ECONOMIC ANALYSIS OF VATTENFALL'S LIGNITE POWER PLANTS OFFERED FOR SALE

DETERMINATION OF THE NET PRESENT VALUE FROM ELECTRICITY SALES

Berlin, October 19th, 2015

Greenpeace Nordic

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1 SUMMARY

The study aims to determine the net present value from electricity sales of Vattenfall’s lignite power plants in Germany offered for sale. For this analysis a scenario with ambitious emissions goals and actions against climate change (and resulting high CO_2 prices) has been assumed. The considered influencing parameters of the scenario are mainly based on two public studies: the EU energy, transport and Greenhouse Gas emissions trends to 2050 (reference scenario 2013) (EU 2013) and the ambitious World Energy Outlook’s 450 ppm scenario (World Energy Outlook 2014 (IEA 2014)) intensified with the assumption set by Greenpeace that the considered lignite power plant will run no longer than 2030. The scenario was calculated using Energy Brainpool’s commercial energy market model Power2Sim.

Based on contribution margins from electricity sales on the day-ahead spot market the calculated net present value (NPV) of the lignite power plant park is 468 M€. Chapter 5 provides detailed advice on the interpretation of this result.

2 INTRODUCTION AND STUDY OBJECTIVES

Vattenfall is currently offering a couple of electricity generation plants for sale. These assets are intended to be sold in two packages: The first package comprises Vattenfall’s lignite power plants and the lignite open-cast mines in Lusatia. Several hydroelectric and pumped storages power plants are included in the second package for sale. A few days ago Greenpeace Nordic announced its intent to purchase the offered power plant portfolio.

In this context, the present study aims to determine the net present value of electricity sales of the power plants for sale in the first package. Therefore only the electricity production from lignite power plants will be taken into account. The scope of the valuation is the determination of contribution margins from electricity sales at the spot market. Sales on the futures market are not in the scope of the study because it is unclear if any long-term contracts are included in the package for sale.

The contribution margins are determined on the basis of a scenario by the year 2030. The scenario is subject to specific assumptions of Greenpeace, which are described in the next chapter.

3 ASSUMPTIONS FOR THE CONSIDERED SCENARIO

In order to model and calculate revenues from electricity sales a bunch of assumptions have to be made. Moreover, the calculation of the net present value of the contribution margins of the offered power plants requires assumptions on operational and maintenance costs of the power plants as well as assumptions on the relevant interest rate.

3.1 CONSIDERED POWER PLANTS AND DECOMMISSIONING

The power plants offered for sale of which the net present value is calculated are listed in the following table. The points in time where the lignite power plants are decommissioned are given by Greenpeace and specified as well in the in Table 1:

Table 1: Considered power plant blocks and decommissioning

POWER PLANT BLOCK	DECOMISSIONING
Boxberg N	31.12.2020
Boxberg P	31.12.2020
Boxberg Q	31.12.2029
Boxberg R	31.12.2030
Lippendorf R	31.12.2029
Jänschwalde A	31.12.2024
Jänschwalde B	31.12.2024
Jänschwalde C	31.12.2018
Jänschwalde D	31.12.2018
Jänschwalde E	31.12.2024
Jänschwalde F	31.12.2024
Schwarze Pumpe A	31.12.2028
Schwarze Pumpe B	31.12.2028

3.2 SCENARIO ON FUTURE POWER MARKET DEVELOPMENT

Future power plants revenues from electricity sales are calculated using the fundamental model Power2Sim (for a detailed model description please refer to Appendix 1). Crucial for future power price development is the development of the power plant park, which is shown in Figure 1 for Germany. The assumptions are based on the reference scenario 2013 from the study EU energy, transport and Greenhouse Gas emissions trends to 2050 (EU 2013).

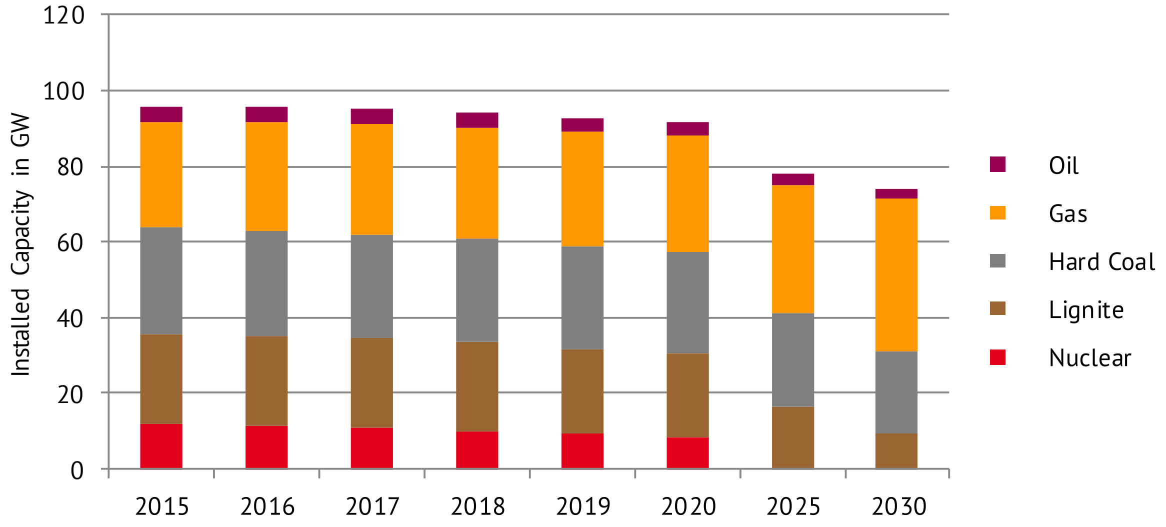

Figure 1: Installed capacity of modelled power plant park (Germany) by fuel

An important assumption is also the future installation of renewable energies. The path for renewables in Germany is taken from recent policy goals (EEG 2014) and for other countries from EU (2013).

