4,000 to 5,000 hours per year (58% generation efficiency) (Fig. 2-1).

Fig. 2-1 Closed/Shutdown Gas-Fired Thermal Power Plants

Owner	Power plant	Country	Capacity (MW)
E.ON	Malzenice	Slovakia	430
Verbund	Mellach	Austria	832
Statkraft	Knapsack1	Germany	800
Statkraft	Herdecke	Germany	417
Statkraft	Robert Frank	Germany	510
Statkraft	Emden	Germany	450
RWE	Gersteinwerk F	Germany	355
RWE	Gersteinwerk G	Germany	355
RWE	Weisweiler G	Germany	270
RWE	Weisweiler H	Germany	270
RWE	Emsland B	Germany	360
RWE	Emsland C	Germany	360
E.ON	Tavazzano8	Italy	300
GDF Suez	Awirs5	Belgium	294
GDF Suez	Ruien 5-7 & 6	Belgium	627

Source : Prepared by the author based on a web site.

RWE has also announced plans to close 3,100 MW of generation capacity within three years in Germany and the Netherlands, including shutting down Lingen (CCGT) Units B and C, which have been operating since September 2010, for six months from April 2014. With an estimated generation efficiency of over 60% for its capacity of 876 MW, the plant was one of the best modern gas-fired thermal power stations in the world. Despite RWE's estimated break-even point for the wholesale electricity price of 5.5–6 euro cents/kWh (approx. 7.3–7.9 yen/kWh), the wholesale electricity price had fallen to as low as 4 euro cents/kWh (approx. 5.3 yen/kWh) by August 2013.

The generous subsidies for renewable energies are causing European power companies to shut down or decommission their gas-fired thermal power plants that have become unprofitable.

The shutdown of gas-fired thermal power plants, which also serve as backup for renewable energies, caused uncertainty in supply capacity, and further revisions to the law became necessary to ensure reserve capacity.

To secure sufficient reserve supply capacity for the network, in December 2012 the German government required by law that BNetzA[6] and the TSOs collaborate to ensure that TSOs sign an

[6] Bundesnetzagentur: Federal Network Agency of Germany

agreement with electricity producers to produce reserve electricity.[7] The details of the requirement were as follows.

(1) Agreement and verification

An electricity producer must indicate to a TSO, by May at the latest, whether or not it will operate reserve power plants. The producers will be selected by bidding, and if several producers are found to be equal in terms of technical requirements such as safety and reliability, the one with the lowest bid will be prioritized. The TSO must sign a preliminary agreement with the electricity producer by July, and prepare a supply plan (scenario) and have it approved by BNetzA by January the following year. Subsequently, the TSO will analyze and verify the track records with BNetzA till April.

(2) Detailed provisions

- The contract term as a reserve power station will be up to 24 months, and may be extended if appropriate.
- Any costs generated after signing the contract will be compensated, excluding the profit or opportunity which would have been gained from the energy market if the plant had not been closed.
- 5% of the costs for employment, preparation for generating power, repair, pollution prevention, and operation will be compensated as general expenses (an amount exceeding 5% will be approved as general expenses if evidence is provided).
- If it judges that a reserve plant cannot serve its purpose, with the necessary approval of BNetzA, a TSO may build and operate a new power plant at an appropriate location. The earnings will belong to TSO until the agreement expires, but the earnings will be capped to maintain incentives to reduce costs.
- The shutdown or decommissioning of existing power stations by inaction needs to be reported by the operator to ensure supply reliability. Furthermore, power generation facilities that temporarily close between April 1 through September 30 (facilities that supply 100% or nearly 100% of its electricity for own use, or those that operate seasonally) may do so without breaching the ban on closure by reporting at least four weeks before closing.
- An electricity producer shall be entitled to claim compensation until the expiration of the five-year contract even if its power generation facility or facilities lose significance as reserve capacity.
- Existing reserve power plants that had signed a reserve power generation agreement with a TSO in the winter of 2011/2012 and 2012/2013 shall not be disadvantaged by these provisions for having done so.
- These provisions are intended to support the gas-fired thermal power plants, come into effect in 2013, and will cease to be effective five years later in December 2017.

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[7] Reservekraftwerksverordnung

3. Establishment of the Capacity Market due to the Shortage of Backup Power Sources

As explained, there is a risk of a supply capacity shortage in Europe due to the low wholesale electricity price and the shutdown and decommissioning of gas-fired thermal power plants.

One of the means being considered to deal with this shortage is the capacity remuneration mechanism. While Germany remains skeptical and hesitates to adopt this mechanism, it has already been introduced in some European countries.

As heated discussions continue about the mechanism, ACER[8] has summarized the status of its introduction and issues at this point in the "Capacity Remuneration Mechanisms and the Internal Market for Electricity". Its key points are:

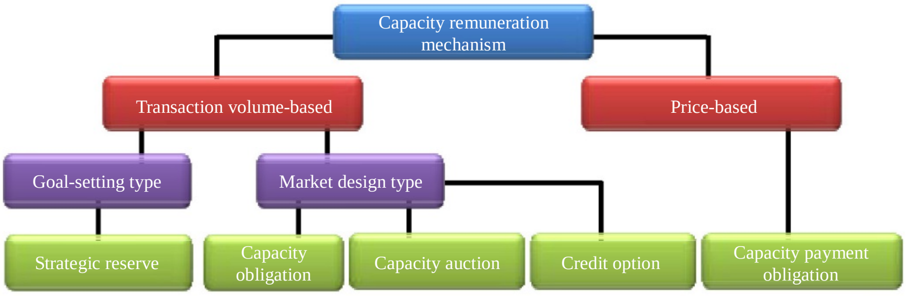
(1) Types of capacity remuneration mechanisms and the status of their introduction

A capacity remuneration mechanism can be tailored to the purpose by combining the following options:

a) Type and capacity of power sources, and consumer involvement
b) Determining the appropriateness of capacity (decision method, unacceptable cases)
c) Setting the term of the capacity agreement
d) Capacity level (whether to include all power sources, or some)
e) Means for proving the usability of the capacity
f) Method for deciding the payment scheme (regulated or auction), threshold[9] and strike price of a capacity
g) Allocation of burden for the capacity
h) Relationship with the energy markets, the rules for running the capacity market and how to stimulate it

[8] Agency for the Cooperation of Energy Regulators
[9] Threshold point

Fig. 3-1 Types of Capacity Remuneration Mechanism

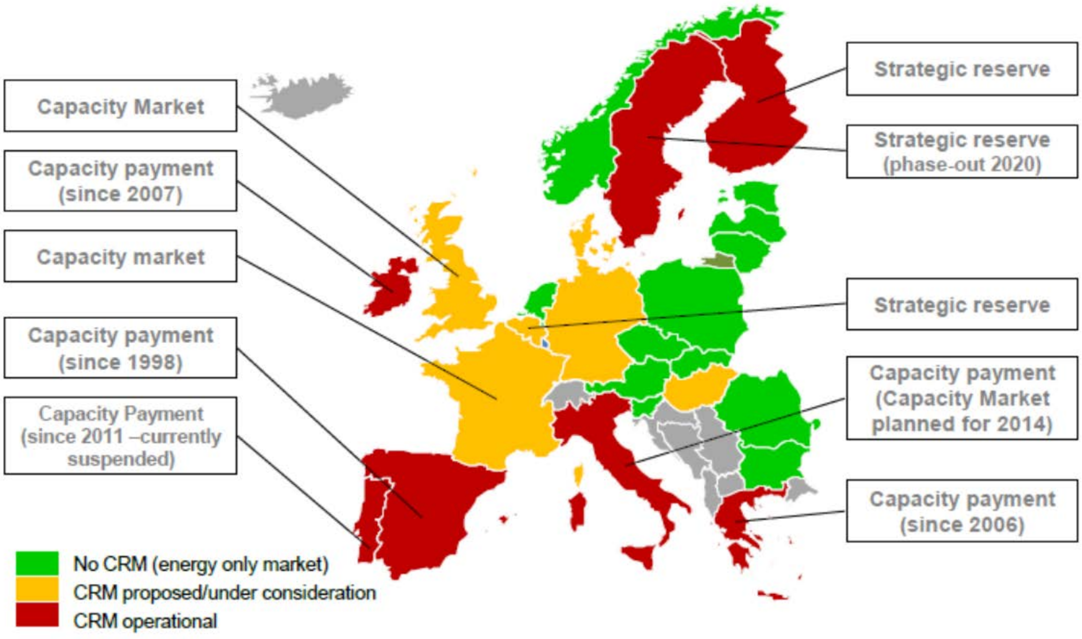


	Description	Advantages and disadvantages	Introduced in:
Strategic reserve	· TSO estimates in advance the amount of shortage that would be needed in an emergency, considers the type of power source and at what time it will be used, and then solicits bids from electricity producers. · The capacity is determined by bidding during the previous year, and the costs are borne by the network users.	· Electricity producers can secure a certain amount of income as a "reserve power plant". · The cost of "reserve capacity" remains unaffected by the market mechanism. · The relationship between the activation threshold and VOLL is unclear.	Sweden, Germany (considering)
Capacity obligation (distributed scheme)	· Retailers (LSEs[10]) required to secure a certain reserve ratio trade (by signing an agreement) capacities with electricity producers. · Capacity obligations are fulfilled by purchasing "capacity certificates" licensed by regulators.	· Reserve capacity can be secured efficiently through the sale and purchase of certificates between producers. · Securing transparency and fairness is a challenge as capacities and prices are relative in transactions. · Non-performance of obligation is punished.	France (considering)
Capacity auction (centralized scheme)	· An independent body opens a capacity market, in which electricity producers bid for power sources. · Prices are set through forward auctions with the participation of all parties. · The costs are paid for by the suppliers (retailers) who charge the end-users.	· It is clear beforehand how much reserve capacity is needed overall, and thus the cost burden is transparent. · No need for retailers to gather (reserve) capacities individually. · Large cost burden due to complex market design and building a centralized management system.	US (PJM), UK (considering)
Credit option	· Electricity producers receive fixed rates based on the rules of regulators (ie. difference between spot price and strike price). · Similar to call option[11] in financial markets.	· Electricity producers can earn stable and foreseeable profits. · Strike price is set to the highest price per unit for the incentive of electricity producers.	Columbia
Capacity payment	· An amount is paid regularly for every unit of capacity (kW) for all power sources of all electricity producers available for power generation.	· Wide variety of options, including power source target (new or existing), time of day (peak or base). · Could affect investment incentives and generation mix of surrounding	Spain

10 Load Serving Entities
11 Sale and purchase of the right to buy at a predetermined price (strike price) regardless of the market price of the day.

		countries in some cases.	

