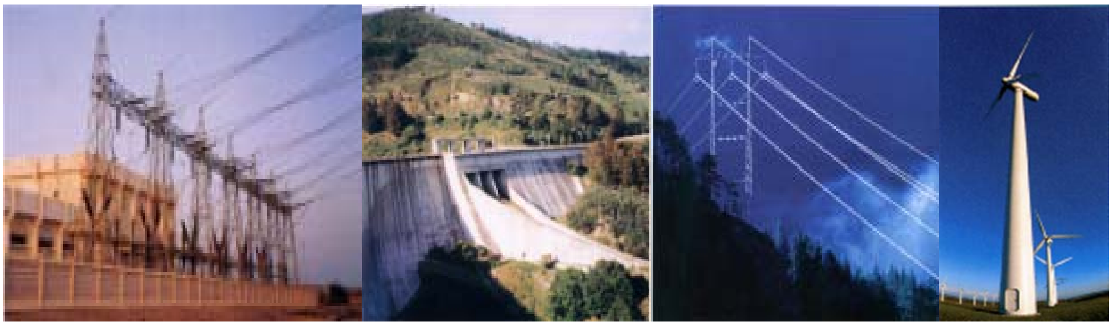
Germany Country Report



Innovative Electricity Markets to Incorporate Variable Production

to

IEA – Renewable Energy Technology Deployment

May 2008

IPA Energy + Water Consulting

COWI A/S

SGA Energy

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IPA Energy + Water Economics
41 Manor Place
Edinburgh
EH3 7EB
Scotland

Tel: +44 (0) 131 240 0840
Fax: +44 (0) 131 220 6440
Email: contact@ipaeconomics.com
web: www.ipaeconomics.com

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1 MARKET MECHANISMS

This section provides an overview of the operation of renewable generation within the German power markets. It primarily considers federal regulations and market conditions, but also refers to regional specifications on the level of the "German Laender" (federal states) where applicable.

1.1 Renewable Generation Capacity

The importance of renewable energy sources (RES) has increased significantly in the German energy markets over the last years, in particular as regards power generation. RES accounted for 12% of electricity generation in 2006 and therefore provides a significant contribution to the German energy supply portfolio. Total installed electrical capacity in 2006 was 30,893 MW, an increase from 4,651 MW in 1990 and 11,448 MW in 2000.[1]

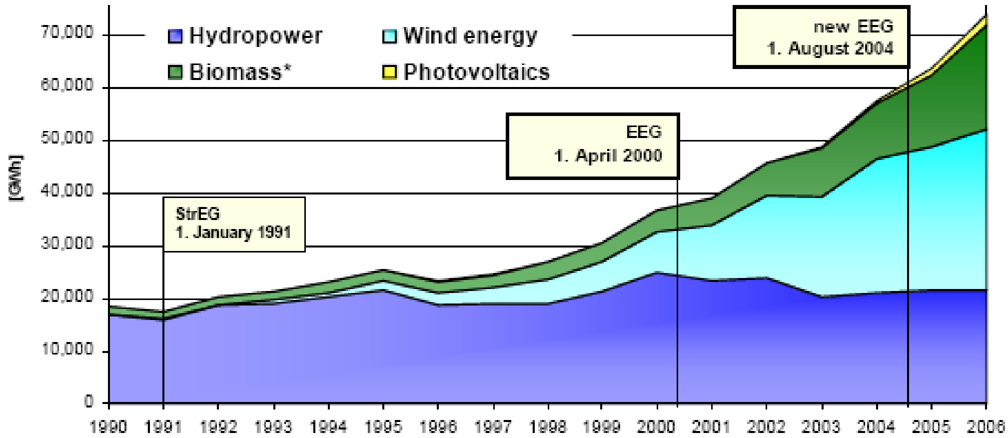
In 2007, the German Minister for Environment recommended an increase in Germany's targets for renewable energy. The Ministry of Environment announced an increase in the target for 2020 from 20% to 27% and added a target of 45% by 2030. Previously, Germany had set a renewable target of 50% of total energy consumption by 2050. [2]

Table 1: Contribution of renewable energy sources to supply in Germany in 2006 [1] [2]

Renewable electricity	TWh
Wind	30.5
Hydro	21.6
Biomass	17.8
Of which, solid (inc. biogenic waste)	*10.8*
Of which, biogas	*5.4*
Of which, liquid biomass	*1.6*
Landfill and sewage biomass	1.9
Photovoltaics	2.0
Geothermal	0.0004
Total electricity	***73.9 TWh***

[1] This includes wind, hydro, biomass, PV and geothermal for electricity production.
[2] This is in line with a recommendation by the Minister for Environment to amend the REA, following the 2007 progress report.

Figure 1: Contribution of renewable energy sources to electricity generation in Germany 1990 – 2006 [2]



*Biomass includes solid, liquid, gaseous biomass, biogenic share o f waste, landfill and sewage gas

1.1.1 Wind

The total installed capacity of wind generation was 20,622 MW in 2006, producing 30.5 TWh of electricity which is 5% of total power supply. This is a growth in capacity of 24% compared to the previous year. However, annual growth rates are decreasing. The slow-down seems to be primarily due to the declining availability of suitable sites. This has lead to an increased focus on "repowering" instead of new-build, which added generation capacity of 140 MW in 2006. The largest potential for new development lies in off-shore wind farms in the North and Baltic Sea, where wind conditions are excellent.

Under the overall management of the Federal Ministry for the Environment, Nature Conservation and Reactor Safety (BMU), the German government has developed a plan to utilise offshore wind energy that takes nature conservation and other interests into account. The installation of 20,000 to 25,000 MW of offshore capacity is seen as possible by 2030. The plan identifies low-conflict areas for consideration as possible special areas suitable for offshore wind energy use. These areas have been appraised with respect to different interests. They are classified as special areas suitable for wind energy utilisation, based on the Marine Facilities Ordinance. The Federal Nature Conservation Act (Bundesnaturschutzgesetz) sets out regulations for the construction of offshore windfarms and is designed to preserve marine nature reserves.

1.1.2 Solar

Germany also has a leading global position in solar energy (both PV and thermal). Due to support under the Renewable Energy Act, solar power increased by a factor of 4 over the last three years, extending annual generation to around 2 TWh. While a significant share of solar energy is used to generate domestic heat, grid-connected PV had a share of 0.3% of total primary energy consumption in 2006.

1.2 Renewable Generation Size

In 2005, a total of 3,320 MW was connected to the low- and medium voltage and transformation grid. There is a tendency towards smaller decentralized generation systems [3].

The remainder of this document focuses on the arrangements for larger transmission connected renewable generation.

1.2.1 Renewable Generation Location and Authorisation

Applications for construction of RES installations, in particular large scale wind farms, are subject to building regulations.

Authorisation: Federal Immission Control Act
The Federal Immission Control Act provides the main legal framework for authorisation of wind farms. Where the total height of the wind turbine installation exceeds 50m (including the rotor), the construction has to be cleared as regards immission[3] controls Smaller installations are subject to the regional building codes of the German “Laender” or states. Over the last few years, decisions under regional regulation concerning wind energy projects have tended to be more restrictive [4].

The authorisation procedure under the Federal Immission Control Act (Bundesimmissionsschutzgesetz) does not generally require public consultation. However, if the wind farm is larger than 20 turbines, an Environmental Impact Assessment (EIA) has to be carried out and the authorisation procedure is carried out in public. In case of six to 19 individual installations, a preliminary evaluation is carried out to decide whether an EIA is necessary. Once authorization is granted, no further mandatory procedures exist.

Location: Federal Building Code
Wind and hydropower plants are (like nuclear power plants) are exempt from the general ban on building in underdeveloped outskirts under the Federal Building Code (“Baugesetzbuch”). Hence wind power installations cannot be contested unless prior official plans for alternative use by the municipality exist.

[3] The term ‘immisions’ refers to the penetration of a pollutant into the environment (as opposed to ‘emissions’, which refers to the output of a pollutant from a source). The term is commonly used in Germany in relation to pollution and noise.

1.3 Renewable Generation and Power Markets

The German electricity market is the largest in Europe. Total net consumption summed up to 532 TWh in 2000. Total installed net generating capacity at the beginning of the year 2000 amounted to 116 GW (25% hard coal, 22% gas, 18% nuclear power, 18% lignite, 8% hydro power, 5% wind, 4% oil and others).

Immediately after liberalization of the energy market, eight major integrated energy companies existed that subsequently developed into four major players through a number of international and domestic mergers and acquisitions: RWE, EnBW, E.ON. and Vattenfall Europe. All these remaining generation companies are vertically integrated, but legally unbundled. After the mergers, the generation capacity share of the largest four companies increased from 42% of total German generation capacity to 61%.

1.4 Degree of Centralisation

The German transmission system comprises four control zones, forming the German control block. Each control zone is operated by one transmission system operator (TSO) which operates and owns the assets. German TSOs are RWE Transportnetz Strom GmbH, EnBW Transportnetz AG, E.ON. Netz GmbH, and Vattenfall Europe Transmission.

Regulation of the electricity market has been assigned to the Federal Network Agency (Bundesnetzagentur) which ensures third-party-access (TPA) to networks and polices the use-of-system charges levied by market players to maintain effective and fair competition.