Another important assumption concerns the development of fuel prices (other than lignite) and CO_2 prices as they affect the merit order of the power plants and heavily impact power prices. Future fuel price development is taken from World Energy Outlook 2014 (IEA 2014). The considered scenario is the 450 ppm scenario which assumes ambitious emissions goals and actions against climate change (and resulting high CO_2 prices). The assumed price development is shown in Figure 2.

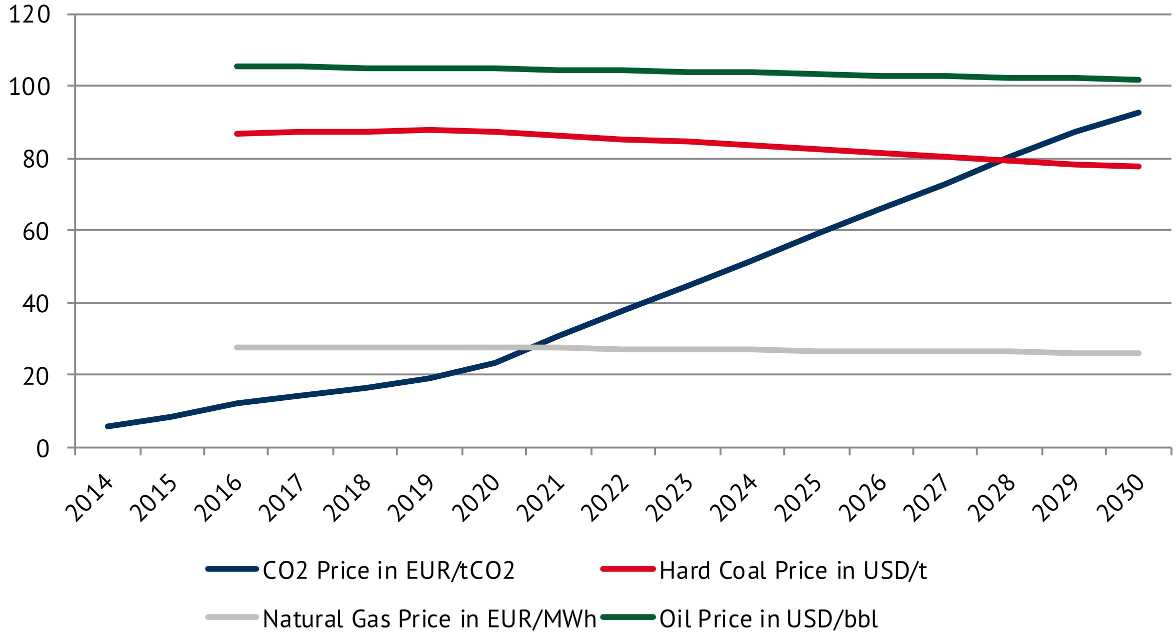

Figure 2: Modelled fuel and CO_2 emission price development

3.3 LIGNITE FUEL COSTS, EMISSIONS AND O&M COSTS

Lignite is a fuel which is traded very scarcely because of its low energy density. Therefore, no market prices for lignite are available. Moreover, Vattenfall's lignite mining activities are offered together with the lignite power plants, so that the mining costs are crucial for calculating the contribution margin.

The costs of lignite are calculated by considering the revenues of lignite mining companies as well as their produced amount of lignite. This data is available from two different sources (Vattenfall Europe Mining AG, 2014 and MIBRAG, 2015) and for both sources the calculation of lignite costs leads to nearly equal values. As the costs vary over time the average of the latest available five years is taken, which is 6.91 EUR/MWh_{th} of lignite. This includes the full costs of lignite mining and assumes a heating value of 2.51 MWh/t raw lignite (Eurostat, 2015). This assumption doesn't take into account further variation (which has occurred in the past) nor a future increase because of an increasing effort to extract lignite.

For the calculation of CO_2 certificate costs, also a value for specific CO_2 emissions of lignite has to be assumed. As the quality of lignite varies from location to location but also through one location, an average value of 404 kg/MWh_{th} is used for the calculations (Umweltbundesamt, 2013).

Cost assumptions for the operation and maintenance of lignite power plants are taken from Buttermann and Baten (2013). They assume yearly costs of 52.3 M€/$GW_{installed}$, which comprise labour, maintenance, insurance and auxiliary costs.

3.4 INTEREST RATE AND TAX

The interest rate is one crucial parameter for the calculation of the net present value as it defines the value of future cash flows. Frequently weighted average cost of capital (WACC) are used, which consider the expected return on shareholder's equity as well as the interest rate of debt capital. KMPG (2014) provides average WACC for different industry branches. For the energy & natural resources industry they came to the result of 7.2% WACC, which is used for further calculations.

Taxes are not taken into account.

4 SCENARIO RESULTS AND NET PRESENT VALUE FROM ELECTRICITY SALES

4.1 YEARLY POWER PRODUCTION AND CO_2 EMISSIONS FROM THE LIGNITE POWER PLANT PARK

In the following, the model results are described. Only revenues from electricity sales on the spot market are considered.