Fig. 3-2 Capacity Remuneration Mechanisms Implemented or Being Considered in Europe



Green :	No CRM[12]: Norway, the Netherlands, Estonia, Latvia, Lithuania, Poland, Czech Republic, Austria, Slovakia
Yellow :	CRM proposed/under consideration: UK, Germany, France, Belgium (strategic reserve), Denmark, Hungary
Red :	CRM operational: Sweden (strategic reserve), Finland (strategic reserve: to be phased out by 2020), Ireland (2007-), Portugal (2011-, currently suspended), Spain (1998-), Italy (2014-), Greece (2006-)

Source : Capacity Remuneration Mechanisms and the Internal Market for Electricity

(2) Issues with the capacity remuneration mechanism

Some suggest that allowing each country to decide its own capacity market could cause strain among countries across the border.

① Short-term effect: The impact on the price could cause competition across the border and change the electricity output inside and outside the region.

② Long-term effect: A possible drop in market price to a lower threshold will lower the income of electricity producers adopting the strategic reserve and capacity obligation mechanisms, affecting their investment decision.
In countries without a capacity market, investment in power plants will drop, forcing plants to be decommissioned prematurely.

③ Spillover effect: The benefits for consumers bearing the costs will spill over to consumers who are not. This could include paying for the capacities of neighboring countries.

12 Capacity reserve market

Shown below are examples of the international impacts of the capacity market.

Case 1. Impact of the CP[13] of Ireland and Northern Ireland on the British market

SEM[14] was established in 2007 for Ireland and Northern Ireland. In this market, participants receive separate payments for capacity and consumption.

In 2013, a total of €530 million is planned to be paid to electricity producers for capacity of 6.8 GW. The payments are to be made in three installments: beginning of the year (30% of the €530 million), beginning of the month (40%), and afterwards (30%).

Traders basically trade day-ahead or with capacity payment certificates, and the transactions for 70% of the available amount tend to concentrate in a certain 30-minute time slot.

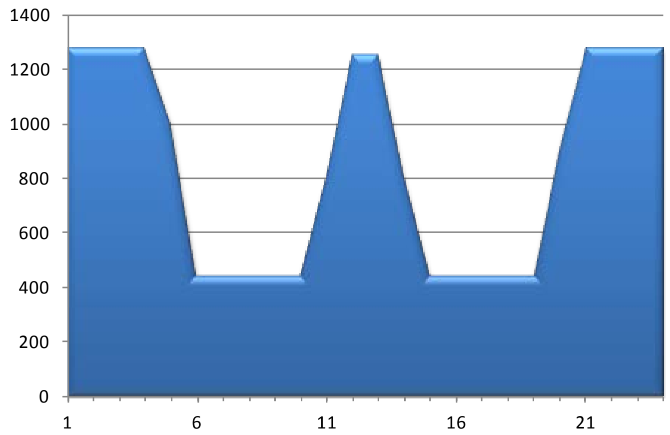
Post-settlement of capacity remuneration payments induces risks for traders and leads to a wider price gap between SEM and the British market. This in turn affects the use of connection lines and the supply of electricity by electricity producers.

Furthermore, if the Irish and British markets are integrated in the future, it will result in the loss of current liquidity of funds, including the payment for capacity associated with the import and export of electricity.

Case 2. Impact of Russian CRM on the Finnish energy market

There is an electricity interchange capacity of 1,400 MW[15] between Finland and Russia, in which electricity exported from Russia is handled as “demand” and thus its capacity cost is determined by the peak capacity volume. Exporters submit export plans to TSO no later than 11:30 of the previous day. Russia’s peak times for February 2012 were 8:00-12:00 and 17:00-21:00 on weekdays, which are 6:00-10:00 and 15:00-19:00 Finnish time (Fig. 3-3).

Fig. 3-3 Trends in International Transmissions between Finland and Russia (2012.2.22)



Source : Lappeenranta University of Technology

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13 Capacity Payment

14 Single Electricity Market

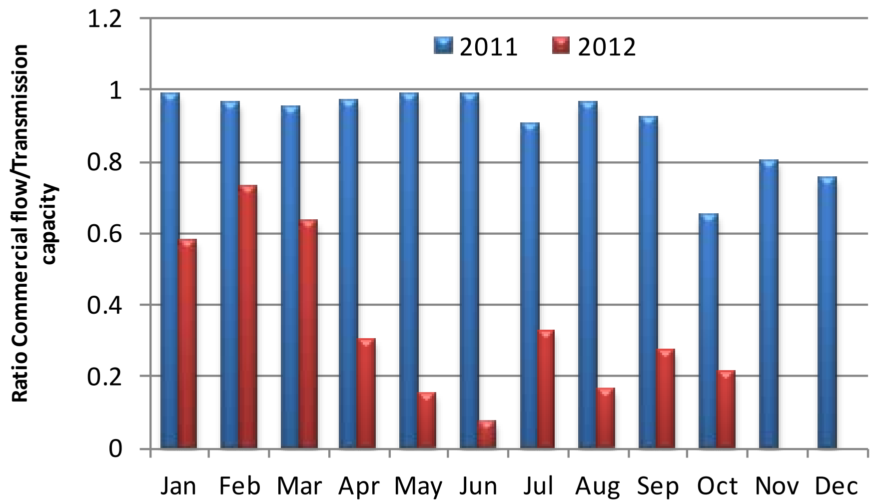
15 Connected by three 400 kV transmission lines (two DC and one AC).

The electricity exported from Russia to the Nordic[16] electricity market costs at least 50€/MWh (20€/MWh for electricity cost, 25€/MWh for capacity cost, and 5€/MWh for wheeling charge). Therefore, the electricity price in the Nordic market must be 50€/MWh or higher for Russian exporters to make a profit.

Meanwhile, the cost of electricity exported from the Nordic market to Russia is 20€/MWh, as the capacity cost and wheeling charge were abolished by the market rule revisions in 2011. Thus, for exporters in the Nordic market to make a profit, the electricity price in the Nordic market must be 20€/MWh or lower. This means that any price between 20 to 50€/MWh in the Nordic market becomes a dead band (a price band at which the transmission line is not used), in which no electricity is fed into the international interchange line by either party.

In 2011, usage of the international interchange line nearly reached its maximum capacity, but it later plunged to one-third of the peak level.

Fig. 3-4 Trends in Electricity Transmission Volume between Finland and Russia (2011/2012)



Source : SWECO

This shows that when introducing the market mechanism, it is necessary to evaluate the adequacy and supply capacity of each power plant, and to thoroughly consider their consequences on the different market designs of both sides.

4. Investment in Transmission Lines due to the Uneven Distribution of Renewable Energy Sources

For Europe as a whole, the European Commission is designating “preferential projects” using

16 The international electricity exchange of Northern Europe.

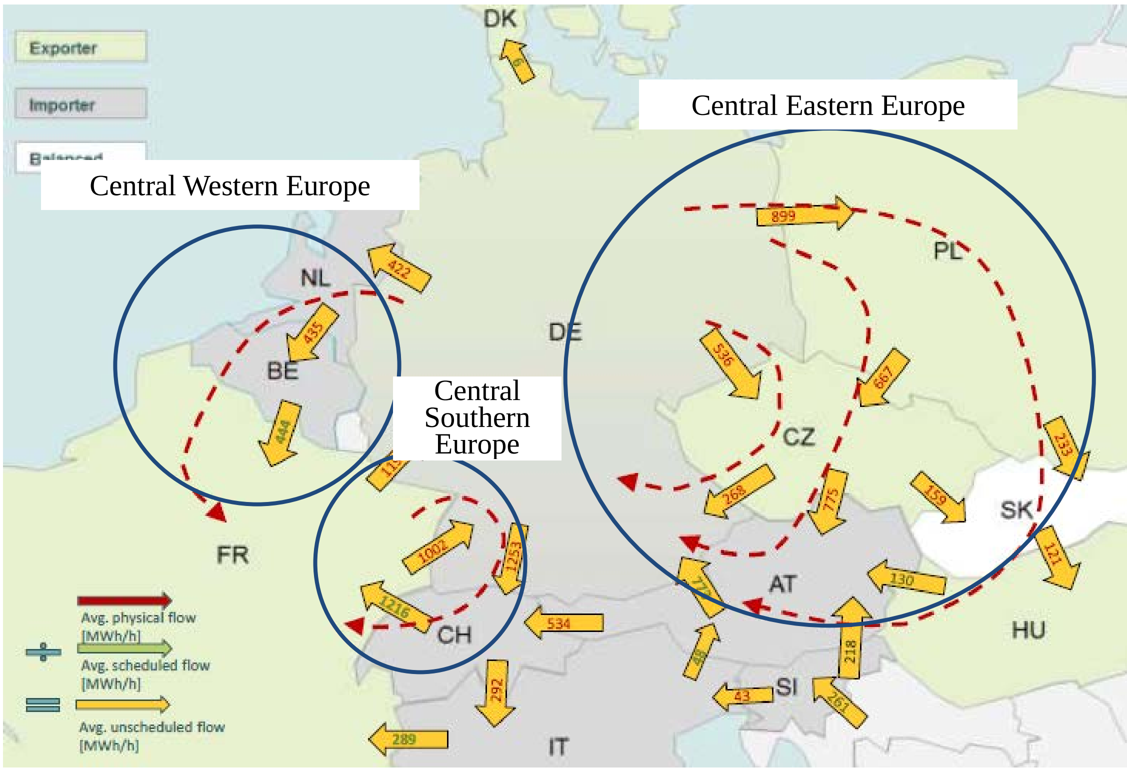
the TEN-E[17] framework. The designation involves meticulously calculating cost performance using numerous parameters and evaluating by category. Meanwhile, in Germany, the regulators are tightening their grip on investment in transmission, which could hamper grid optimization. Future challenges include the impact of excess wind power on surrounding countries and strengthening the north–south transmission network.

The following is a comparison between Germany and the whole of Europe on transmission line construction (investment).

(1) Germany

Located at the center of Europe, Germany is feeding large volumes of renewable energies into the grid. The limitation in transmission capacity between the northern and southern parts of the country, and preferential electricity supply obligations based on the FIT system, are causing loop and transit flows[18] to occur. The phenomenon is occurring mainly at the following three locations: Central Eastern Europe (Germany ⇒ Poland ⇒ Czech Republic ⇒ Austria), Central Western Europe (Germany ⇒ Netherlands ⇒ Belgium ⇒ France), and Central Southern Europe (France ⇒ Germany ⇒ Switzerland ⇒ France). Particularly, the loop flow from the northeast, where wind power plants are concentrated, is significantly affecting other countries.