1.5 Support Mechanisms

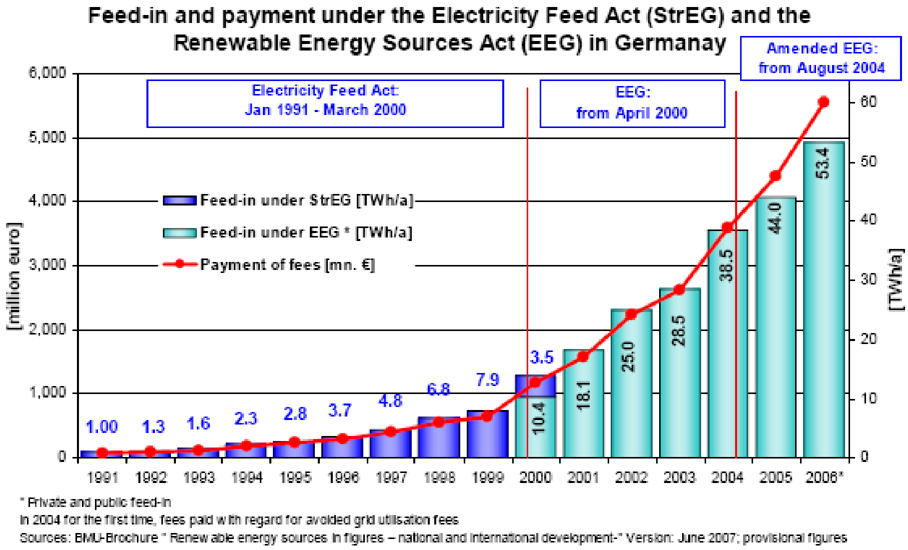
RES in Germany are mainly promoted by feed-in tariffs under the Renewable Energy Sources Act (Erneuerbare Energien Gestez, EEG), the Market Stimulation programme and a number of smaller indirectly supportive government programmes and policies. In addition, the Reconstruction Loan Corporation ("Kreditanstalt fuer Wiederaufbau", KfW) offers and manages a number of preferential loans systems and capital grant schemes for RES installation.

1.5.1 2004 Renewable Energy Sources Act

The Federal Electricity Feed-In Code was replaced by the Renewable Energy Sources Act (EEG) in 2000. The Act was amended on 1 August 2004. The particular aims of the amended EEG are to increase the share of renewable sources in the total electricity supply to at least 12.5% by the year 2010 and to at least 20% by the year 2020.

About 54% of the revenue from feed-in tariffs is captured by wind power while 15% is allocated to PV installations. The contribution from independent RES generators is relatively high, amounting to 45 TWh of power provision in 2006 [5].

Figure 2: Cost of the feed-in tariff and total generation [2]



* Private and public feed-in
In 2004, fees began to be paid to generators for avoiding utilisation

The core elements of the EEG are:

- Priority connection of installations for the generation of electricity from renewable energy and from mine gas to the general electricity supply grid
- Priority purchase and despatch of this electricity
- A consistent fee for this electricity paid by the grid operators, generally for a 20-year period, for commissioned installations. This payment is geared around the costs
- Nationwide equalization across TSOs of the electricity purchased and the corresponding fees paid.
- The fee paid for the electricity depends on the energy source and the size of the installation. The rate also depends on the date of commissioning; the later an installation begins operation, the lower the tariff (degression) [4].

The degression also leads to installations being constructed as quickly as possible, in order to obtain a high payment level. This is intended to discourage operators from waiting until installations become cheaper. The EEG is also designed to promote high-quality installations as payment is made per kWh produced, so there is an incentive for operators to run their installations efficiently and with as little interruption of operation as possible, at least during the usual 20-year payment period.

[4] Degression is the percentage reduction in the tariff in upcoming years. It serves to reduce the tariff to compensate for expected future price reductions in the capital cost of the RES asset.

Feed-In Tariff Rates

The EEG prescribes fixed tariffs which grid operators must pay for the feed-in of electricity generated from hydro, landfill gas, sewage treatment and mine gas, biomass, geothermal, wind, and solar sources. The minimum payments (differentiated by energy source) vary depending on the size of the installation.

The tariff level is based on actual generation cost of the respective technology. Table 2 shows tariff rates for the year 2004.

Table 2: Payment under the Renewable Energy Sources Act

Technology	Size	Remuneration in 2004	Annual reduction factor for newly commissioned plants
Hydro, sewage gas, landfill gas, marsh gas	< 0.5 MW	€ 0.0767 per kWh	-
	0.5 – 5 MW	€ 0.0665 per kWh	
Biomass	< 0.5 MW	€ 0.101 per kWh	1% p.a.
	0.5 – 5 MW	€ 0.089 per kWh	
	> 5 MW	€ 0.084 per kWh	
Solar	< 5 MW	€ 0.457 per kWh	5% p.a.
Wind	No limits	€ 0.059 per 0.087 per kWh[1)]	1.5% p.a.
Geothermal	< 20 MW	€ 0.0895 per kWh	-
	> 20 MW	€ 0.0716 per kWh	

[1)] *Depending on specific wind conditions on site.*

The tariff rates are adjusted annually. However, in principle the guaranteed payment period is 20 calendar years (or for hydropower 15 or 30 years, depending on plant characteristics). The tariff for the year of commissioning remains constant for that generator, with the exception of wind energy.

In order to take account of technological developments and of the economic efficiency of these developments, and to optimise the use of cost reduction potential, the tariffs for most branches are digressive in structure. The digression annually lowers the payment rates in all branches for new installations (except small hydropower plants).

Two different rates are paid for electricity generated by wind: for an onshore wind farm, a starting fee is paid for electricity produced for the first five years after commissioning. After these first five years, a lower basic fee is applied. It is an unusual feature that low-cost renewable energy producers are compensated at lower rates than higher-cost producers, providing strong incentives for the development and operation of renewable energy installations on lower-quality sites. The period of higher fees can be extended according to the wind conditions at the site. Regardless of siting, the total payment period is restricted to 20 years. For offshore wind farms, starting fees are paid for 12 years. This period is extended for installations located further from the coastline and erected in deeper water.

Wind farms which do not achieve at least 60% of the reference yield at the planned location cannot claim payment under the 2004 law. For coastal sites in particular there are new incentives for so-called “re-powering”: the replacement of old, smaller installations with modern, more efficient ones. Higher starting tariffs for offshore wind farms will be paid for installations commissioned before 2010.

More wind energy is generated in the North of Germany due to higher wind speeds. To prevent regional inequality in electricity cost to consumers, the transmission grid operators undertake a nationwide equalisation of the electricity volumes purchased under the Renewable Energy Sources Act (EEG).

Future Support
Germany's Renewable Energy Sources Act is reviewed every three years. Germany's Ministry for the Environment issued a progress report in July 2007 [7] that lays out recommendations to amend the Renewable Energy Sources Act. The recommended new rules would, if adopted, significantly increase the tariffs for offshore wind energy, hydroelectricity and geothermal energy beginning in 2009. The annual degression rate for onshore wind energy, solar/PV and biomass will be reduced.

1.5.2 Market Stimulation Programme

In 1999, the new government also introduced the Market Incentive Program (MAP), which offered government grants totalling 203 million Euros in 2003 alone for the commercialization and deployment of renewable energy systems. The Program earmarks 30 million Euros for export promotion. The German government considers MAP to be one of its most effective current renewable energy promotion programs, particularly since funds from the program may be leveraged with other government funds.

RES are not exempt from the eco-tax which applies to all electricity irrespective of generation source.

Revenues from this tax are used to finance the Market Stimulation Programme which supports the further development of RES technologies. The Programme primarily serves the expansion of heat generation from biomass, solar power and geothermal energy.

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1.5.3 Federal States Support for RES

In addition to federal policies, laws and funds, the federal states (Laender) provide further support for RES. Hence there may be regional variations in technological focus and levels of financial support. While the most successful instruments of support at the federal level concern the use of renewable sources for electricity generation, on a regional state level the promotion of renewable technologies focuses on heating and cooling. Photovoltaic and biogas systems receive the majority of support.

1.5.4 Loans and Capital Grant Schemes by the Reconstruction Loan Corporation

The Reconstruction Loan Corporation offers and administers several soft loans schemes which have been set up to indirectly support the deployment of RES technologies. Financing programmes are open to the private and public sector and focus on various technologies. Most programmes offer sub-market level interest rates with credit terms varying between ten and twenty years and a redemption-free initial phase.

Table 3: Loans and Grant Schemes by the Reconstruction Loan Corporation

Preferential Loan Programmes	
Technological focus	use of RES and conversion of heating systems; solar power generation; construction and modernisation of energy efficient buildings
Eligible parties	Private building sector targeted under SME Programme ("KfW-Mittelstandsprogramm"); public sector targeted under Infrastructure Programme ("KfW-Infrastrukturprogramm")
Credit terms	10 to 20 years
Redemption-free phase	Varied
Interest rate	1 to 2% below market interest levels
Value	Varied
ERP-Environment and Energy Savings Programme *(since 1990)*	
Technological focus	Traditionally wind power, but recent increase in support for solar PV
Eligible parties	Private companies, freelancers, public-private partnerships
Credit terms	10 to 20 years, maximum of 50% of total capital cost is eligible for funding but loans can be combined with other KfW loans
Redemption-free phase	2 to 5 years
Interest rate	1 to 2% below market interest levels (average in 2006: between 4% and 7%)
Value	€10.7billion between 1990 and 2005
Producing Solar Power *(since 2005)*	
Technological focus	Small investments in solar PV generation
Eligible parties	Mainly private investors seeking loans for projects up to €50,000
Credit terms	10 to 20 years, 100% of the investment cost can be financed
Redemption-free phase	2 to 3 years
Interest rate	3.6% to 4.15%
Value	€784 million in July 2006

1.6 Trading

A single power exchange operates in Germany, the European Energy Exchange (EEX).

The first German power exchange, the Leipzig Power Exchange (LPX), started operations on 15 June 2000 and was the first market which quoted hourly prices.

The trading system mirrored Nord pool's SAPRI scheme while the Scandinavian power exchange was also a major shareholder (35%). On 8 August 2000, a second power exchange opened, the EEX in Frankfurt. EEX used Eurex's XETRA trading system. Both exchanges merged in July 2002 and formed the new EEX based in Leipzig.