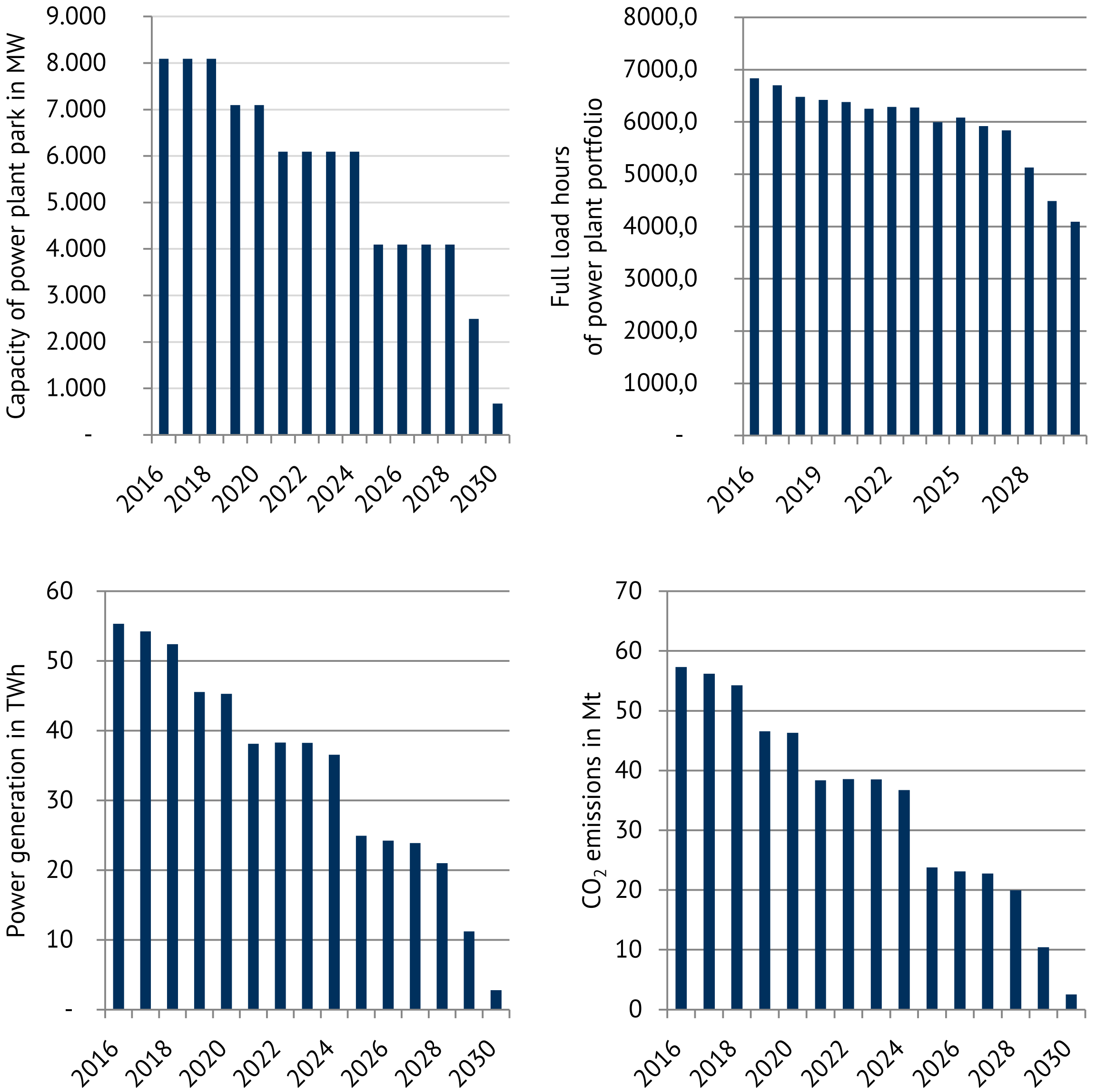

Figure 3: Capacity, full load hours, power generation and CO_2 emissions of the power plant park

Figure 3 shows the capacity development, the calculated average full load hours, development of power generation as well as the development of CO_2 emissions of the park until 2030. With decreasing installed capacity, obviously power generation and CO_2 emissions also decreases.

The graph on full load hours reflects the increasing share of renewable energies in the electricity market. Because of their low marginal cost the renewables displace lignite power plants which in consequence are used less.

4.2 YEARLY CONTRIBUTION MARGIN OF THE POWER PLANT PARK

Figure 4 shows the development of cash flows (contribution margins) as well as discounted cash flows of the power plant park. It is visible that after 7 years in which a positive contribution margin has been reached the revenues from electricity sales at the spot market are not sufficient any more to cover fuel costs, costs for CO_2 certificates as well as operating and maintenance costs. This is because of increased CO_2 certificate prices and decreased operational hours. Decommissioning of the (relatively inefficient) remaining Jänschwalde blocks at the end of 2024 leads to an increasing contribution margin for a short period. In the next year, cashflows decrease again. In 2027 and 2028, the negative contribution margin gets even lower than operational costs. This is because in the fundamental model, lignite power plants are assumed to offer their power at the spot market at marginal costs (which might be significantly lower than average fuel costs). Because of the high CO_2 prices in this period of time, lignite power plants are relatively frequently the price-setting marginal power plants and in these times revenues from sales only cover the marginal costs and therefore are not sufficient to generate even the full fuel costs.