Fig. 4-1 Average Annual Unplanned Flows in 2011 and 2012



Source : THEMA Report 2013-36s

17 pan-European energy network
18 The loop flow phenomenon.

The increase in introduction of renewable energies in Germany is threatening stable operation of the interchange line between Germany and Poland. There have even been cases where Poland initially planned to export electricity one hour ahead of operation, but Germany ended up exporting electricity above the operational capacity[19] of the transmission line.

Furthermore, in the Germany-Switzerland interchange line, the amount of excess German electricity, which reaches Switzerland after traveling through the Netherlands, Belgium, France, and back to Germany, is exceeding the planned volume by approximately three times.

Fig. 4-2 Status of Use of the Germany-Poland Interchange Line (2012.02)

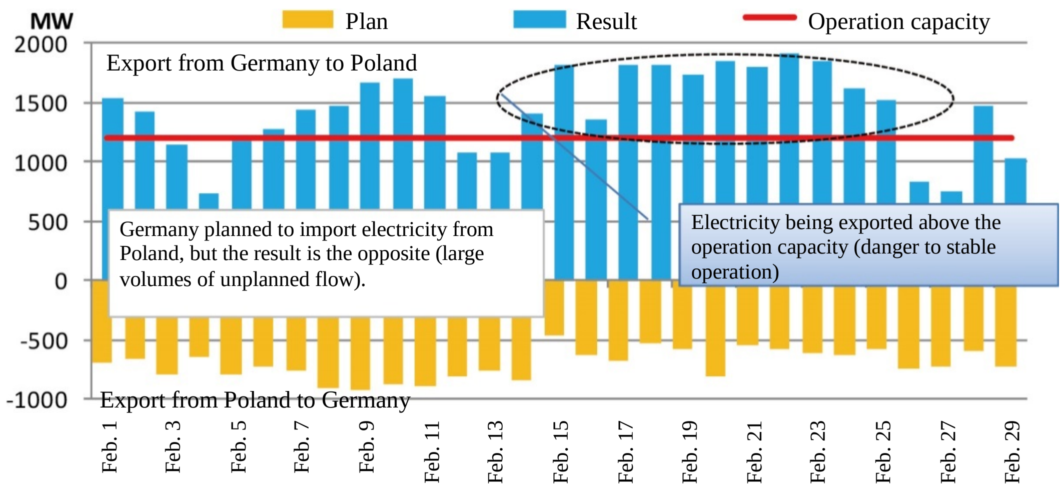
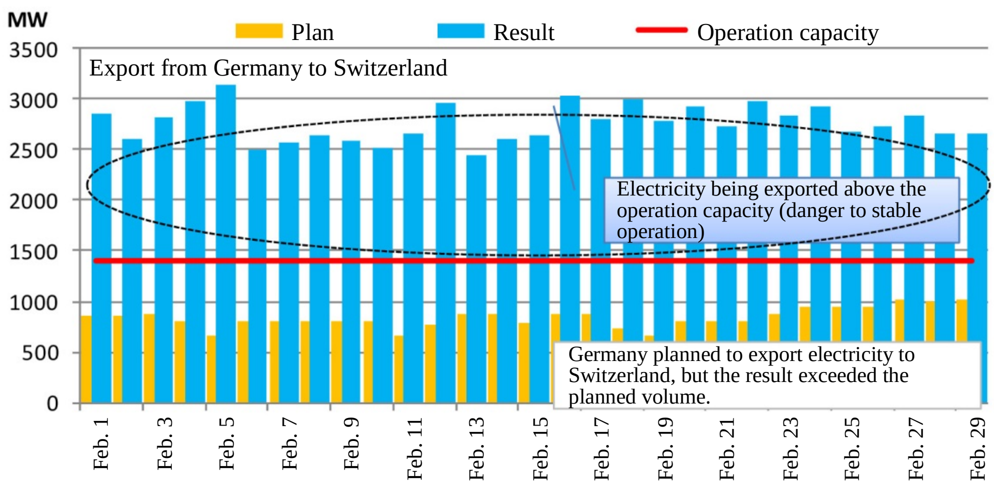


Fig. 4-3 Status of Use of the Germany-Switzerland Interchange Line (2012.02)

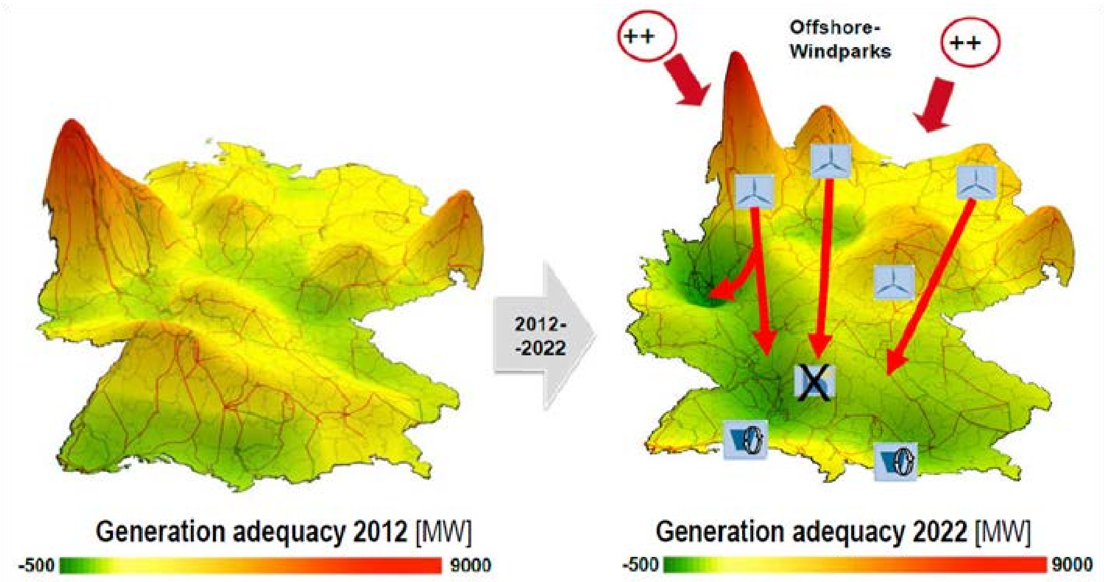


Source : ENTSO-E

19 Day-ahead. 2011 value, as the DE-PL data value is undisclosed for 2012.

Thus, it is necessary to transmit wind electricity from the northwestern and northeastern parts of the country, with relatively abundant electricity, to the central western and southern parts which need more (Fig. 4-4).

Fig. 4-4 Requirements for Electricity Transmission Lines



Source : Bundesnetzagentur; Energy infrastructure development and financing in Germany

GDP[20] is a grid enhancement and strengthening plan developed by the TSOs based on ENTSO-E's[21] TYNDP[22]. The basic concept involves strengthening the existing 380kV AC lines and connecting the north and south with HVDC lines, and prioritizes optimizing the network and constructing new transmission lines. Furthermore, three scenarios have been developed as an extension of GDP, and for each case, the future share of renewable energies and CO_2 emissions have been calculated.

Scenario B : Expansion of renewable energies and natural gas

Scenario A : Moderate expansion of renewable energies; increasing the ratio of conventional thermal power plants

Scenario C : Ambitious target for renewable energies to match the federal target

20 Grid Development Plan

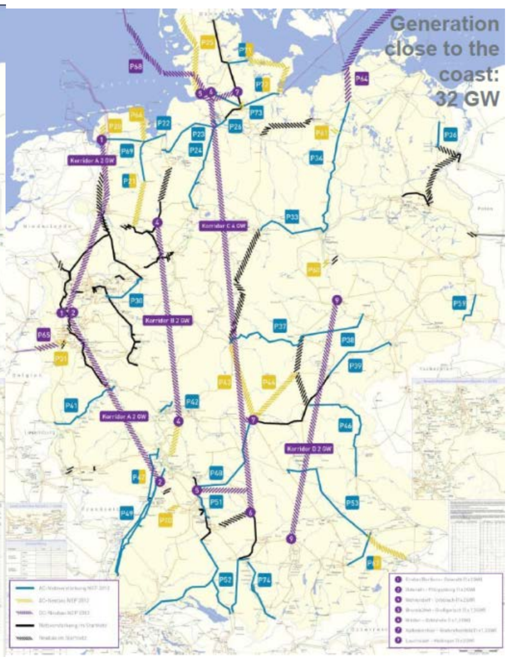
21 European Network of Transmission System Operators for Electricity

22 Ten-Year Network Development Plan

Fig. 4-5 Plan and Reduction Effect of Each Scenario

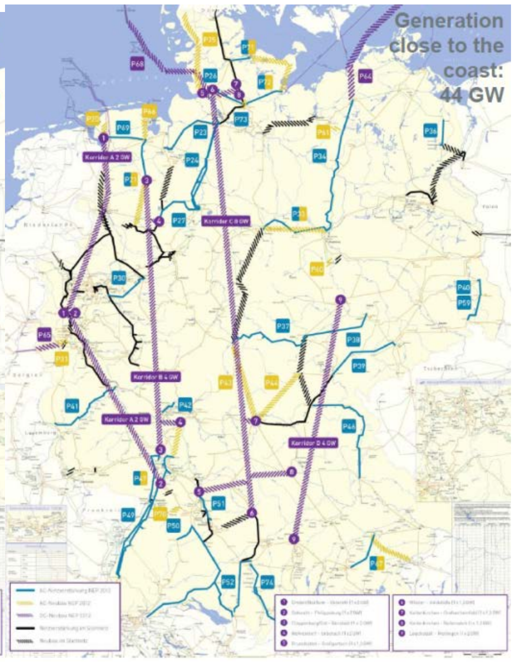
GDP 2012

Scenario B 2022



Scenario A 2022

Scenario C 2022



	GDP 2012	Scenario B	Scenario A	Scenario C
Primary energy consumption		**▲ 23%**	**▲ 13%**	**▲ 38%**
Share of renewable energies		**50%**	**45%**	**60%**
CO_2 emissions		**▲ 40%**	**▲ 36%**	**▲ 45%**
Optimization of existing routes				
New AC construction in existing routes	800 km	2,800 km	2,800 km	2,700 km
AC enhancements and AC power circuit overlays on existing routes:	400 km	1,300 km	1,400 km	1,200 km
DC circuit overlay systems:		300 km	300 km	300 km
Grid expansion in new routes				
Route construction	700 km	1,700 km	1,700 km	1,700 km
4 DC corridors				
Transmission capacity		10 GW	10 GW	18 GW
New DC route construction		2,100 km	1,800 km	2,400 km
Estimated total investment	€5 bil	€20 bil	€19 bil	€23 bil
Power generation close to coast		32 GW	27 GW	44 GW

Source : Power Grid Development Plan 2012

Currently, Scenario B, the moderate case, is positioned as the leading plan.