- **Long-term:**

  EEX-Futures Market, OTC-Trading

- **Day-ahead:**

  No grid constraint restricting day-ahead trading across Germany no fee for crossing control area boundaries

- **Intra-day:**

  Ex-post schedule modification within control areas cross control area modifications between EnBW and RWE on 3 specific points in time per day

- **Balance energy and control power:**

  Procurement by each TSO predominantly from Germany-based power plants

- **Cross-border capacity allocation:**

  Explicit auctions at the borders to DK, NL, PL/CZ

The EEX organizes the day-ahead spot market and intra-day spot market. The market area for the day-ahead spot market encompasses the four German control zones and the Austrian control zone of Verbund Austrian Power Grid (APG). The intra-day market consists of the four German control zones only.

EEX also offers a derivative market for futures (including monthly, quarterly, yearly) and options for the Physical Electricity Index (Phelix) (base load or peak load). The Phelix is based on the day-ahead market price and calculated daily, with the Phelix base load index representing the average spot price at the hourly German/Austrian auction.

While there are numerous market players in the electricity market, it is not considered competitive, due to the high degree of vertical and horizontal integration, and the dominance of a few large companies. The German electricity industry is dominated by four large electricity companies (RWE, E.ON, Vattenfall and EnBW), which together control 90% of the country's generating capacity, almost the entire high voltage transmission network and about half the retail market [8]. This structure, in combination with the congestion prevailing at all German borders except Austria, is thought to prevent the development of effective competition. Although many new suppliers entered the market upon its liberalization in 1998, the number has fallen sharply in recent years with many providers choosing to exit the market. Of the new entrants that have remained, most are active in the industrial sector, with only very few competitors striving for market share in the household sector. Electricity end-user prices for households were regulated until 1 July 2007. German customers pay electricity prices that are among the highest in the EU.

Wind power is not traded directly on the spot market but indirectly via the balancing mechanism. As a result the day-ahead wind power forecast influences the spot market price. Intra day deviations from the forecast are valued via the balancing mechanism. Wind is not balanced through the conventional balancing mechanism, but instead through a dedicated renewable energy balancing group coordinated by the TSO.

Theoretically wind could participate in the EEX intra-day market. However due to the feed in mechanism there is no need for it to participate in the market. As a consequence, only the TSOs actually deliver wind power into the market.

German TSOs are obliged purchase and balance wind and other renewable power generation. Consequentially, even though wind generators do not trede directly on the market the day-ahead wind power forecast influences the spot market prices at the EEX and can decrease the daily average sport market price by €1.89/MWh per additional 1000MW of predicted wind power generation.

A 'tri-market coupling' between Germany’s neighbours, Belgium, France and Netherlands was established November 2006. Germany and Luxembourg electricity markets are set to be integrated with these markets into a single regional area by 1 January 2009.[5] The intention is that market coupling of short-term electricity markets will lead to a more efficient use of interconnection capacities, providing more opportunities for energy suppliers to buy and sell power and to optimize their portfolios.

1.7 Despatch

The obligation to purchase and transmit power from RES is legally binding under the Renewable Energy Sources Act: transmission system operators are obliged to purchase and transmit all available electricity from these installations. Consequentially, variable energy including wind and solar power are prioritised in despatch and usually not curtailed for economic or operational reasons unless security of supply is at risk.

If over-frequency is greater than 50.52 Hz, wind farms connected to the transmission system are required to limit their output power.

1.8 Notification

Variable power flows have an influence on electricity trading in Germany as regards the day-ahead wind power forecast.

[5] A Memorandum of Understanding (MoU) agreeing on the implementation of a coupled market was signed between governments, regulators, power exchanges, transmission-system operators and the electricity associations of the participating countries on 6 June 2007.

The EEX uses the SAPRI exchange system for the auction market of single hours. Bids and offers must be submitted to the exchange by 12pm. of the day before delivery. Market results are published by EEX by 12:30pm and become binding half an hour later. All trading ceases at 2:30pm when binding schedules have to be reported to the TSOs. While trades in principle are possible between the end of the EEX auction and market closure at 2:30pm, traders report that volumes on the OTC market are low in that period.

Table 4: Day-ahead and Intra-day Trading

	Day-ahead	*Intra-day*
Market area	Four German control zones + APG	Four German control zones
Opening	7:30am at D-14	3pm on D-1
Gate closure	12pm at D-1	75 minutes before delivery
Contracts	Hourly supplies, block contracts	Hourly supplies

1.9 Imbalance Settlement

The German balancing system is based on distributed balance responsibility, administered by the balance responsible parties (“Bilanzkreisverantwortliche”). Imbalance is settled on a 15minute basis. The energy prices for imbalance are directly based on the actual costs for balancing power of each TSO.

To balance unforeseen variations in power immediately, minute and hourly reserves must be provided as positive and negative regulation capacities. Positive reserve capacity is needed to compensate for unexpectedly low generation (or high demand). Negative reserve capacity is needed to compensate for unexpectedly high generation (or low demand). These capacities must be maintained in operational readiness.

Prices for positive and negative imbalance are symmetric; hence, a balance responsible party with a surplus of energy receives the same compensation per MWh that a balance responsible party with a shortage must pay, independently of the status of the control zone.

1.9.1 Impact of wind on balancing

In 2003, an average of 1,200 MW and a maximum of 2,000 MW of wind-related positive regulation power had to be available one day ahead in Germany. By 2015, that amount is expected to have risen to an average of 3,200 MW and a maximum of 7,000 MW. The mean value corresponds to 9% of the installed wind power capacity and the maximum to 19.4%. These capacities have to be available as positive minute and hourly reserves [9].

Due to the priority despatch of wind and other renewable energy under the Renewable Energy Act (EEG), negative reserve capacity has to be maintained to compensate for high wind generation.

As regards negative regulation capacities in the 2003, an average of 750 MW and a maximum of 1,900 MW had to be available one day ahead. By 2015, that amount is expected to have risen to an average of 2,800 MW and a maximum of 5,500 MW. The mean value corresponds to about 8% of the installed wind power capacity, and the maximum to 15.3% [9].

1.10 System Balancing

Both producers and consumers are obliged to contract their true expected generation and consumption on regular electricity markets. A balancing/reserve market exists to meet unforeseen variations in demand and supply.

In Germany, TSOs are responsible for provision of reserve and balancing services. Availability of a total of 6 to 8GW reserve and balancing capacity is required. This capacity is directly contracted by TSOs in a tendering procedure and therefore is not available on regular markets.

The reserve power consists of primary and secondary reserves and minute reserves. The main difference between primary, secondary and tertiary reserve is the time delay before the reserve capacity is available.

Primary control:

- Provided by all TSOs inside the UCTE (Union for the Co-ordination of Transmission of Electricity) area
- Activated within 30 sec
- Time period per single incident: **0 to 15 minutes**

Secondary control:

- Direct and automatic activation by the affected TSO
- Activated within 5 min
- Time period per single incident: **30 seconds to 15 minutes**

Minutes reserve (also known as tertiary or reserve power):

- Telephonic and schedule-based request by the affected TSO at the respective suppliers
- Manually activated according to the 15 minute schedule time frame or within 15 minutes.
- Time period per single incident: **less than 15 minutes up to one hour** (or several hours in some circumstances)

According to the UCTE rules, the four German TSOs participate in the provision of primary control power that is required within the entire synchronous area of the UCTE.

Each TSO is responsible for the maintenance of secondary control and minutes reserve power in its own control area. By means of a mathematical approach, the German TSOs determine the necessary volume of secondary control and minutes reserve power for their control areas in such a way that the defined residual risk probability of a power surplus or deficit that cannot be balanced is not exceeded.

The German TSOs are required to procure their primary control, secondary control and minutes reserve in an open and non-discriminatory control power auction. Primary control and secondary control power are procured in a six months cycle. Daily auctions for minutes reserve are also in place, which are held independently of the regular electricity market and regionally separated for the four balancing and reserve zones.

Procurement is ensured through competitive bidding on a tender basis in the German control power market where a large number of suppliers (generators as well as consumers) participate, especially for minutes reserve. The response time limits the types of plants able to provide the service, especially for primary and secondary reserve. Primary and secondary reserve can be provided by storage and pump storage plants, and by operating plants that can vary their load factors. Tertiary reserve can also be provided by “cold reserve”, such as gas turbines. Potential suppliers of balancing power must pre-qualify by proving that they are able to meet requirements for the delivery of balancing power (including technical competence, and operational and economic capability).

Due to the close cooperation among German TSOs, a supplier can provide his control power successfully within the German control block without being immediately connected to the control area of the procuring TSO. Since 2004, suppliers from the Austrian control areas of TIRAG and VKW have also participated in the German market for minutes reserve.

The tariff system for the settlement of imbalances of a balancing responsible party is a single price system showing the following characteristics:

- Prices for balancing group deviations are calculated on a 15 minute basis;
- Prices are determined on the basis of the TSO’s payments for (or revenues from) the secondary control and minutes reserve energy used;
- Single, symmetrical price per 15 minute time interval, i.e. no price spread between positive and negative balancing group deviations;
- Balance responsible parties showing a <u>surplus</u> get <u>paid</u> the price for balancing group deviations;
- Balance responsible parties showing a <u>deficit</u> have to <u>pay</u> the price for balancing group deviations;
- Prices for deviations are published on the TSOs’ websites accessible to all market participants;

- Costs for the maintenance of primary and secondary control power and minutes reserve (power prices) are part of the socialised transmission network tariffs.

1.10.1 Balancing of Variable Generation

There is a high regional dependency in the system balancing of wind and other variable generation. Considerably more electricity is generated from wind power in northern Germany than in the south.