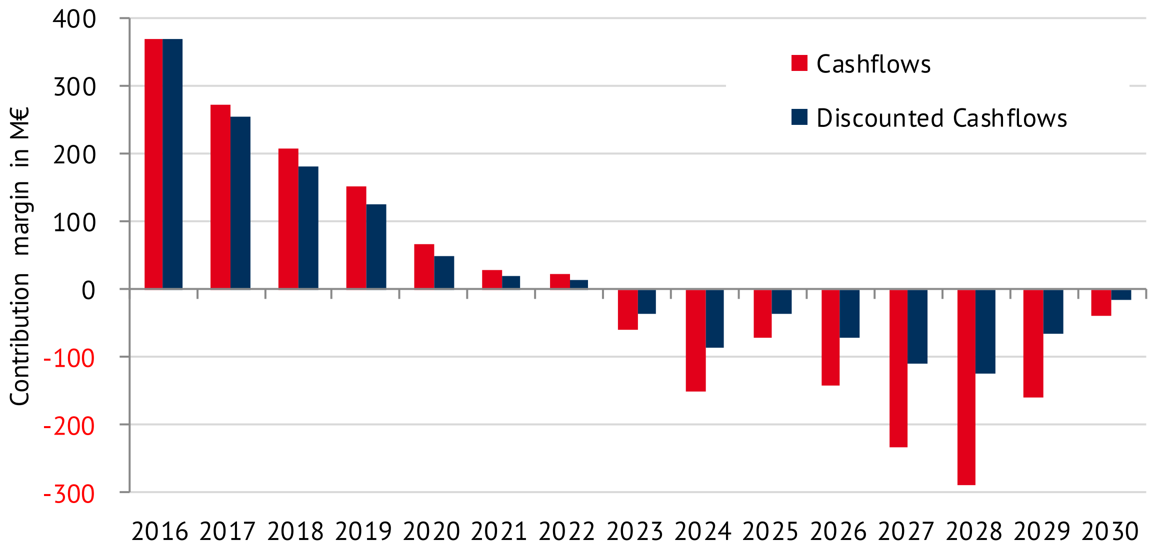

Figure 4: Yearly cash flows (contribution margins)

Figure 5 shows the development of the cumulated NPV over the time.

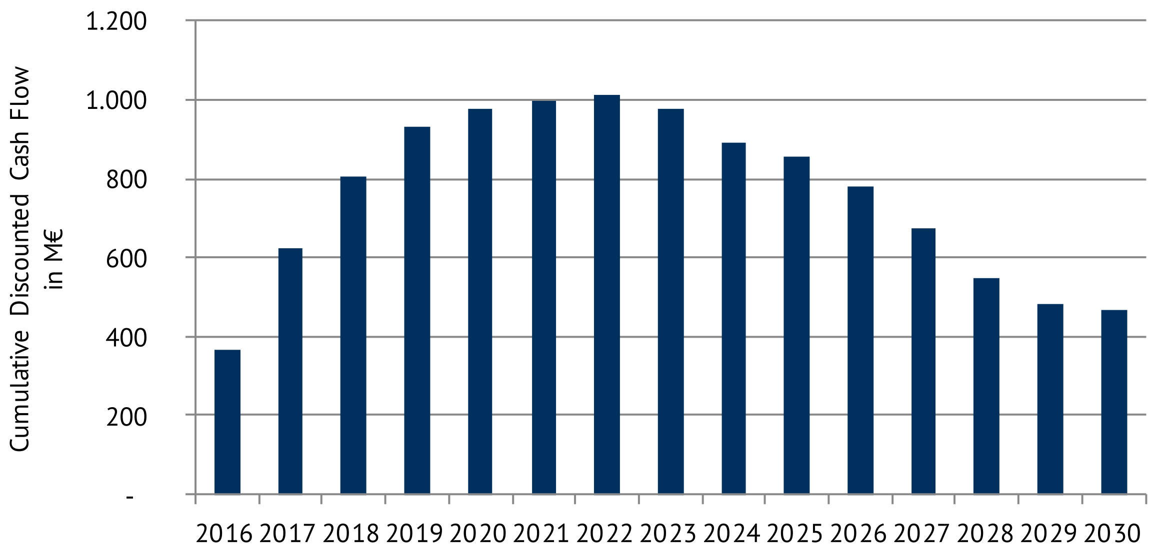

Figure 5: Development of the cumulated net present value over the time

The net present value (NPV) of the power plant park is 468 M€.

5 CONCLUSION

When interpreting the results and in particular when comparing the net present values calculated here with values from the public discussion, the following points should be considered:

- The calculations are based on an ambitious CO_2 scenario, in which the considered lignite power stations are shut down completely by the year 2030.
- The CO_2 and primary energy prices of the scenario come from the World Energy Outlook 2014 (IEA 2014). The prices are significantly higher than current prices at the futures market. This constellation of primary energy and CO_2 prices leads to an overestimation of revenue from electricity sales in the coming years. A second scenario calculation with current future prices for primary energy and CO_2 shows negative cashflows even for the years 2016 to 2020 (for more details please refer to Appendix 3).
- Due to the large amounts of coal and electricity even small changes in the input parameters such as the heating value or the specific emissions of lignite lead to significant influences on the net present value. Therefore, the input parameters of the model have been carefully researched and, if possible validated with literature values. Nevertheless, those values might develop differently in the future than assumed in this study.

- Despite complex and careful research the available data to determine the net present value of a single block-unit power station must be called incomplete. For this, much more specific plant data and business data for the lignite-fired power plants would be needed, which existed neither in the preparation of this analysis, nor is publicly available.

Despite these limitations, the result can be considered a solid assessment within the scenario assumptions.

In addition to the considered contribution margins from electricity sales as far as focussed on in this study, for a comprehensive calculation of the net present value of lignite power plants more cost and revenue items should be taken into account.

Additional revenue can be generated from, for example:

- Sale of heat
- Provision of operating reserve
- Use of the real option of the power plant commercially or in hedging (sale of elecriticity at the futures market, optimisation at the spot market)
- Optimisation of power plant dispatch in intraday markets
- Participation in redispatch mechanisms
- etc.

Whilst the first point (sale of heat) is probably of minor importance, especially the use of future markets for the sale of electricity (third point) might have generated significant benefits in the past for the company in comparison with selling at the spot markets only. This is due to decreasing electricity prices over the last years. Assuming for example that Vattenfall had sold all of its electricity generated in 2014 at the futures market at the last trading day of the year 2013 would have led to nearly 300 M€ higher revenues compared to selling at the spot market only. This calculation doesn’t take into account further power plant optimisation at the spot market.

However, if benefits will remain as high in the future depends on the sales strategy and price development at the futures market and therefore can’t be calculated exactly.

When evaluating the net present value additional revenues from an inclusion of the power plants in the Capacity and Climate Reserve planned by the federal government as well as further announced changes to the electricity market design with respect to the revenue stream of lignite power plants should be considered. For both, economic details are not available so far.