In 2009, the regulator BNetzA changed the cost restrictions on TSOs from every year to every five years as an incentive. In addition, it is promoting the increase in international interchange capacity and the development of off-shore wind power by attracting investments by setting a regulatory remuneration rate, which is higher than that of other countries, of 9.29% for new investments by TSOs (first regulatory period 2009–2013: 9.29%, second regulatory period 2014–2019: 9.05%).

(Reference) Regulatory Remuneration Rate of Each Transmission Company

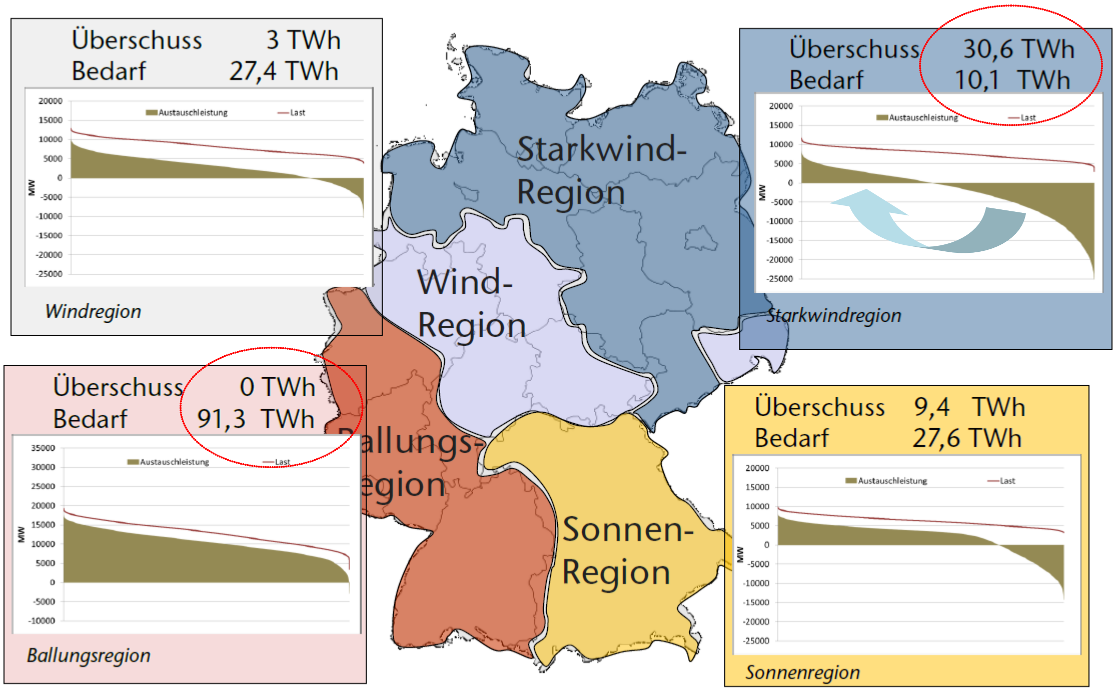
Country	Remuneration type	Calculated:	Percentage
Austria	Weight-averaged capital cost (WACC[23])	Pre-tax	6.32%
Czech Republic	Weight-averaged capital cost (WACC)	Pre-tax	7.65%
Germany	**Return on equity (ROE) (expansion investment)** **Return on equity (ROE) (maintenance & repair investment)**	**Pre-tax**	**9.29%** **7.56%**
Spain	Return on assets (ROA)	2009	6.00%
France	Return on equity (ROE) Return on assets (ROA)	Post-tax Pre-tax	6.90% 7.30%
Hungary	Return on assets (ROA)		4.50%
Italy	Weight-averaged capital cost (WACC)	Pre-tax	6.90%, 2/3% added
Netherlands	Weight-averaged capital cost (WACC)		6.00%
Norway	Weight-averaged capital cost (WACC)	2009	6.19%
UK	Weight-averaged capital cost (WACC)	*[24]	5.05%

[23] WACC = D/(D + E) × rD × (1 − tax rate) + E/(D+E) × rE (D: debt, E: equity, rD: debt expense, rE: equity expense)
[24] After equity tax, before taxation of quasi tax effect debt

Source : Agency for Natural Resources and Energy: Inter-area connection lines of Europe and the US

However, to meet the “ambitious targets” sought by the government, it is necessary to achieve New Scenario B, which adds distance and cost to Scenario B, and New Scenario D, which is an extension of Scenario B until 2032.

Fig. 4-6 Regional Load/Exchange Efficiency Duration Curve in 2032



Source : efzn; Dezentralisierung und Netzausbau

According to a simulation of Scenario D (2032), which is an extension of Scenario B, the wind power capacity of northeastern Germany will reach nearly three times the regional demand, and will need DSM, PSW and a system for storing hydrogen-converted energy for utilizing the excess electricity. Northwestern and southeastern parts of Germany will also produce excess electricity, though not much, but the southwestern part will be in short supply year-round, highlighting the importance of constructing and enlarging transmission lines.

Despite the investments in and verification of transmission lines and deregulation by the regulators, the licensing processes for many projects are being delayed due to federal and state regulations. So far, only 15% or 268 km of the necessary 1,855 km of transmission lines has been completed.

Furthermore, the construction of transmission lines for carrying wind power from northern to southern Germany is being opposed by the leader of the conservative CSU, the ruling party of the state of Bayern in southeastern Germany.

CSU, a sister party of Prime Minister Merkel’s CDU, is confronting the center-left SPD, which is a part of the ruling coalition. In Bayern, home to many of Germany’s flagship energy-intensive industries including Audi, Siemens and BMW, there is growing opposition to the construction of transmission lines in order to preserve the scenery, despite the risk of electricity shortages in 2022.

(2) Europe

In November 2013, ENTSO-E proposed a guideline for evaluating projects based on the costs and benefits they generate. Europe had been taking a "bottom-up" approach to its transmission line plans until TYNDP[25] 2010, in which the plans were drafted based on electricity generation and load, but has turned to a "top-down" approach since TYNDP2012 to ensure alignment with the macro-economy and the policies of each country, as well as Europe's Triple 20 target. Extracts from the guidelines are shown below. In case there are many parameters and multiple scenarios, the development plans may be prioritized by assessing the risk in transmission line operation by using a probabilistic approach.

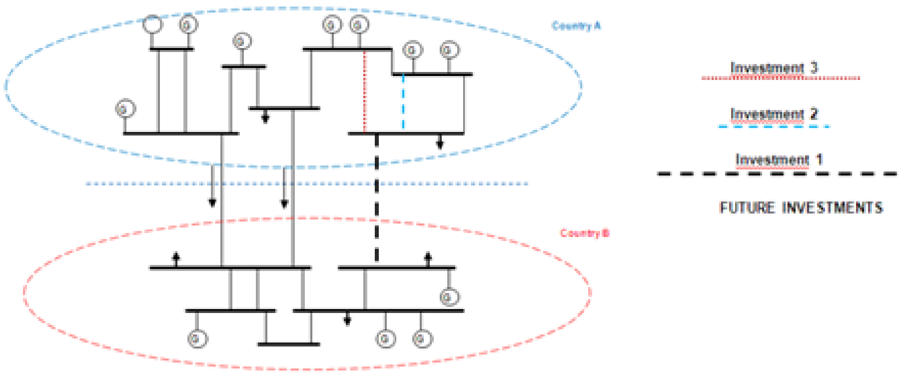
A) Setting the time frame

- Medium-term target (N+5, N+10): Based on the forecast at the present time, regional characteristics, new projects, and TYNDP are re-analyzed.
- Long-term target (N+15, N+20): A systematic assessment is performed by, for example, preparing four scenarios.
- Super-long-term target (N+30): This is qualitatively based on the TYNDP2050 report.

B) Setting necessary parameters

- Economic factors[26]; technical factors[27]; power plant-related[28]; demand side-related[29]; and other factors[30]

Fig. 4-7 Image of Clustering



[25] Ten-year network development plan

[26] Economic growth, and costs for coal, petroleum, gas, brown coal lignite, nuclear, CO_2 and biomass

[27] Efficiency (Europe-wide for new plans, nationwide for old plans), utilization capacity factor, CO_2 emission rate, SO_2 emission rate, NO_2 emission rate, reserve electricity, must-run power source, no power feed rate, output fluctuation and startup cost

[28] Biomass, coal, gas, petroleum, brown coal lignite, nuclear, wind power, solar power, geothermal heat, wave power, CHP, hydropower, storage and CO_2 CCS facilities

[29] Economic growth, demand growth per sector, load management, sensory temperature, fuel shift, extreme climates, change in population, inter- and intra-area flows

[30] Voltage level, multi-level trip, stability, lost load, thermal load, relief index, short-circuit capacity

Source : ENTSO-E

C) Prioritizing and clustering investments

- Where GTC_1[31] represents major investments such as international interchange lines, GTC_2 represents enhanced investment such as intra-regional interchange lines, and GTC_3 represents other investments in interchange lines, ΔGTC_1, ΔGTC_2, and ΔGTC_3 can be clustered if additional investments are as follows:

  $\Delta GTC_2 > \Delta GTC_1 \times 0.2$, $\Delta GTC_3 > \Delta GTC_1 \times 0.2$ (Fig. 4-7)

D) Analyzing at least two scenarios

- For analyzing scenarios, a reference scenario and a sensitive scenario are needed. A reference scenario is divided into seven categories, and a sensitive scenario has a further two categories.

  ① Improved supply security
  ② Socioeconomic benefits
  ③ Adjustment of renewables
  ④ Variation in transmission loss
  ⑤ Variation in CO_2 emissions
  ⑥ Technical resilience, system safety
  ⑦ Flexibility
  ⑧ Environmental impact
  ⑨ Social impact

  Reference scenarios

  Sensitive scenarios

E) Cost analysis tools: TOOT and PINT methods

There are two methods for project assessment: TOOT[32] and PINT[33].

TOOT is a method which evaluates the benefits that have actually been achieved, regardless of the order of a project or investment.

PINT is a method which evaluates the benefits by also considering the competitiveness of a project or investment and the steps up to completion.