Because of this there are times when generation can exceed demand in the northern control zones (RWE Transportnetz Strom, E.ON. Netz and Vattenfall Europe Transmission). This is not a problem in the southern control zone (EnBW Transportnetze).

Renewable generation is not part of general system balancing, but is instead balanced by a separate balancing group (EEG Bilankreis). After a horizontal equalisation of renewable energy feed-in between the four TSOs the balancing responsibility is taken by each TSO for their own grid area.

The TSO then has responsibility to balance the variable contribution from renewable energy compared to the nominated value. They do this through OTC trades, intraday markets and minute and secondary reserves. The cost of balancing this renewable generation is met through the socialised transmission tariff.

2 CROSS BORDER TRADING

Germany is connected to most of its neighbouring countries, except Belgium. Information on the German borders with the Nordic region (i.e. the Swedish and Danish borders), and with the Netherlands and France can be found in the respective country reports.

2.1 Current Cross Border Flows

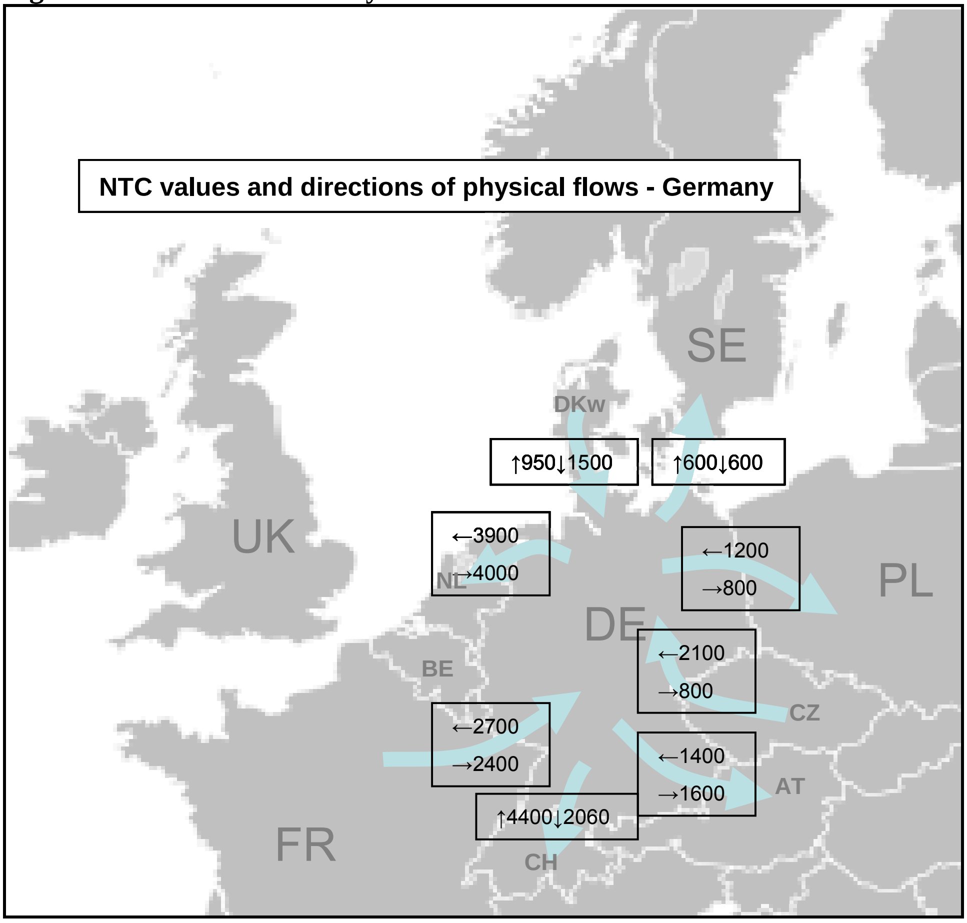
In practice, transmission capacities at all Southern borders are unconstrained. Congestion is also rare on the French border. On the Eastern borders, and especially for export to the Czech Republic, congestion occurs more often.

The networks of Germany, Poland and the Czech and Slovak Republics are strongly interacting. The total net transfer capacity from Poland to the Czech Republic, Germany and the Slovak Republic is 900MW but the return value is given as zero.

The maximum cumulated export capacity from Germany to the Netherlands, France and Switzerland is 8500MW, with usage highly depending on the wind situation in Germany [10].

The map in Figure 3 depicts the NTC values as calculated by the German TSOs and its neighbouring counterparties and also indicates the flow direction of average physical transfers in 2006.

Figure 3 NTC Values and Physical Flow Directions[6]



While power is imported from Denmark, France and the Czech Republic, German exports largely target Sweden, Poland, Austria, Switzerland and the Netherlands.

2.1.1 Potential Future Interconnector Capacity

Germany's central geographical position makes it a major player in the European power market. However, crossborder connections remain congested, in particular in the North. To alleviate the situation, a feasibility study is currently being carried out on the possibilities of increasing the NTC values between Germany and the Netherlands. Further, planning activities to increase NTCs are ongoing with both TSOs in Poland and Germany.

There are also ongoing planning activities concerning a new interconnector between the Czech Republic and Germany (Vitkov the Czech Republic to Mechlenreuth or from the Czech Republic to Pleinting). A first feasibility study of an additional 380kV interconnection between Vitkov and Mechlenreuth was carried out.

[6] ETSO, UCTE

Planning activities between Austria and Germany exist concerning a replacement of the existing 220-kVinterconnector Altheim-St. Peter (AT) by a new 380-kV-interconnector St. Peter (AT) – Isar (DE) to increase the transport capacity between Austrian TSO APG and E.ON Netz.

2.2 Cross Border Capacity Mechanisms

Cross-border capacity for all borders is allocated in explicit auctions on a yearly, monthly and daily basis.

Currently, no wind power is explicitly traded over the borders. However, the levelling procedure for wind power by the German TSOs requires a procurement of power from the day-ahead market. In principle, this power could be generated outside Germany as long as the interconnector capacity is available day-ahead.

The UCTE day-ahead congestion forecast (DACF) is based on the schedules of the different control blocks and the allocated capacity. As such it takes into consideration the exchange flows based on wind power trade as far as they are nominated day ahead.

All TSOs apply short-term predictions of the aggregated wind power generation in their control areas.

The production has to be scheduled day-ahead (i.e. 9.5 – 33.5 hours before delivery). There is a limited possibility for intra-day trading: schedules can be updated 3 times a day but the option is restricted.

The intra-day market currently is mainly a national market. As far as wind power is traded intra-day this also happens on a national market. For Germany, an intra-day coupling to Nord Pool and with Austria could facilitate the use of hydro power for compensating the wind power prediction error [10].

2.2.1 Germany - Switzerland Interconnector

On the German-Swiss interconnector, capacity is allocated in annual, monthly and daily auctions with a clip size of 1MW.

Capacity restrictions apply to annual and monthly auctions where only 40% of the total available transmission capacity can be auctioned. Auction prices are only charged if the sum of bids by users is above available capacity.

Different control areas exist on the German-Swiss interconnector and daily auction participants notify their schedules for crossborder trading between Germany and Switzerland to TNG, RWE TSO, VKW Netz and swissgrid in those control areas between which they purchased capacity.

On-sale is allowed; the use-it-or-loose-it principle applies.

2.2.2 Germany - Austria Interconnector

On the German-Austrian border, capacity is virtually considered unconstrained. Therefore, the APG control zone can participate in the EEX day-ahead market even without flow-based market coupling.

2.2.3 Germany – Czech Republic and Poland Interconnector

The East-German border is part of the multilateral market between the Czech Republic, Poland and Slovakia.

Congestion management

At present, capacity for minimum volumes of 1MW and maximum volumes of 50MW is allocated via annual, monthly and daily explicit auctions. CEPS a.s. and Vattenfall Europe Transmission GmbH (VE-T) have agreed to investigate the possibility of crossborder intraday trading on their common border.

However, the auction price is set forth independently of the actual use, and other transmission fees if applicable, separately in each control area.

Each auction participant is entitled to link his bids – create a group of bids for reservation of capacity on more than one commercial profile or, in case of a daily auction, for more than one hour. Linking bids means that when all bids in the group – linked bids – are successful, the auction participant will acquire the promise of the capacity according to auction rules.

Allocated capacity is freely transferable on an hourly basis but capacities allocated by way of daily auctions cannot be transferred to other auction participants. The use-it-or-loose-it principle applies.

2.3 Cross Border Trading

Within the context of the first round of mini fora (as established in Florence 2005), the Germany EEX has initiated discussion on open market coupling in the Central West Europe region (including France, Benelux and Germany), by which transfer capacity is allocated concurrently with electricity being traded via implicit auctions, organised between two or more separate market operators. Germany is currently looking into the feasibility of implementing OMC.[7] A memorandum of understanding was signed in June 2007 for the introduction of OMC in Central Western Europe [14]. OMC would see the introduction of one regional auction coordinator and available transmission capacities will be calculated through a load flow-based process. Market coupling is also planned with the Nordic Countries and implementation has started between Germany and Denmark [15].

[7] Studies on the feasibility of OMC are in references numbers [11], [12] and [13]

2.3.1 Germany – Switzerland

Available transmission capacity on the German-Swiss border is traded within annual, monthly, daily and intraday explicit coordinated auctions. The participating TSOs are EnBW and RWE on the German side and VKW together with the Swiss capacity coordinator swissgrid (formerly ETRANS) on the Swiss side. EnBW is the auction coordinator.

The auction partners make transmission capacity available within their range of means, i.e. capacity is traded non-firm.