APPENDIX 1:
DESCRIPTION OF THE FUNDAMENTAL ENERGY MARKET MODEL POWER2SIM

Power2Sim is a software for the simulation of hourly electricity prices until the year 2050 for all countries of the European Union, Norway and Switzerland. Energy Brainpool’s long-term experience in the field of analysis and consultancy for the energy industry, politics and technology contributes to the constant update and improvement of Power2Sim.

Operation and usage

Power2Sim has established itself successfully on the market for many years. The versatile range of applications can be customised individually according to the customers’ requirements, such as:

- Evaluation of corporate strategies
- Short-term forecasts down to the hour for trading purposes
- Contract and asset valuations
- Investment planning
- Cost and revenue planning
- Power plant scheduling and optimisation
- Analysis of the main influential factors for electricity prices and the influences of the injection of renewable energies

A1.1 STRUCTURE AND FUNCTIONALITY

Power2Sim is a modular fundamental model. Based on individual requirements, the electricity price model can be complemented by independent sub-models. These sub-models ensure that historical fundamental data can be reasonably projected into the future. Power2Sim uses an underlying reference scenario, based on public fundamental data and future trends. In addition, Energy Brainpool‘s market know-how, acquired by continuous development and improvement, as well as current market trends enhance the model. All input parameters in Power2Sim can be easily adjusted in order to set up individual scenarios according to your requirements and ideas.

A1.2 ELECTRICITY PRICE MODEL (MERIT ORDER MODEL)

Power2Sim maps the energy-only market by calculating the electricity price according to the merit-order principle. Essential factors within this context are the marginal costs of electricity generation. Thereby the cost for the most expensive power station that is still needed to cover the demand determines the price for each individual hour.

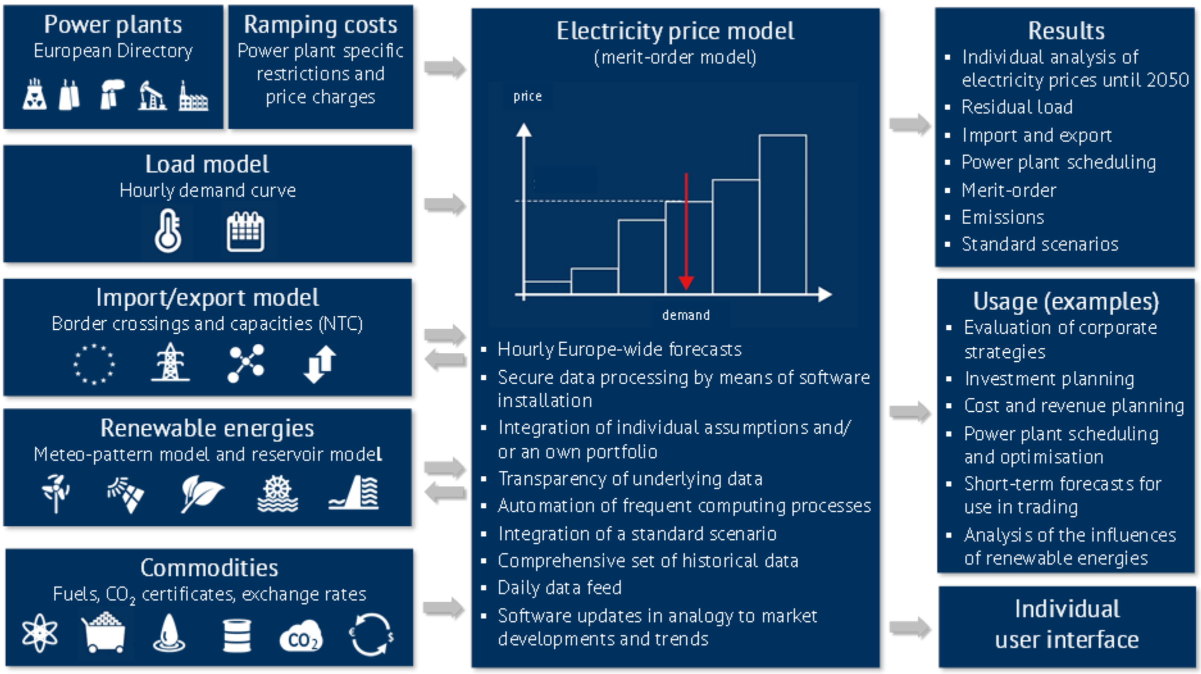

Figure 6: Schematic structure of Power2Sim

Marginal costs are determined by the relevant fuel costs, CO_2 certificate costs, if applicable, as well as the efficiency of the specific power plant. Besides short-term costs, modified operation and transport costs for fuels may result in modifications of the cost structure. In addition the sub-model “ramping costs“ considers surcharges and specific power plant restrictions.

European power plant directory

Core of the conventional power park fleet in Power2Sim is the European Power Plant Directory – a comprehensive database of more than 3,300 conventional power plants all over Europe. Power plants are listed separately according to the energy sources lignite, hard coal, oil, natural gas and uranium.

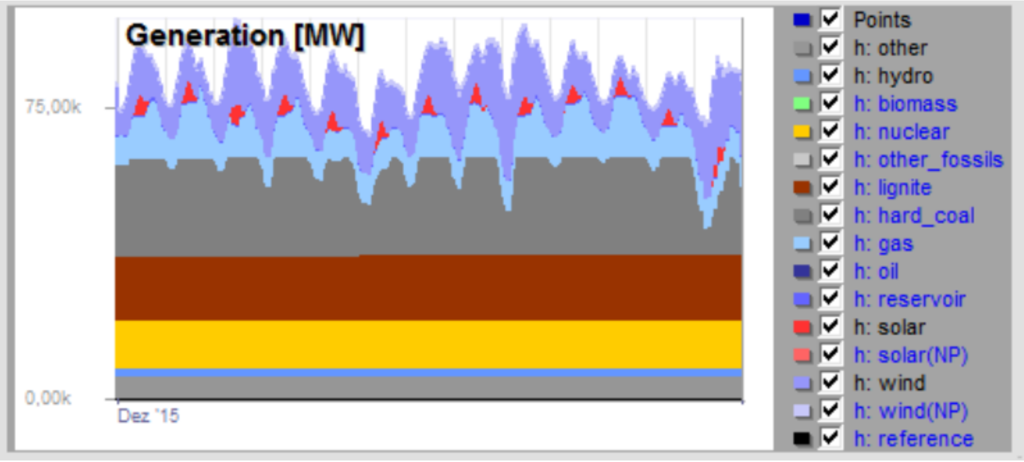

Figure 7: Modelled electricity generation by energy source

The directory provides, among other aspects, information on the generation capacity, efficiency and commissioning.