TOOT is suitable for analyzing broad-range cost performance such as TYNDP, and PINT is suitable for evaluating individual projects outside the TYNDP.

The overall business expense is estimated by forecasting the material and assembly costs[34], geographical requirements, discount rate and equipment lifecycle, after studying (A) through (E) above.

The colors in Fig. 4-8 and Fig. 4-9 (light-green, green and dark-green) each represent the effect (impact) on the system. A darker color represents a stronger effect (impact).

Finally, the results of Fig. 4-8 and Fig. 4-9 are indexed and converted into a radar chart (Fig.

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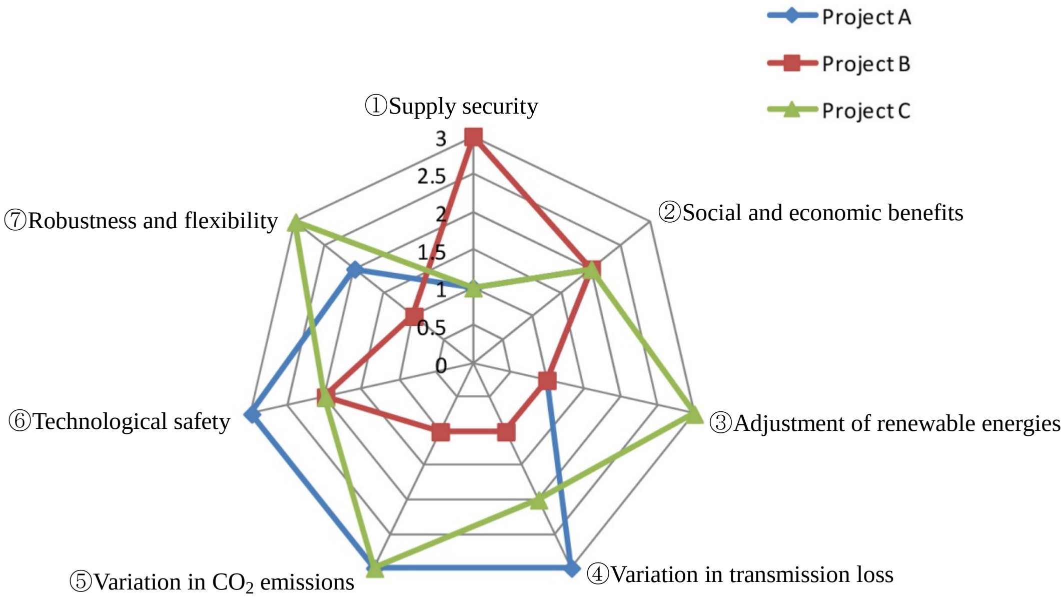
31 Grid transfer capability
32 Take Out One at a Time
33 Put In One at a Time
34 Utility poles, basements, wires, cables, transformers, and protection & control systems

4-10).

Fig. 4-10　Sample Project Assessment



Source : ENTSO-E

F) Estimating VOLL[35]

"(1) Supply security" can be obtained theoretically as "uncertain cost" by using VOLL, but is difficult to evaluate in monetary terms. This is because a project is affected by the generation mix and industrial structure of each country, as well as seasonal factors. The level of VOLL can be used as a basis for investment decisions, but it can cause overinvestment if too high and can affect supply reliability if too low. CEER[36] is demanding a "nationwide cost investigation on electricity disruption and voltage troubles by the regulatory authorities", and accordingly, issued a guideline in December 2010.

In Japan, the Electric Power System Council of Japan conducted a "Survey on the future direction of Japan's grid system headed for a low-carbon society" in 2009, in which it estimated the cost of blackouts. The cost is 2,000 yen/kWh for business facilities and 3,000 yen/kWh for individuals on average, and the median values are 900 yen/kWh for business facilities and 800 yen/kWh for individuals.

35 Values of Lost Load
36 Council of European Energy Regulators

Fig. 4-11 VOLL Evaluated for European Countries

Country	VOLL (€/kWh)	Year	Planned use	Method/reference
Austria (Econtrol)	WTP[37]; Industry 13.2 WTP; Residential 5.3	2009	NO	Incentive regulation R&D, investigation on WTP and direct value
France (RTE)	26 Large industries, small industries, services, infrastructure, residential and agriculture	2011	YES (Average)	CEER; investigation on transmission plans that use WTP, studies on direct value and cases
UK	19.75	2012	NO	Incentive regulation, initial value proposed by Ofgem
Ireland	Industry 8 Residential 68 Average 40	2005	NO	R&D, production function approach
Italy (AEEG)	Business 21.6 Residential 10.8	2003	NO	Investigation on incentive regulation, use of WTP and direct value (SINTEF)
Netherlands (Tennt)	Industry 6.0 Residential 16.4 Average 8.6	2003	NO	R&D, production function approach
Norway (NVE)	Industry 10.4 Service sector 15.4 Agriculture 2.2 Public sector 2 Large industries 2.1	2008	YES Value for sector	Investigation on incentive regulation, use of WTP and direct value (SINTEF)
Portugal (ERSE)	1.5	2011	YES (Average)	Tariff code of Portugal
Spain	6.35	2008	NO	R&D, production function approach
Sweden	Industry 7.1 Residential 0.2 Agriculture 0.9 Public sector 26.6 Service sector 19.8	2006	NO	R&D, WTP, joint analysis

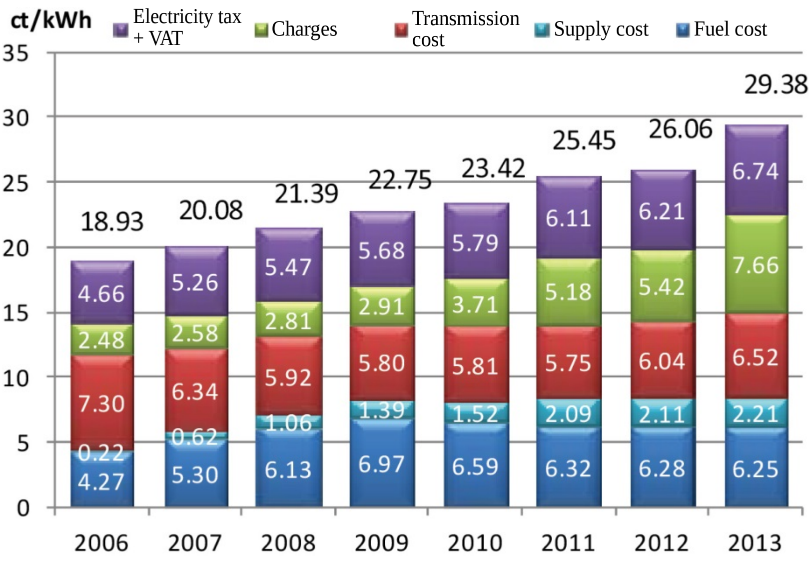
5. Conclusion

(1) Evaluation of Germany's Energiewende[38]

Germany's Energiewende, or energy transition policy, has been a model for breaking away from nuclear power since the Great East Japan Earthquake, but is now facing the need for a major revision. The FIT system has expanded the share of solar power electricity, but the surcharge on residential electricity tariffs has bloated to as much as 18% of the bill. Furthermore, electricity tariffs also rose by 55% between 2006 and 2013 (Fig. 5-1 and Fig. 5-2).

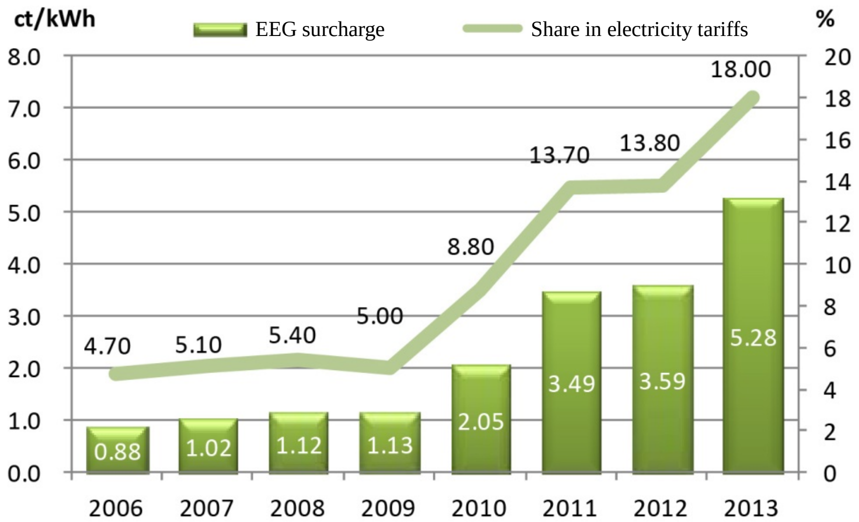
37 Willingness-to-pay
38 The great energy transition policy.

Fig. 5-1　Trends in Residential Electricity Tariffs



Source : BNetzA Monitoringberichte

Fig. 5-2　Trends in EEG Surcharge (residential)



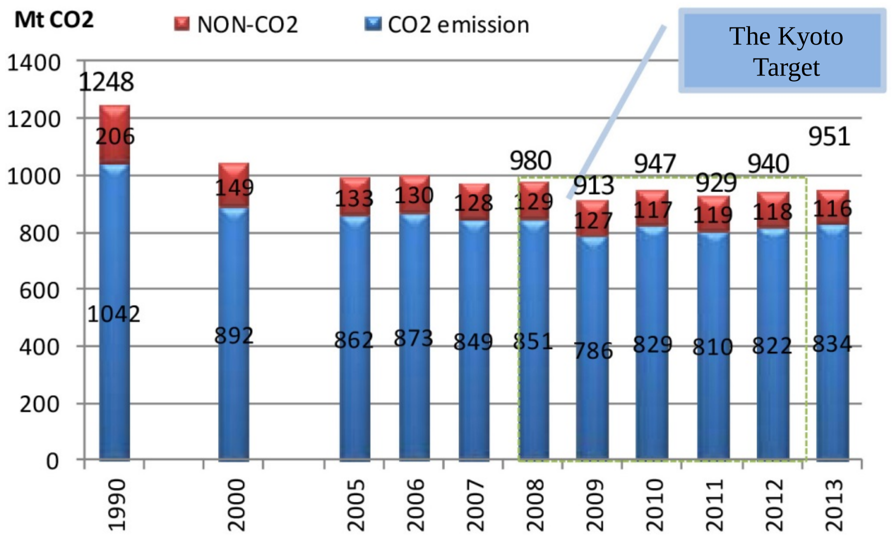
Source : BNetzA Monitoringberichte

Recently, the ratio of the “energy poor” who spend at least 10% of household expenses on energy is rising, reaching 17% or 6.9 million people in 2011.