The deadline for the latest auction is on working days at 9.30 on D-1 (one day ahead of real time). Capacity for this auction is published 30 minutes before and the user is notified of its allocation at 10h. The capacity holder then has to submit a schedule before 14.30h.

Apart from the annual, monthly and daily auctions, intraday trading is also possible, with the first auction at 14.30h and the latest auction at 18h. Purchase is free of charge on a first-come-first-serve basis and with obligatory use.

Capacity rights can further be traded in secondary trading and resale is possible into subsequent auctions. Balancing power can be provided crossborder: EnBW Transportnetze AG holds energy accounts in form of accounting grids for traders that are active within its control zone. EnBW, as the responsible TSO within the control zone, ensures a balanced account each 15 minutes. Prices for balancing energy are calculated based on the costs of obtaining power to balance load cover in the control zone [16].

Lack of information is a problem on Southern German interconnectors: While spot market prices in countries South of Germany are comparable on average, they can differ significantly at specific instants in time although no congestion occurred. This is because at gate closure of the national day-ahead spot markets, the market results of the other markets are not known. Implicit auctions in the form of market coupling of interconnector capacity are generally considered a solution for this.

2.3.2 Germany – Austria

On the German-Austrian border, capacity is virtually considered unconstrained. Therefore, the APG control zone can participate in the EEX day-ahead market even without flow-based market coupling.

2.3.3 Germany – Czech Republic and Poland

Due to the technical constraints in the regional transmission grid, technical profiles may be congested while contracts for electricity transmission are realised. Therefore, TSOs agreed to continue in a common regional auctioning procedure of capacities on the borders between them and to allocate available capacities on the congested technical profiles to market players. Auctions are organised by one auction office (www.e-trace.biz), managed by CEPS a.s., the Czech TSO.

Auctions in 2008 are held for capacity to be reserved for both directions of each of the commercial profiles mentioned in chapter 1.2.5 above for the following reservation periods[8]:

- Annually, the reservation period starts on 1 January 2008 and ends on 31 December 2008,
- Monthly, the reservation period starts on the 1st day and ends on the last day of a calendar month for the year 2008,
- Daily, the reservation period lasts for each individual hour throughout 24 hours of a calendar day for the year 2008 (23 or respectively 25 hours when daylight savings time changes).

Capacity is auctioned firm. After notification of available capacity at 9h, the deadline for the latest submission of bids in daily auctions is 9.45h. In the event that the offered capacities of a daily auction cannot be published by 09:45 due to any operational change, the daily auction for this day and the technical profiles/commercial profiles concerned will not be organized.

The auction participant is informed of the outcome of his bid at 10h but only aggregate results are published. If the results of the daily auction are not published until 10:15 due to any operational change, the auction is also cancelled without compensation.

Deadlines for notification of the schedule to the TSO differ: In Germany, the deadline is 14.30h for both E.ON and VE-T while the deadline with CEPS is 13h. In Poland, the schedule needs to be submitted by 13h for the first half year of 2008; this is changed to 12h for the second half of 2008.

Bordering TSOs compare/match delivered individual fixed schedules on individual common borders.

Provision of ancillary services is only allowed “interregional” between Poland and the Czech and Slovak Republic. Monthly or yearly allocated capacity confirmed to be reserved for deliveries of balancing energy on these border profiles is not subject to the principle "use it or lose it" but can be transferred under specified conditions.

In emergency situations and/or to prevent emergency situations concerned TSOs may buy back an allocated capacity (allocated in monthly and/or yearly Auction) as alternative to curtailment. The transfer of capacity as result of buying back the allocated capacity shall be notified to the auction office. The selection of auction participants (transferors) and other

[8] The reservation of capacity on the commercial profiles listed above is a result of the Auction process based on the individual bid prices for the chosen commercial profiles and directions. This process takes into account offered capacities on all technical profiles.

conditions of capacity transfer which are not set forth by auction rules are out of scope of auction rules.

Future

At present, the TSOs of the Central Eastern Europe (CEE) region are involved with the development of the coordinated allocation of transmission capacity to eight TSOs (incl. APG (Austria), ELES (Slovenia), MAVIR (Hungary) in addition to the current five TSOs). A flow based allocation method is being considered which would include the application of physical transmission rights. The method is supposed to allow cross-regional purchase of transmission rights within the CEE region, i.e. immediate adjacencies to enable trade would become redundant. A decision on implementation is expected end 2007 after investigations are concluded.

2.4 Renewable Support Mechanisms

2.4.1 Germany – Feed In Tariff

The German Renewable Energy Sources Act (EEG) is valid within the German economic zone. As the main support mechanisms within this law, the feed-in tariff, priority grid access and purchase obligation, is applicable to generators and TSOs within the German network only, cross-border trading of electricity is hence not affected by this law.

2.4.2 Switzerland

Switzerland, like Germany, supports RES development by a feed-in tariff and prioritisation of RES in grid connection and construction of facilities.

RES development in Switzerland is constrained by budgetary limits. By 2010, it plans to generate an additional 3% of heat (equalling 3,000GWth) and 1% electricity from RES installations over the baseline year 2000.

2.4.3 Austria

Austria also pays a feed-in tariff to RES installations, based on production costs, and gives RES connection priority to the grid. Concession to buy and sell RES is only given to companies who have residence and main administration within the Austrian federal area (“Bundesgebiet”).[9]

Austria is already producing around 70% of its energy from RES, mostly hydro and biomass.

[9] Austrian Oekostromgesetz Art.10 and Art.14b

2.4.4 Czech Republic

To fulfil its RES targets, the Czech Republic has set minimum prices ("green bonuses") by individual types of RES and made purchase mandatory by distributors. Support applies to facilities in the Czech Republic [17].

The Czech Republic committed itself to increase the share of electricity produced from RES under EU accession agreements. The accession treaty envisages to achieve a target share of 8% RES in gross electricity consumption by 2010.

2.4.5 Poland

In Poland, the instrument to promote electricity from renewable energy sources is a quota obligation and a system of tradeable green certificates. Under the quota obligation, the distribution companies are obliged to provide a certain minimum share of energy produced from RES in their total yearly sale. Tradeable certificates of origin were introduced in 2005. They are traded separately from physical power. At present, trade of these certificates is restricted to Polish companies within Poland only.

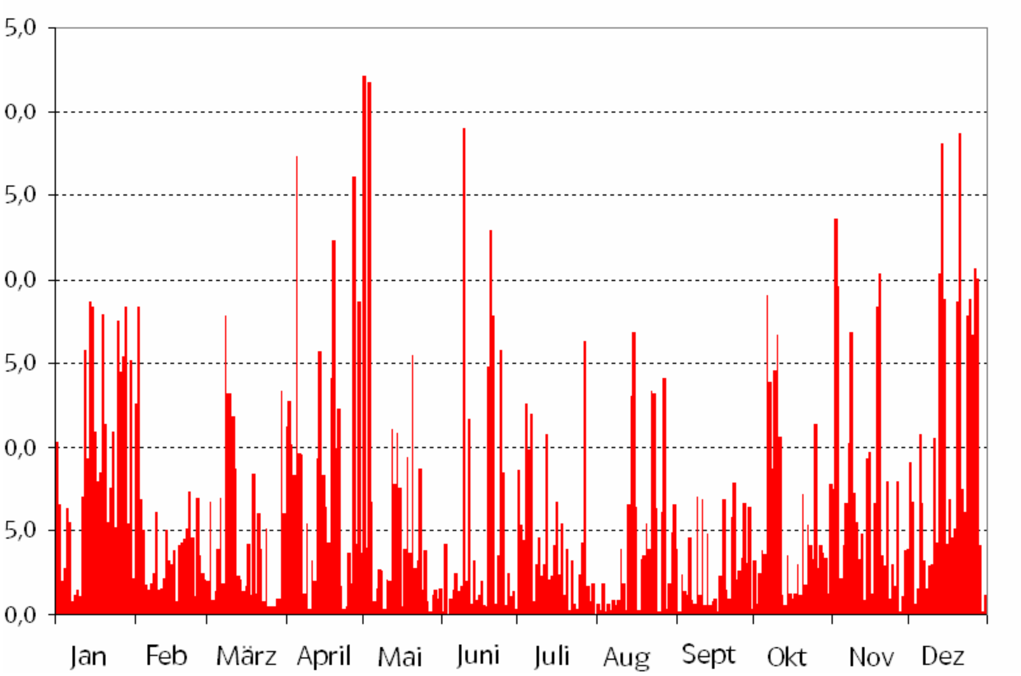
Poland is also bound by EU accession agreements and set a 7.5% RES share as an initial strategic target to 2010. By 2020, the government is looking to increase this share to 14%. Technically, experts expect RES shares of 5% by 2010 due to slow uptake of RES, competing against predominant cheap coal use.

2.5 Utilisation for Variable Generation

In certain situations (strong wind and low load), Germany sees a surplus in power generation on a few days a year. In such situations, huge power flows to neighbouring countries can be observed. High load flows from Northern Germany, mainly from off-shore wind farms, lead to noteworthy additional pressure on neighbouring grids Poland, the Czech Republic, the Netherlands and Belgium. A reduction of wind power generation to manage system security is only possible if the fundamental network- and market-related measures fail in the management of overloads and the maintenance of the secure operation of the power system (security management); therefore, in the case of disturbances further load is shifted on to neighbouring grids to release pressure on the German grid [9].

Figure 4 shows the annual share of daily wind power in daily peak demand in the E.ON grid, demonstrating large variability across the year in terms of wind power feed-in.