LOAD MODEL

The load model calculates the electricity demand over the entire forecast horizon down to the hour based on scenario specifications.

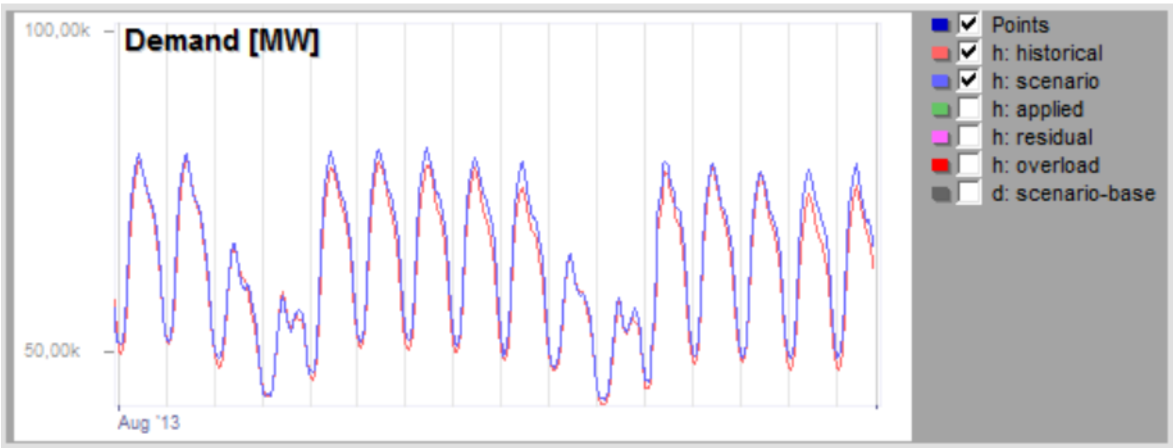

Figure 8: Historical (red) and modelled (blue) load

Therefore the load model uses country-specific sensitivities for temperature, weekdays, public holidays, etc., which have been derived from historical load data.

IMPORT/EXPORT MODEL

The import/export model is an extension of the merit-order model for the calculation of cross-border flows between European states. Taking into consideration the specifications for cross-border lines and their capacities, Power2Sim calculates the optimal utilisation of individual lines and thus the influence of import and export of electricity on national electricity prices.

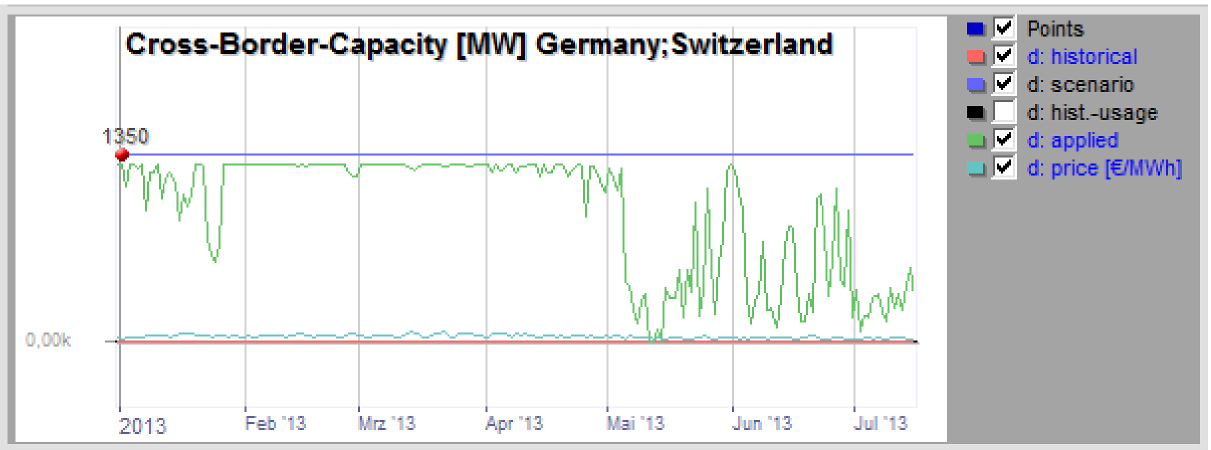

Figure 9: Cross-border import and export of electricity from Germany into Switzerland

RENEWABLE ENERGIES

Above all, electricity generation from renewable energies is determined by the availability of the energy source.

This simulation is done via model approaches that consider the particularities of the individual energy sources. Stochastic profiles for the future are determined for wind and solar feed.

Generation from water power is divided into run-of-the-river, reservoir and pump storage plants. Other renewable energies such as biomass and geothermal energy are considered in sum.