To deal with this grave situation, in January 2014, the Federal Economic Affairs and Energy Minister Sigmar Gabriel announced an outline of revisions to the EEG bill, which include revising the reduction and exemption of surcharge for energy-intensive industries, in order to alleviate the burden on the residential sector.

Even more of a problem is CO_2 emissions. Germany’s CO_2 emissions have increased for the second consecutive year due to Energiewende and the impact of the global fuel market. According to the Federal Environment Ministry, the CO_2 emissions for 2013 are estimated at 834 million tonnes, the highest figure in the last five years. The value for 2013 exceeded even the value for 2010, before the political decision was taken after the Great East Japan Earthquake to shut down eight nuclear power plants, higher by as much as 6.1% than the 786 million tonnes of 2009 which was the lowest since Unification in 1990 (Fig. 5-3).

Fig. 5-3 Germany's GHG Emissions (1990–2013 (forecast))



Source : World Nuclear News

(2) Implications for Japan

In Japan, the reforms of the electric power system are ongoing, although the third phase of the reforms, which includes legal unbundling, could be significantly delayed as the Basic Energy Plan was not finalized due to the change in government.

Furthermore, the restarting of the nuclear power plants is being delayed due to the rigorous reviews by the Nuclear Regulation Authority, causing many general electric utilities to consider raising (again) electricity tariffs in view of their worsening finances. Furthermore, while the supply reserve margin for this summer for the nine utilities of 4.6% does meet the minimum level of 3% required for stable supply, the supply situation remains tight at 3.4% for the six utilities of central and western Japan, and 3.0% for Kansai and Kyushu.

① Securing electricity sources

In the short term, the nuclear power plants that have reached the international standard of safety should be restarted promptly, with the approval of the local community, to alleviate concern over supply in the near-term. Planned blackouts like those after the earthquake, should they recur, could cause economic losses such as the cost of blackouts described under VOLL.

In the long term, the government must set a direction for the energy mix, otherwise the power companies will not feel it is safe to invest. The decision must be made as soon as possible, considering the long construction lead-time for electricity sources (nuclear: approx. 20 years; coal and gas-fired thermal: approx. 10 years). However, the decision must also be made wisely, as there are various approaches to securing electricity sources, as exemplified by Europe's capacity markets, and the future design may change drastically depending on whether the government will be involved in securing capacity, or if it will be left to the market mechanism.

② Investing in electricity transmission

In Germany, the development of scenarios is led by the regulator (BNetzA), which ensures, through revisions to the energy business law (EnWG) and the grid expansion acceleration law (NABEG), that the scenarios are in line with the national policy targets. Regulatory authority is being strengthened by transferring to BNetzA, from the licensing right which has belonged to respective states, the land expropriation right for transmission lines that run across state or national borders.

Meanwhile, ENTSO-E's assessment is a more balanced one in which the cost benefits of the entire project, including the adjustment needed for renewable energies and the CO_2 emissions, are evaluated.

The approaches have both advantages and disadvantages, and both should be used as the situation demands.

Securing the incentives and funds for investment is becoming a challenge in Europe, which needs to double its current investment in transmission to achieve the 20-20-20 target. One option is to ensure that costs can be recovered by setting a revenue cap as in the UK, but this involves dealing with challenges such as the problems associated with the transmission company's organizational structure, and financing for and reducing the risk of new types of projects.

③ Wholesale transaction market

New players are essential for boosting the market, but it is difficult for FIT-assisted renewable energies to compete in the same market with conventional power sources. In Germany, gas-fired thermal power has been driven out of the market after being converted into a backup source. For renewables and conventional power sources to compete on an equal footing, either the renewable energies should abandon the FIT, or conventional power sources should be given allowances such as compensation for serving as a backup.

Furthermore, as an energized market will make it difficult to secure reserve capacity (kW), reserve capacity and energy security must also be considered.

The issues such as those outlined above must be solved while promoting the reforms of the electric power system. It is difficult to cherry-pick only the best and reduce nuclear dependency while also significantly reducing CO_2 emissions, while also curbing the rise in electricity tariffs.

The electricity business is becoming less profitable in Europe as well as in Japan. As the restarting of nuclear power plants continues to be delayed, the focus is shifting to how far the power companies can raise the tariffs (the size of increase that consumers can accept). For the survival of the power companies, the key is to find the right strategy for allocating funds to power generation, demand response and “smartization”, and how to switch to new high value-added businesses.

Schedule for the Reforms of the Japanese Electric Power System

	Timing	Note
Phase 1 **Establishment of a wide-area grid operator**	To be established by 2015	Established on November 13, 2013
Phase 2 **Full liberalization of entry to electricity retail business**	To be implemented by 2016	Bill submitted to the regular Diet session in 2014
Phase 3 **Further neutrality of the transmission and distribution sector by legal unbundling**	To be implemented between 2018 and 2020	Bill to be submitted to the regular Diet session in 2015

(Reference)
Germany’s Balancing Mechanism and the Strategic Actions of the Market Players

In Japan, the load dispatching control station of each electric utility matches the actual supply and demand of electricity of the entire grid every 30 minutes (30-min balancing rule). In Germany, TSO balances the supply and demand for each 15-minute time slot on the previous day, and adjusts the error in estimation on the day (planned balancing rule). As TSO is responsible for the balancing group’s[39] task of matching the supply and demand, TSO can be considered as part of the balancing group. The task of supply-demand matching performed by TSO using the market is called the “balancing mechanism”. The method of balancing supply and demand in Germany is outlined below (according to the author’s understanding).

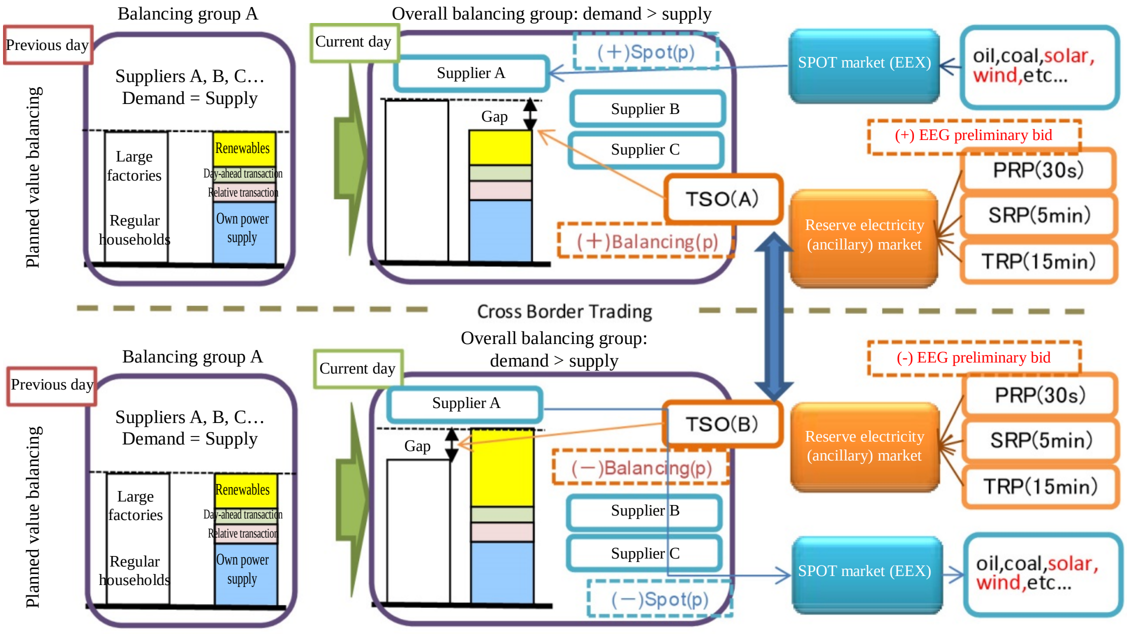
(1) Balancing mechanism of Germany

Germany’s electricity market consists of three main mechanisms:

① (General) electricity market
② Reserve electricity (ancillary) market
③ Balancing mechanism

[39] A number of electricity producers and retailers grouped together.

Reference Fig. 1 Relationship between the Balancing Groups, the SPOT Market and the Reserve Electricity Market



Source : Prepared by author.

A balancing group is participated in by a large number of players including suppliers, large-scale consumers, electricity producers and traders. Balancing group A (Suppliers A, B, C, …) must make the supply and demand match for the group at gate-closing time, based on the planned values, using its own electricity output, the transaction volume fixed on the previous day (renewables) and the relative transaction volume (Reference Fig. 1).

After the gate closes, the responsibility to ensure supply-demand balance is transferred entirely to TSO.

On the day, in balancing group A's supply area, suppose that the actual value (actual demand) exceeds the planned value (estimated demand) due to high temperature, trouble in supplier A's power supply (for instance, trouble in one of the thermal power plants), etc.

Supplier A tries to cover the shortage by increasing the output of its other power supplies and purchasing from the spot market, and to meet the demand contract with the customers.

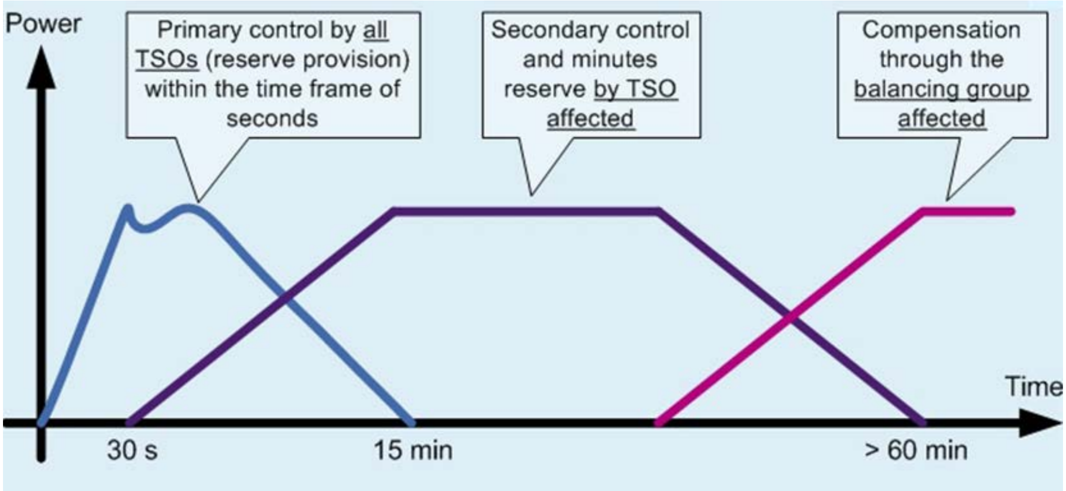
Meanwhile, being responsible for balancing the supply and demand within the area, TSO(A) tries to fill the gap between the planned and the actual values by purchasing from the reserve electricity market (separate from the spot market) the energy required to resolve the imbalance and the ancillary electricity for frequency adjustment[40]. This reserve electricity traded in the imbalance market is called primary control[41], secondary control[42] and tertiary control[43] depending on the

40 Referred to as the Balancing Mechanism.
41 Responds within 30 seconds after activation.
42 Responds within 5 minutes after activation.

response time (Reference Fig. 2). The reserve electricity is settled at the capacity price (€/MW) or reserve energy price (€/MWh) bid for in advance.