Figure 4 Annual share of daily wind power in respective daily peak demand in E.ON-grid (UCTE)



Large scale power generation from wind turbines in Germany can impair considerably the reliable operation of the grids in neighboring countries. Particularly during weekends with strong wind conditions and during low load nighttime hours, the cross-border interconnectors and the transmission lines in frontier areas are operated close to the (n-1) limit. Topology and re-dispatching measures (changes of power plant scheduling) have been implemented to comply with the (n-1) criterion in the transmission grid due to temporary high load flows from North to South that occurred from the strong feed-in of wind energy in Northern/Eastern Germany and high power demand in the South of Europe [18].

The injection of wind power not only affects the individual national systems but also the cross-border electricity transits between neighbouring countries. In the case of Germany, this is true for all transports from Denmark to Germany and from Germany to the Netherlands. If the offshore wind power expansion aimed for by the German Federal government by 2010 is realized and if the wind-related expansion measures in the transmission system already apparent today are not achieved by such date, this will lead to a significant reduction of the capacities available today to European electricity traders.

The impact of wind power will become more intense with new generation capacity added. Wind farms are built on sites with high average of wind speed which are often far away from the main load centres and new overhead lines are therefore necessary to transport the surplus of electricity produced in these regions to where it is consumed. The variable contributions from wind power must be balanced almost completely with other back- up generation capacity located elsewhere. This adds to the requirements for grid reinforcements.

As a reaction to findings as outlined above, Germany adapted its grid codes several times over the last years, the last time in 2006: New installations are required to have common fault-ride-through-capability and voltage support. In addition to this, monitoring systems are required for each wind farm to prevent voltage collapses due to reactive power consumption.

3 GRID PLANNING

This section provides an overview of different planning approaches for integration of renewable generation in Germany. The work investigates proactive initiatives for investment planning that have been developed to meet the growing demand for variable generation connection, and to increase the efficiency of their incorporation in the grid system. The work focuses on large-scale integration of renewable sources with special emphasis on planning issues for wind power in Germany. The work will discuss the extent to which grid investment can be a barrier for renewable generation development.

The forecasted wind power capacity in Germany for year 2015 is 36 GW (26.2 GW of onshore wind and 9.8 GW of offshore wind). By year 2020 it is expected to install 27.9 GW onshore and 20.4 GW offshore wind power in Baltic and North Sea. The additional wind power plants are planned to be installed in peripheral regions with bellow average power demand, and limited transmission capacity of the regional network. The grid infrastructure needs upgrading and modification in order to accommodate efficiently the increasing amounts of offshore wind power generation. During the periods of strong wind the total wind power output cannot be consumed locally and flows to load centres over long distances in the transmission grid.

3.1 Grid Investment

This section reviews different factors driving investments to incorporate renewable energy sources in Germany. The work will also examine issues in the development of transmission grids to connect offshore wind as well as new regulations regarding planning of new interconnecting links and offshore wind farms.

3.1.1 Current regulation of electricity transport

Since July 2005 new regulatory agencies have been responsible for regulation and unbundling of the electricity- and gas transport segments. One regulatory agency at federal level (“Bundesnetzagentur”) is located within and under supervision of the federal ministry of economics. Additionally, on the level of the federal states respective regulatory agencies located within the ministries of economics of the federal states (“Landesregulierungsbehörden”).

- Regulation of the Bundesnetzagentur includes authorisation concerning grid access and the ex ante-control (cost based) of net prices (limited until the end of 2007), which means net prices can be reduced by the Bundesnetzagentur. Conflicts with the regulatory agency have to be decided by courts.
- In 2008 net prices will not be regulated on cost basis, but on the basis of an incentive regulation (based on a price-/revenue-cap regulation). In May 2006 the Bundesnetzagentur presented a draft for the incentive regulation (“Anreizregulierung”): The aim is rationalisation by means of separating cost from profits. With the price-/revenue-

cap regulation an energy supply company can merely increase their profit in minimising costs.

- Furthermore, the Bundesnetzagentur controls “system responsibility” of the transport segment.
- The regulatory agencies within the economic ministries of the federal states are responsible in the same way as the Bundesnetzagentur concerning electricity transport companies with less than 100,000 clients and if their net is within the borders of the respective federal state.

3.1.2 Costs for grid connection of renewable energy sources

The planning of grid investments in Germany is carried out by electrical utilities and Transmission System Operators (TSOs). According to reference [28] no formal regulator is involved in grid planning in Germany.

In general costs for grid connection of renewable energy sources are split in to costs for internal electrical installations and costs for connection of the generator to the electrical grid [27]. The internal installation is typically the medium voltage grid that connects the generator unit(s) to the Point of Common Coupling (PCC). If the generator is large and the distance to the grid long there may be a need for a common step-up transformer from medium voltage in the generator grid to the local high voltage transmission level. The cost for local electrical installations is in the range 3-10% of the total cost. This item is highly dependent on the generator size and hence the voltage level for connection to the existing grid as well as on the local equipment prices, local technical requirements, soil conditions, the distance between single generator units etc.

The grid connection costs for onshore and offshore wind farms are significantly influenced by the selected line solution. Conventional overhead lines are used as typical solution for grid connection of wind farms on land. The transmission grid connection for off-shore wind farms can be done by underground AC cables or High Voltage Direct Current lines either by traditional HVDC with tyristor-based converters or by HVDC with IGBT- based converters. The AC cable solution is the best and cheapest solution for offshore wind farms close to the shore. The HVDC line solution is recommended when the lines connecting the wind power plant to the transmission grid exceed 120 km [29]. The recent advances in HVDC technology using IGBT- based converters offers multi-terminal HVDC networks with technical advantages in power control capability and flexibility.

The different cost items for a typical 150 MW wind farm installed onshore and offshore are compared in Table 1, which is adapted from reference [27]. E.g. the cost for grid connection of a 150 MW offshore wind farm (offshore transformer station, internal electrical grid for the wind farm and transmission grid connection) is estimated to be roughly 25% of the total cost for the wind farm. The cost for grid connection of the respective onshore wind farm is 15% of the total wind farm cost.

Table 5: Comparison of costs for 150 MW wind farm

	Offshore wind farm %	Onshore wind farm %
Foundations	16	5,5
Wind turbines	51	71,0
Internal electrical grid	5	7,5
Offshore transformer station	2	-
Grid connection	18	7,5
Operation & maintenance facilities	2	
Engineering, project administration	4	2,5
Miscellaneous	2	7,0
Total	**100**	**100**

3.1.3 Grid reinforcements for large-scale integration of renewables

The process of grid upgrading requires short-term measures (optimisation of existing infrastructure, adapted procedures for energy management etc.) as well as long-term grid investments to enable integration of renewable energy. The long-term measures comprise:

- Reinforcement and extension of existing transmission and distribution lines and substations,
- Establishment of new transmission and distribution line substations,
- Establishment of new voltage control devices (such as capacitor banks or advanced SVC devices).
- Establishment of back up capacity

The new grid constructions in Germany up to year 2015 are planned to extend the existing 380 kV and 220 kV network by a total of 850 km corresponding to a share of 5% of the existing transmission grid. The German Energy Agency (DENA) has quantified the system integration cost for adding renewable energy sources to the electricity supply in Germany. The DENA study focuses especially on onshore and offshore wind power and assumes that the share of wind power in Germany increases from the existing 5% to a level of 15% in year 2015.

The DENA study [9] finds that wind power introduces a net increase in the price of electricity sold to private households in the order of 0,39-0,49 Cent €/ kWh.

In general the system integration costs comprise of generation cost for wind power (investment and operation costs), additional balancing cost (to cope with uncertainties for overall system demand and generation), network upgrade costs and social savings (CO2 emission savings). System integration costs determined the under conservative assumptions (low gas price, low to zero benefit from the carbon price) form a fraction of the actual consumer price for electricity.

For a wind penetration level of 15% (corresponding to 36 GW installed capacity) in year 2015 the grid extension cost due to wind integration is 0,025 Cent €/ kWh. The fraction needed to cover 220 / 380 kV network upgrades is around 7% of the additional cost for integration of wind power in the system [9],[29]. The planned construction of offshore wind farms in the North and the Baltic Sea call for massive grid investments in the north-south direction to avoid bottlenecks in the existing transmission grid. Further extensions to accommodate offshore wind power beyond year 2015 would require approx. 1,000 km reinforcements to transmit the power, from the North Sea region with high offshore wind power penetration and low energy consumption to German regions with high energy consumption.

3.1.4 Offshore Connection

To improve the financial feasibility of off-shore wind energy, the 2006 Infrastructure Acceleration Act (Infrastrukturplanungsbeschleunigungs-gesetz) was passed. The Act obliges transmission system operators to pay for and install the necessary grid connection from an onshore connection point to the offshore wind farms. The costs of the submarine cable connection up to the point of grid connection on the shore would be covered by the wind farm developers from the revenues from feed-in tariff under the Renewable Energy Act.

3.2 Planning & Security Standards

The conventional integration of renewable sources (wind turbines on-land, local heat and power cogeneration units etc.) has been typically performed in distribution grids in close proximity to the consumer. The benefits of small-scale distributed generation in local grids are clearly recognised as reduced losses, reduced need for grid reinforcement etc.

The large-scale integration of renewable energy sources requires an integrated approach for planning and security requirements in distribution and transmission grids. E.g. off-shore wind farms connected to the transmission network are considered as power plants with capacities that are comparable to conventional power plants.

The interconnection of renewable production in Germany is highly controlled by mandatory set of rules according to references [19], [21], [22], [23] and [24]. Grid codes and grids access requirements distinguish between low and high penetration levels for distributed generation. Grid operators (transmission, distribution) in Germany have complemented the rules for connecting generators (grid codes) with specific codes for wind power plants [25]. The wind turbine manufacturers have responded to these requirements with particular measures in the field of wind turbine control and electrical system design. Some of the essential requirements in the German grid codes follow:

- Active power control
- Frequency control
- Voltage control
- Voltage quality
- Tap-changing transformers
- Wind farm protection
- Wind farm modelling and verification
- Communications and external control

The conventional planning (and control) methods related to variable production and variable demand [29] are adequate for dealing with penetration levels of wind power up to approx. 20% of gross demand. Power systems with larger wind power penetration have to accommodate proactive procedures and planning tools as well as excessive requirements with regards to ancillary services[10] such as fault ride-through capability, frequency, voltage control etc.