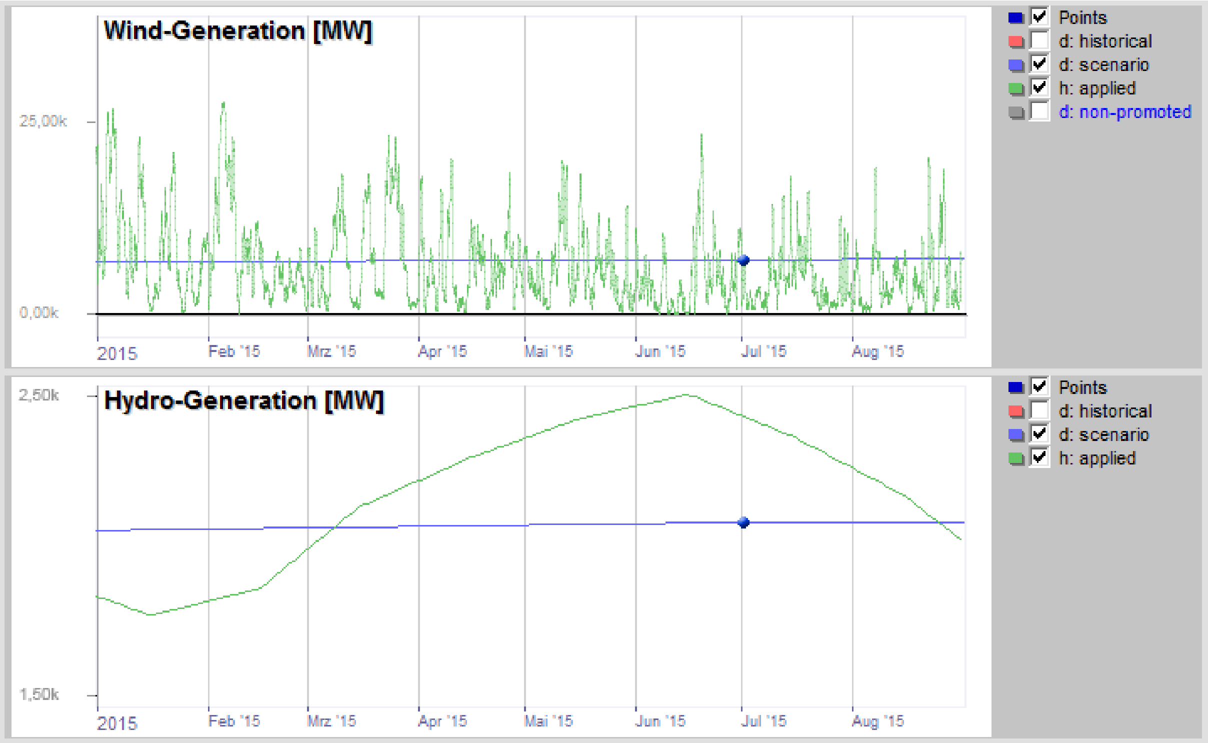

Figure 10: Modelled generation from wind and water power

For all renewable energy sources, the user specifies electricity production and installed capacity in Power2Sim. From these specifications, specific hourly generation curves are generated.

APPENDIX 2: DETAILED MODEL RESULTS

Table 2: Yearly model results

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Capacity of power plant park in MW	8095	8095	8095	7095	7095	6095	6095	6095	6095	4095	4095	4095	4095	2495	675
Full load hours of power plant portfolio	6835	6703	6477	6420	6381	6254	6285	6274	5998	6085	5922	5836	5126	4485	4089
Power generation in TWh	55.3	54.3	52.4	45.6	45.3	38.1	38.3	38.2	36.6	24.9	24.3	23.9	21	11.2	2.8
Lignite consumption in Mt	56.6	55.4	53.5	45.9	45.7	37.8	38	38	36.2	23.4	22.8	22.5	19.7	10.3	2.5
CO_2 emissions in Mt	57.3	56.2	54.2	46.6	46.3	38.4	38.6	38.5	36.7	23.8	23.1	22.8	19.9	10.4	2.5
CO_2 costs €/tCO2	12.2	14.5	16.7	18.9	23.5	30.6	37.7	44.8	51.9	59	66.1	73.2	80.3	87.3	92.7
Cash flow (contribution margin) in M€	368.5	272.6	209.1	153.3	66.1	28.1	22.3	-59.7	-150	-70.5	-144	-234	-290	-159	-38.4
Discounted cash flow (contribution margin) in M€	368.5	254.3	181.9	124.4	50	19.8	14.7	-36.7	-86	-37.7	-71.8	-109	-126	-64.4	-14.5
Cumulative discounted cash flow in M€	368.5	622.8	804.8	929.2	979.2	999.1	1013.7	977	891	853.3	781.6	672.5	546.6	482.2	**468**

APPENDIX 3: SENSITIVITY ANALYSIS ON THE NET PRESENT VALUE

As discussed, the net present value (NPV) is subject to numerous influential parameters. To quantify the influence of primary energy and CO_2 prices on the NPV a second scenario was calculated. With one exception, the assumptions and input parameters are identical to the scenario examined above: Instead of primary energy and CO_2 prices from the World Energy Outlook 2014 (IEA 2014) current future market prices from EEX (gas, coal, CO_2 certificates) and ICE (oil) are taken into account as shown in Figure 11. As future prices are only available for years in the relatively near future the analysis includes the years until 2020 only.