Furthermore, in the advance bid for reserve electricity, bids are placed for both "positive (increase)" and "negative (decrease)" amounts in order to respond to the large fluctuations in renewable electricity output[44].

Reference Fig. 2 Image of Response of Reserve Capacity



Source : Amprion

On the contrary, if the actual value (actual demand) underruns the planned value (estimated demand), as in balancing group B, supplier A decreases its own power supply, and TSO (B) uses a "negative" amount to cancel out the oversupply.

GCC[45] is a coordination organization based in Germany which facilitates communication between the TSOs, to control energy in a technically and economically optimal manner. GCC started out with three TSOs (50Hertz, TENNET, TransnetBW), and eventually covered the entire nation by later adding Amprion (Reference Fig. 3).

The first advantage of GCC is international connection. It has the grid open to the TSOs of surrounding countries in the cooperating area, achieving possible synergies in network control as well as flexible response. Even if electricity temporarily runs short, the flows can be controlled without putting supply security at risk.

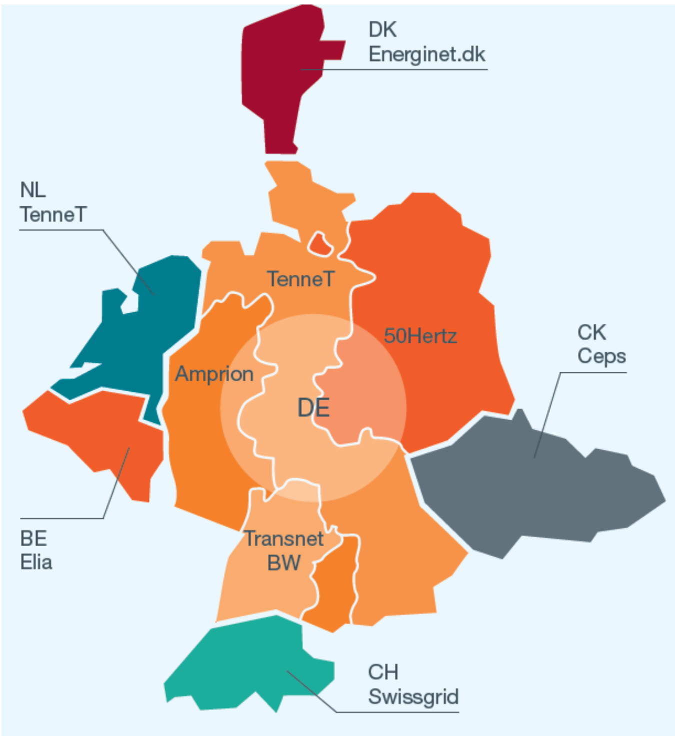
The second advantage is establishing a uniform reBAP[46] within the control area. This allows the differences between the German balancing groups to be billed based on the same reBAP[47].

Originally, the four major German TSOs, namely Amprion, 50Hertz, Tennet and transnetbwEnBW, operated the grid individually by area until May 2009, then the three companies

43 Responds within 15 minutes after activation. Complement for Secondary control.
44 Required by BNetzA to purchase electricity from a fair market, to ensure the reliability of the area.
45 Grid Control Cooperation
46 Balancing energy (mechanism) price
47 Revision of the single imbalance tariff is being considered.

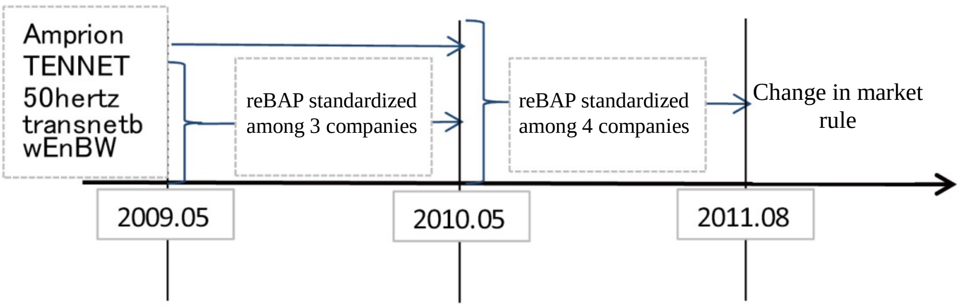
excluding Amprion decided to collaborate and standardize the reBAP. One year later, in May 2010, Amprion joined the collaboration, standardizing the reBAP among all four companies (Reference Fig. 4).

Reference Fig. 3 Connection with the Surrounding Countries by GCC



Source : GCC

Reference Fig. 4 Standardization of the Balancing Price (reBAP)

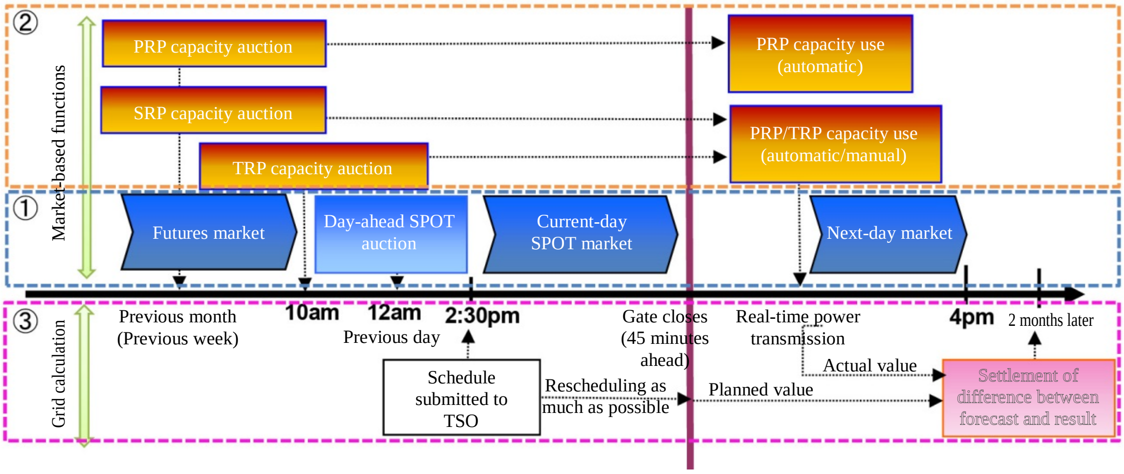


Source : Prepared by author.

(2) Time flow in the German market

The time schedule for the electricity market and the reserve electricity market are as follows (Reference Fig. 5).

Reference Fig. 5 Relationship between the Electricity Market Price and the Reserve Electricity Market



Source : Strategic Behavior in the German Balancing Energy Mechanism

① Energy market: A market in which real electricity from power stations is sold and purchased. The day-ahead spot market opens at 12 PM. Day-time market sessions are also held, the gates of which close 45 minutes before the actual supply and demand occurs, considering temperature changes and power supply troubles.

② Reserve electricity market: In parallel to ①, TSOs also purchase reserve capacity. Reserve capacity is purchased by TSO after the gate closes, to fill the gap between the estimated and actual demands. Reserve capacity is divided into primary control, secondary control and tertiary control depending on the response time, and is settled based on capacity price (for maintaining reserve capacity, €/MW), or based on reserve energy price (the amount required in real-time, €/MWh). Secondary control is divided into two segments[48] (peak and off-peak), and tertiary control is divided into six segments[49] of 4 hours, and are each bid for “positive” (increase) or “negative” (decrease) amount.

③ Balancing mechanism: This is closer to accounting than market transactions. Reserve energy cost is distributed to the party which caused the imbalance. The imbalance between balancing groups is balanced out using reserve energy. The balancing price is informed two months later.

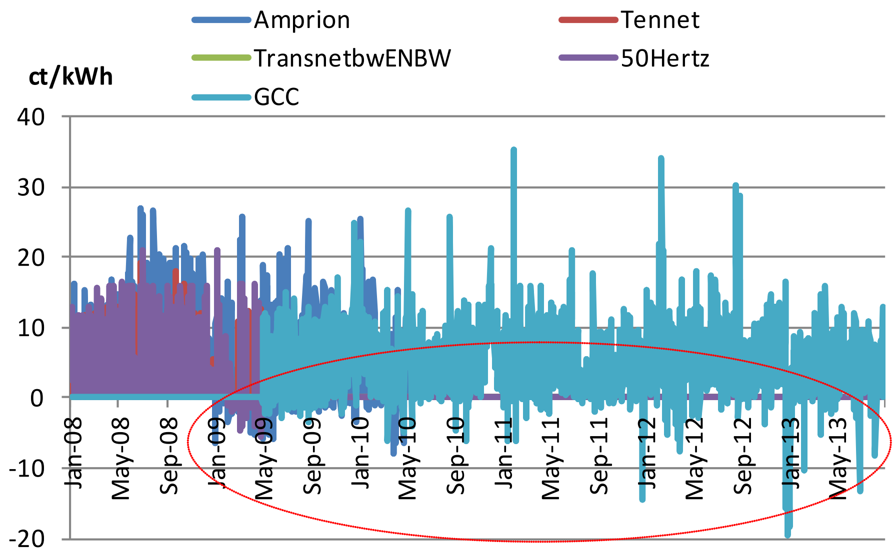
(3) Strategic actions of market players

Regarding BMP[50], recent trends show an increase in the number of days with large peaks in increments (positive). Furthermore, the price of negative amount of energy, which was stable until 2008 at around 0 euro cent/kWh, has begun to drop after the regulators began to allow negative

48 Weekly or monthly. Peak: 8:00–20:00, Off-peak: 0:00–8:00, 20:00–24:00
49 Daily. 0:00–4:00, 4:00–8:00…20:00–24:00
50 Balancing mechanism prices

(minus) prices in 2009. Since then, in case of oversupply, surplus wind power is sometimes being given away at a price, to achieve the supply-demand balance (Reference Fig. 6[51]).