The German Energy Agency has investigated the power system security and reliability with respect to increasing the amount of renewable generation in Germany up to the year 2015. The grid study investigates planning standards and transmission grid constraints due to unintentional wind power rejection on one hand and a surplus of wind energy on the other. Ordered reduction of wind power generation is used especially in the German regions Schleswig-Holstein and Lower Saxony to optimise the active and reactive power flows in the network and avoid exceeding thermal ratings of grid components. This limitation of wind power output to a pre-calculated threshold requires advanced control systems for wind farm management.

A large surplus of wind power generation is experienced in Germany during few days each year due to strong wind and low load conditions. If it is not possible to export the wind power surplus in the neighbouring regions, reduction of power output from wind farms has to be ordered or additional measures such as storage facilities have to be applied. The Renewable Energy Act obligates grid operators in Germany to remedy wind-related grid congestion at their own expense [19]. For example, E.ON Netz GmbH, TSO in the north German costal states, is particularly affected by this obligation.

[10] Grid supporting services

The DENA study points out that restrictive grid requirements and improved technical performance such as ride-through-capability of wind turbines in Germany is crucial for power system security. In order to avoid large-scale rejection of wind turbines due to faults in the transmission grid it is recommended that new wind turbines do not disconnect from the grid until the voltage sags far below 80%. To improve the situation it is further recommended to replace old wind turbines by new ones [9].

The long-term planning of large wind power projects and grid infrastructure related to wind power integration in Germany calls for enhanced coordination at national and European level. The guidelines for The Trans-European Networks for Energy (TEN-E) can provide a good framework for future wind power development and grid integration of wind power in Europe. Further studies need to be undertaken to investigate the trans-national aspects of wind power and harmonise the various national grid integration efforts [29].

The future development of power systems with a large amount of renewable sources calls for innovative planning and redesigning of electricity networks that encourages flexible principles. E.g. flexible consumption and generation patterns, generation storage, virtual power plants based on clusters of distributed sources (as well as in combination with conventional power plants), and utilization of interconnections need to be incorporated in the overall power system planning. Reference [28] proposes technical and economical incentives for an "active network", where the distribution and transmission networks are designed and operated in a closely integrated platform. This approach facilitates intelligent distributed control and active management of distributed generation in a deregulated electricity market with large scale renewable generation. E.g. offering equal conditions for central and local electricity production units will allow all power plants to contribute with ancillary services to system stability and flexibility [28].

3.3 Transmission Access & Charging

The transmission access and charging of renewable generation in Germany is regulated by the Renewable Energy Sources Act of July 2004 [19].

The costs for additional network and connection of renewable generation are typically covered by local/regional customers via additional grid tariffs. Connection costs related to the connection of larger RES plants that are connected directly to the transmission system, e.g., new large wind farms, are typically covered by the transmission system operator. In general producers pay a grid tariff for using the transmission network.

There is congestion in the distribution system at every voltage level. There are also large gaps in the information available from distribution network operators. A number of distribution network operators have introduced congestion management systems. This effectively restricts or delays connection for decentralised generation [3].

3.3.1 Connection to the Transmission Network

By 2006, a large proportion of distribution network operators (80%), and all transmission companies, had concrete conditions in place for connecting new generators to the network. Generators are obliged to pay the cost of feasibility studies, access and expansion, and any additional reservation premium for access capacity taken into account in project realisation [3].

Under the EEG, installers bear the costs of shallow connection and grid operators take on other necessary costs for upgrading the grid. They can take these costs into consideration in their charges for use of the grid. The grid upgrading costs must be declared to ensure the necessary transparency. This obligation aims, in the interests of consumer protection, to prevent costs being shifted unfairly to electricity consumers. This is intended to create incentives for renewable energy generators to agree on generation management with the grid operators in their mutual interest. This is especially relevant for grid upgrading and stand-by energy. Such an agreement can take the variable electricity supply into consideration in a way that enables the costs for grid upgrades, reserves and stand-by energy to be minimised. To facilitate better integration of renewable sources into the electricity system, the 2004 amendment to the EEG contains an obligation to measure and record the capacity for installations with a capacity of 500 kilowatts or more.

The administration of the respective federal state (Bundeland) authorizes the construction of new grid connections. Generators are required to agree a contract with the respective TSO, which has an obligation to give renewable generators priority access.

Despite existing legislation to ensure system adequacy, Germany is facing a shortage of transmission capacity in the near future unless steps are taken to expand the existing transmission grid. Individual wind farms already have been required to disconnect due to overload of the grid in 2003 where critical grid conditions could be observed. Adjustments to the grid code in 2003 brought improvements to the situation: New-built wind turbines will disconnect themselves from the grid only in case of voltage sags far below 80%, or only with a time delay.[11]

This situation has developed due to the fact that construction of new generation capacities exceeds the pace of grid upgrading. While TSOs are legally obliged to provide sufficient transmission infrastructure in general, enforcement mechanisms are vague and unspecified as yet. In addition, grid upgrade is only obligatory where this is "economically reasonable".

3.3.2 Third Party Access (TPA)

Through the National Energy Act of 1998 ("Gesetz zur Neuregelung des Energiewirtschaftsrechts 1998"), state regulation was reduced in favour of

[11] DENA

a more market orientated coordination. One of the changes was that negotiated third party access (TPA) was introduced instead of regulated access. The Transmission System Operators were obliged to open their network and to give distribution companies and energy consumers the possibility of choosing their supplier.

According to the IEA, TPA is still unsatisfactory in the German power market. They identify significant improvements needs to the TPA rules: First, the TPA tariffs should accurately reflect cost (the so-called principle of "efficiently incurred costs", *Kosten der elektrizitätswirtschaftlich rationellen Betriebsführung)* which will be ensured by better transparency and benchmarking of costs. Second, competition should be developed in the supply of frequency and voltage control power (*Regelenergie*), also principally by improving the procurement methods. Third, the possibilities of residential consumers to switch suppliers must be improved by better implementation of the already agreed procedures.[12]

3.3.3 Transmission Use of System Charges

Transmission use of system charges apply to consumers only (not generators). They recover the costs of infrastructure, system services and losses.

Network charges make up a large proportion of the electricity price to consumers in Germany (39% for household consumers). The Federal Grid Agency, which supervises transmission connection and charges, found in 2006 that network charges were above reasonable limits for three out of four TSOs. Consequently, charges were cut by 14% at RWE Transportnet Strom GmbH, EnBW Transportnetze AG and distribution network operator (DSO) TEN Thueringer Energienetze GmbH. Previously, in the same year, VET had been ordered to reduce transmission charges.[13]

3.3.4 Grid losses

The Energy Industry Act (Energiewirtschaftsgesetz) and Electricity Grid Access Ordinance (Netzzugangsverordnung Strom) oblige the grid system operators to procure energy required for the compensation of grid losses (loss energy) in a transparent, market-oriented and non discriminating manner (e.g. public tender).

The costs of grid losses are socialised through the transmission charges.

[12] IPA
[13] DENA

3.4 Summary

The note reviews different planning approaches to incorporate renewable energy sources in Germany and puts special focus on the increasing amount of wind generation in Germany. The work examines investment and regulatory issues in the development of transmission grids to connect renewable generation.

The general frameworks for renewable energy in Germany acknowledge that technical requirements and costs for grid connection depend to a large extent on the penetration levels and the nature and robustness of the existing electrical infrastructure such as the overall composition of generation sources and regional interconnections.

The increasing contribution of wind energy in Germany requires massive grid reinforcements and advanced solutions for wind generation units to keep the high level of power quality and security of supply.

ANNEX A – ABBREVIATIONS

Acronym	Definition
AC	Alternating Current
APG	Austrian TSO
BMU	Federal Ministry for the Environment, Nature Conservation and Reactor Safety (Bundesministerium fuer Umwelt)
CEE	Central Eastern Europe
CfD	Contract for Difference
CWE	Central Western Europe
CZ	Czech Republic
DENA	German Energy Agency (Deutsche Energie-Agentur)
DK	Denmark
EC	European Commission
EEG	Renewable Energy Sources Act (Erneuerbare Energien Gestez)
EEX	European Energy Exchange
EIA	Environmental Impact Assessment
ETSO	European Transmission System Operators: ETSO is an International Association of TSOs.
EU	European Union
EWIS	European Wind Integration Study, initiated by the European Transmission System Operators
GW	Gigawatt = 1,000,000 kW (unit of power/ capacity)
GWh	Gigawatt hour = 1,000,000 kWh (unit of energy)
HVDC	High Voltage Direct Current
IEA	International Energy Agency
IGBT	Insulated-Gate Bipolar Transistor
KfW	Reconstruction Loan Corporation (Kreditanstalt fuer Wiederaufbau)
kW	Kilowatt = 1,000 Watts (unit of power/ capacity)
kWh	Kilowatt hour = 1,000 Watt hours (unit of energy)
LPX	Leipzig Power Exchange
MW	Megawatt = 1,000 kW (unit of power/ capacity)
MWh	Megawatt hour = 1,000 kWh (unit of energy)
NL	Netherlands
NTC	Net Transfer Capacity

Acronym	Definition
OTC	Over The Counter
PCC	Point of Common Coupling
PL	Poland
PTR	Physical Transmission Rights
PV	Photovoltaic
RES	Renewable Energy Sources
RETD	Renewable Energy Technology Deployment
SO	System Operator
TPA	Third Party Access
TSO	Transmission System Operator
TWh	Terrawatt Hour = 1,000 MWh (unit of energy)
UCTE	Union for the Co-ordination of Transmission of Electricity. The association of transmission system operators in continental Europe.

ANNEX B – GLOSSARY

Term	Definition
Bilateral	Trades or other contracts between two participants, for example a generator and supplier.
Capacity	Cf. Energy, Power. The maximum ability of a generating station to generate an amount of electricity in a given time. Measured in units of power (kW). The actual energy generated is dependant on the load factor.
Clip Size	The minimum size of interconnection capacity contracts.
Credit Cover	The cash or other financial security that must be provided.
Day Ahead	The day prior to the day that is being traded for or balanced.
Deep Connection Costs	Cf. Shallow Connection Costs. The costs of reinforcing and upgrading the wider network to enable additional generation or demand to be connected.
Degression	The percentage reduction in the tariff in upcoming years. It serves to reduce the tariff to compensate for expected future price reductions in the capital cost of the RE asset.
Energy	Cf. Power, Capacity. Formally defined as the ability for a system to do work. In the case of an electrical energy this is measured in kWh. Energy cannot be stored in the transmission network, so at any given time the total energy generated must equal the total energy demand and total losses (due to heating of wires etc.) This is known as balancing the system.
Gate Closure	The last time at which energy can be traded before the markets are closed. Balancing trades may take place closer to real time on a separate balancing market.
Group Processing	This means that the grid operator puts applicants into a queue and groups them into areas or zones. Reinforcement is then carried out on selected zones to accommodate the applicants in that zone. There is no guaranteed timescale for connection.
Intraday	Within the day that is being traded for or balanced.
Laender	German federal states
Load Factor	Also may be known as a capacity factor. The ratio of the actual energy output of a power plant over a period of time and its energy output if it had operated a full capacity of that time period. For example, an onshore wind farm might have a load factor of 30-40%. This means that on average it generates at 35% of its capacity, although at any given time it may be generating anywhere between 0% and 100% of its total capacity.
Locational	Cf. Postage Stamp. Differentiated by geographical location. For example, in the case of transmission charging, this typically will mean higher charges further from demand centres.
Long	Cf. Short. Where a participant has more generation than is required to balance their demand (including losses where applicable)

Term	Definition
Main Price	Cf. Reverse Price. The balancing price where a participant is out of balance in the same direction as the market, for example a participant that is "short" when the market is "short".
Merit Order	The order that a system operator will place generators in based on the costs to deliver a certain quantity of generation. Those generators that will allow the forecast demand to be met at the lowest costs (subject to system constraints) are described as being in the merit order and are despatched.
Postage Stamp	Cf. Locational. Uniform, equal throughout the network.
Power	Cf. Energy, Capacity. Power is the ability to create energy in a given time, and can be expressed in the following equation: $Power(kW) = \frac{Energy(kWh)}{Time(h)}$
Price Maker	Cf. Price Taker. In the context of an electricity pool, a price making generator will submit a number of bids/offers indicating how much electricity they would be prepared to despatch at a given price. The system operator will place the generators in order of cost to determine which plants will be despatched.
Price Taker	Cf. Price Maker. In the context of an electricity pool, a price taking generator will not submit a bid or will submit a bid at zero. This means it will always be despatched (subject to system constraints) and will receive the pool price. Price taking generators include variable generators with low marginal costs, such as wind.
Real Time	The actual time period that energy is being traded for or balanced.
Reverse Price	Cf. Main Price. The balancing price where a participant is out of balance in the opposite direction to the market, for example a participant that is "short" when the market is "long".
Shallow Connection Costs	Cf. Deep Connection Costs. The costs of physically connecting a generator to the nearest appropriate point in the transmission network, this may typically be the closest substation. This does not include costs associated with any required reinforcements to the wider transmission network.
Short	Cf. Long. Where a participant has less generation than is required to balance their demand (including losses where applicable)
Supplier	Normally used to describe a retail electricity supplier that sells electricity to final consumers, this can include domestic, commercial and industrial consumers
Vertical Integration	Vertical integration is the degree to which a firm owns its upstream suppliers and its downstream buyers. For example, within the electricity industry this can be used to describe the situation where a parent company owns both an electricity retail supplier and generator.

ANNEX C – REFERENCES

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ANNEX D – INTERCONNECTOR TABLE

Countries / Stations	Unavailability (min/year)	Operator		Transmission Capacity	
		Substation in Germany	Substation Neighbouring Country	Present (thermal) Transmission Capacity (MVA)	Limitations by transformer or substation
Germany - Netherlands					
Diele – Meeden	10013/6938	E.ON Netz	TenneT	2 x 1382	1000 (circuits)
Siersdorf – Maasbracht		RWE Transportnetz Strom	TenneT	1645	-
Rommerskirchen – Maasbracht	9430	RWE Transportnetz Strom	TenneT	1698	-
Gronau – Hengelo	4004/42301	RWE Transportnetz Strom	TenneT	2 x 1790	-
Germany - Luxembourg					
Niederstedem – Vianden		RWE Transportnetz Strom	SEO	2 x 490	-
Bauler – Vianden		RWE Transportnetz Strom	SEO	2 x732	-
Bauler – Flebour	5260	RWE Transportnetz Strom	CEGEDEL	492	--
Bauler – Roost	5270	RWE Transportnetz Strom	CEGEDEL	490	-
Trier – Heisdorf	28630	RWE Transportnetz Strom	CEGEDEL	492	-
Quint - Heisdorf	63976	RWE Transportnetz Strom	CEGDEL	492	-
Germany - France					
Uchtelfangen – Vigy	666/46170	RWE Transportnetz Strom	RTE	2 x 1790	-
Ensdorf – St-Avold	16739	RWE Transportnetz Strom	RTE	282	-
Eichstetten – Vogelgruen	8195	RWE Transportnetz Strom	RTE	492	457 (circuits)
Eichstetten – Muhlbach	500	RWE Transportnetz Strom	RTE	1790	-
Asphard – Sierentz	14157	Atel/NOK	RTE	1660	-
Germany - Switzerland					
Gurtweil – Laufenburg	3051/1543	EnBW Transportnetze	EGL	2 x 492	2 x 457 (circuits)
Kuehmoss – Laufenburg	108841/6370	EnBW Transportnetze	EGL	2 x 492	2 x 456 (circuits)
Kuehmoss – Laufenburg		EnBW Transportnetze	EGL	492	476 (circuits)
Kuehmoss – Laufenburg	4640/3091	EnBW Transportnetze	EGL	2 x 1698	-
Kuehmoss – Laufenburg	49519	RWE Transportnetz Strom	EGL	1698	1580 (circuits)
Tiengen – Laufenburg	52734	RWE Transportnetz Strom	EGL	1158	-
Tiengen – Beznau	22131	RWE Transportnetz Strom	NOK	1158	-
Tiengen – Beznau	22128	RWE Transportnetz Strom	NOK	335	-
Tiengen – Klingnau		RWE Transportnetz Strom	AWAG	58	-
Kuehmoss – Asphard	32708	EnBW Transportnetze	Atel/NOK	1659	-
Engstlatt – Laufenburg	45357	EnBW Transportnetze	EGL	1790	-

Germany - Austria					
Obermooweiler – Buers	3113/1362	EnBW Transportnetze	VIW	2 x 1369	-
Hoheneck/Tiengen – Buers		RWE Transportnetz Strom	VIW	389	-
Dellmensingen – Buers	4500	RWE Transportnetz Strom	VIW	492	-
Neuoetting-Braunau		E.ON Netz	ÖBK	102	82 (lines)
Stammham – Braunau	578	E.ON Netz	ÖBK	102	82 (lines)
Neuoetting – Ranshofen		E.ON Netz	APG	90	-
Egglfing – Antiesenhofen		E.ON Netz	APG	102	-
Altheim – St.Peter	8703	E.ON Netz	APG	301	-
Simbach – St. Peter	5598	E.ON Netz	APG	301	-
Ering – St Peter		E.ON Netz	APG	2 x 152	2 x 137 (circuit), 2 x 114 (line)
Egglfing – St Peter		E.ON Netz	APG	105	
Pirach – St Peter	8835	E.ON Netz	APG	518	457 (circuit)
Pleinting – St Peter	3299	E.ON Netz	APG	518	457 (circuit)
Passau/Hauzenberg – Ranna		E.ON Netz	EAGOÖ	90	-
Rosenheim – Oberaudorf		E.ON Netz	ÖBK	93	-
Kiefersfelden – Oberaudorf		E.ON Netz	ÖBK	102	-
Leupolz – Westtirol	729	RWE Transportnetz Strom	APG	1316	-
Memmingen – Westtirol	2240	RWE Transportnetz Strom	APG	762	-
Oberbrunn – Silz	16922/25916	E.ON Netz	TIRAG	2 x 793	2 x 762 (circuit)
Oberaudorf – Kufstein		TIRAG	TIRAG	90	-
Oberaudorf – Ebbs		TIRAG	TIRAG	127	-
Germany – Czech Republic					
Etzenricht – Hradec	24024	E.ON Netz	CEPS a.s.	1639	1316 (circuit)
Etzenricht – Prestice	6345	E.ON Netz	CEPS a.s.	1645	1579 (circuit)
Roehrsdorf – Hradec	23707/2824	VE Transmission	CEPS a.s.	2 x 1660	2 x 1320
Germany - Poland					
Vierraden – Krajnik		VE Transmission	PSE-O s.a.	2 x 460	-
Hagenwerder – Mikulowa		VE Transmission	PSE-O s.a.	2 x 1660	2 x 1320