Reference Fig. 6 Trends in Average BMP (2008-2013.08)



Source : Amprion

For BMP, there tends to be a gap between the increment and decrement prices. The sale of balancing energy is held weekly for secondary and daily for tertiary. The price of balancing energy is determined by the price of secondary, which has a large share.

i. Relationship between BMP and SCP[52]

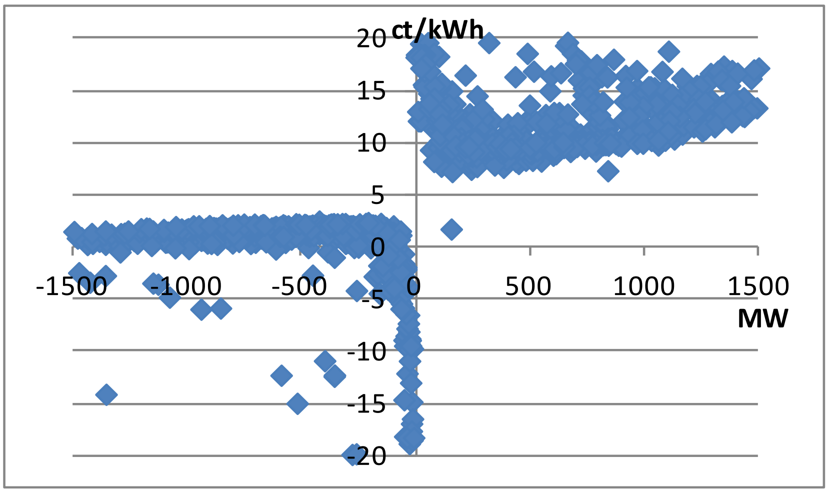
(Reference Fig. 7) shows the relationship between the increments (decrements) in MW and the BMP in the daytime[53].

The price of increments in energy is generally higher than 10 euro cents/kWh while the price of decrements is lower than 2 euro cents/kWh, though they vary slightly each year.

On the other hand, for the secondary market of the same month (Reference Fig. 8), the bidding price for increments of reserve electricity is an average of 17.30 euro cents/kWh while that for decrements is an average of 2.48 euro cents/kWh. The bids for increments tend to exceed 10 euro cents/kWh and those for decrements tend to be lower than 2 euro cents.

51 13:00–16:00
52 Secondary control prices
53 8:00–20:00

Reference Fig. 7 Relationship between the Amount in MW and BMP during Peak Hours (2012.01)



Source : Amprion

Reference Fig. 8 Trends of Bids in the Secondary Reserve Electricity Market (2012.01)

	Product name	Capacity price [EUR/MW]	Energy price [ct/kWh]	Offered power [MW]	Award
Bidder A	POS_HT	95	12.10	5	yes
Bidder B	POS_HT	98	25.17	40	yes
Bidder C	POS_HT	98	26.96	50	yes
Bidder D	POS_HT	99	25.23	30	yes
…	…				
Average			17.30		

	Product name	Capacity price [EUR/MW]	Energy price [ct/kWh]	Offered power [MW]	Award
Bidder A	NEG_HT	269	3.60	5	yes
Bidder B	NEG_HT	286	3.06	23	yes
Bidder C	NEG_HT	287	2.07	23	yes
Bidder D	NEG_HT	287	2.48	10	yes
…	…				
Average			17.30		

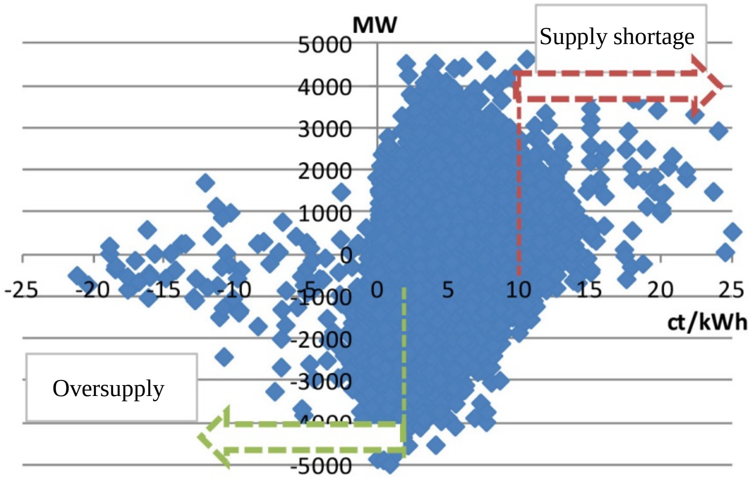
Source : regelleistung.net

ii. Relationship between the spot price and imbalance

In Germany, the reserve/balance energy prices and spot prices (day-time market sessions) are not linked in principle. However, BMP can be estimated to a certain extent by analyzing the BMP released two months later.

Furthermore, it became clear that the overall electricity market tends to face supply shortages when the price of positive amounts exceeds 10 euro cents/kWh, and face oversupply when the price falls below 2 euro cents/kWh.

Reference Fig. 9 Relationship between Spot (p) and Imbalance (MW) (2012)



Source : Prepared by author based on EPEX and reBAP.

For example, rather than increasing the output of oil-fired thermal power at a high cost or purchasing expensive electricity from the market, a supplier can cut costs by causing an imbalance (supply shortage) so that the TSO would use the balancing energy.

Therefore, by forecasting that the imbalance would become larger than expected due to wind power, it would be possible to take strategic actions like bidding for "negative" amounts of electricity at higher-than-normal prices in the reserve electricity market.

Dominant Strategies of Suppliers

	Spot (p) < Decrement (p)	Decrement (p) < Spot(p) < Increment (p)	Spot (p) > Increment (p)
Reserve electricity market	Negative bid	Strategic action (as in a game)	Positive bid
Spot market	Oversupply		Supply shortage
Expected risk	Disruption of must-run power source outside the market		(Planned) blackouts due to supply-demand crunch

In February 2012, due to historically cold weather, Germany experienced a critical supply shortage which could have resulted in a blackout. Despite the suppliers' claim that the supply capacity could not catch up with the unexpected force of the freeze, there were media reports that the suppliers intentionally avoided buying electricity from the expensive spot market, and used balancing energy instead. They suspected that the imbalance[54] within a balancing group is the result of arbitrage between the spot price and balancing mechanism price.

54 Oversupply or supply shortage

iii. Three disadvantages of strategic action

① Increase in reserve electricity to unnecessary levels

The share of spot transactions amounts to approx. 36%[55] in Germany. The strategic actions of the market players are making it necessary to secure reserve electricity to match these transactions.

② Arbitrage between the spot price and balancing price

While the energy costs to be financed from the market should be borne by suppliers, they can put it on consumers' bills as a wheeling charge by using balancing energy instead.

③ Increase in blackout risk

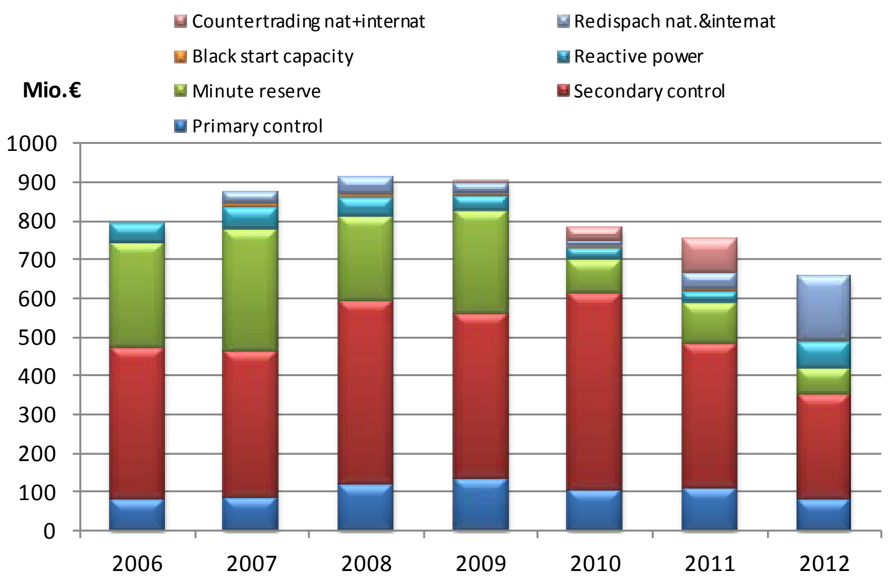
In case spot prices reach extreme levels, they could trigger an increase in inevitable load rejections and blackouts. The economic loss caused by the blackouts in northeast America and parts of Canada in August 2003 was estimated at 7–10 billion dollars.[56]

Germany's VOLL is estimated at 5,000–10,000€/MWh, and so one hour of blackout of 70,000 MW could cause an economic loss of €350–700 million.

Reference Fig. 10 shows the cost for ancillary services used for frequency adjustment, of which primary, secondary and minute (tertiary) accounts for 70 to 80%.

The cost of reactive power had been decreasing until 2011, but started to rise in 2012. Refeeding and counter trading (contrarian trading of selling when the price is rising and buying when the price is falling) are also increasing, making frequency adjustment more difficult.

Reference Fig. 10 Cost of Ancillary Services



Source : BNetzA Monitoringberichte

55 The ratio to the electricity consumption of Germany and Austria, as the electricity volume of these countries is announced as a total.

56 ICF, 2003

iv. Remedies

One remedy is to separate BMP and REP[57] (secondary, tertiary). It is not easy to extract BMP singly considering the grid system and related costs, but at least it will encourage redistribution to the market players. In its nature, the One Price Balancing Mechanism is prone to arbitrage, due to the mismatch with the spot market during major load fluctuations and the meticulous, 15-minute (balancing) scheduling.[58]

Another remedy is the contract term for secondary reserve. This could be shortened from the current one week to make it link more closely with BMP. This would help decrease strategic incentives, as the price of purchasing from the wholesale market and the reserve market would cease to be as great.

v. Future challenges

As described above, we confirmed that Germany is making up for the intermittency of renewable energies by using the balancing mechanism. The question remains, however, as to why the volume needed to offset the error in forecasting for renewable energies does not equal the sum of the volume on the market on the day and the balancing volume. To answer this question, we need to investigate the mechanisms that Amprion and other companies are using for controlling refeeding and achieving a balance between supply and demand.

57 Reserve Energy Prices

58 For example, in the morning when the load spikes, the first 15 minutes would be an oversupply while the last 15 minutes would be a supply shortage.