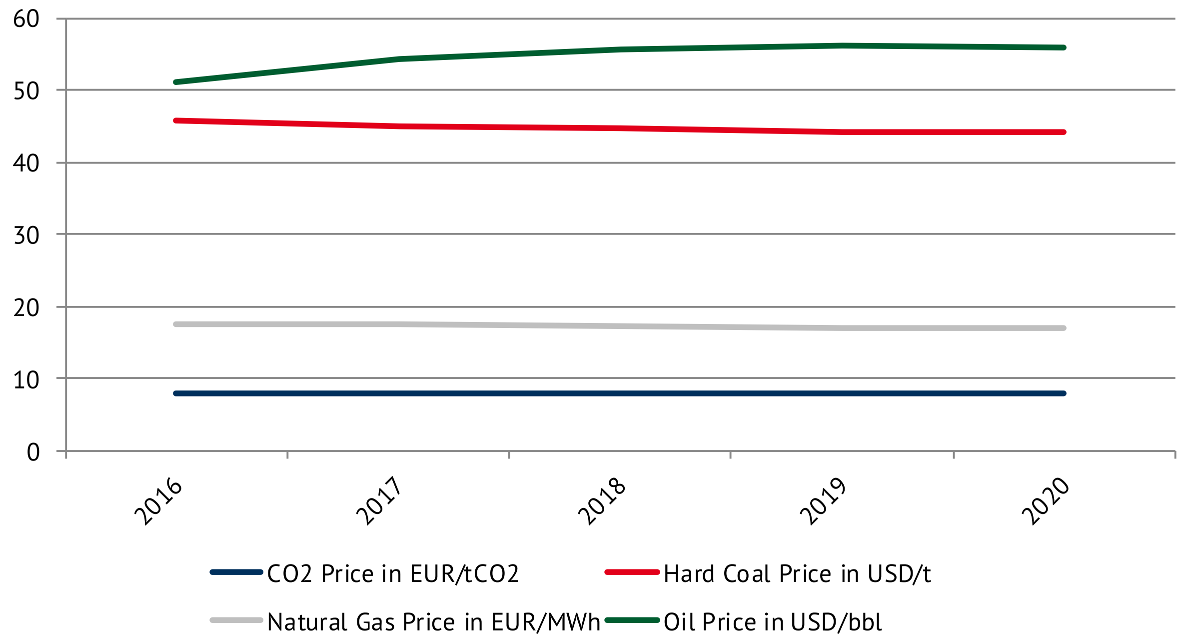

Figure 11: Fuel and CO_2 emission price development (Scenario future market prices)

These future market prices quote significantly below the prices of the WEO and affect the price of electricity significantly. With lower primary energy and CO_2 prices, electricity prices are lower and, consequently, the contribution margins of lignite power plants are also lower. As shown in Figure 12, in this scenario the yearly contribution margins from electricity sales are negative.

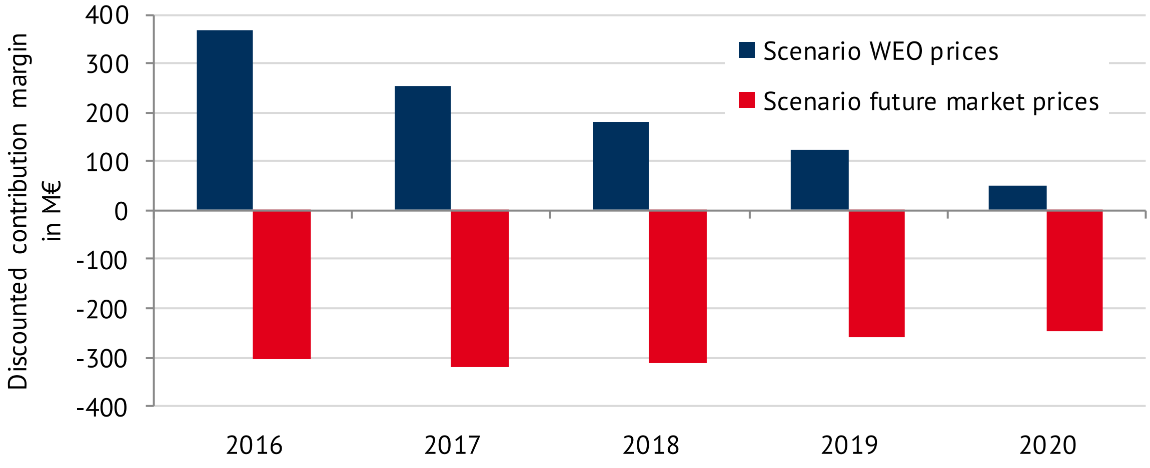

Figure 12: Comparison of yearly discounted cash flows (contribution margins)

Over the period 2016 to 2020 the discounted cash flows add up to 979 M€ in the scenario with WEO prices and to minus 1,444 M€ in the scenario with future market prices. These results demonstrate the great influence of input parameters on the net present value. Therefore, great efforts have been made to model the scenarios consistent. When interpreting the results shown the notes mentioned in chapter 5 should also be considered.

Further scenario results are shown in Table 3 below.

Table 3: Yearly model results (Scenario future market prices)

	2016	2017	2018	2019	2020
Capacity of power plant park in MW	8095	8095	8095	7095	7095
Full load hours of power plant portfolio	6813	6684	6457	6416	6396
Power generation in TWh	55.2	54.1	52.3	45.5	45.4
Lignite consumption in Mt	57.1	56.0	54.1	46.5	46.4
CO_2 emissions in Mt	57.1	56.0	54.1	46.5	46.4
CO_2 costs €/tCO_2	8.1	8.0	8.0	8.0	8.0
Cash flow (contribution margin) in M€	-304	-344	-360	-318	-328
Discounted cash flow (con-tribution margin) in M€	-304	-321	-314	-258	-248
Cumulative discounted cash flow in M€	8095	8095	8095	7095	7095

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ABOUT ENERGY BRAINPOOL

Energy Brainpool is the independent market specialist for the energy sector, with a focus on the electricity and energy trade in Europe. Our expertise includes **analysis**, forecasting and modelling of energy markets and prices, scientific and practice-oriented studies, **individual consulting** as well as **training** for the energy sector.

OUR PHILOSOPHY

Neutrality, independence, reliability and a comprehensive understanding of the energy sector and energy markets – these are the basics for implementing optimal solutions to the challenges in a changing market. As a competent partner, we offer combined services to handle all issues of the energy trade under one roof. Our services are shaped by your needs and combine our expertise in the fields of analysis, consultancy and training for your future business success.

INDIVIDUAL PRODUCTS AND SERVICES

With our comprehensive service concept, we are able to support our customers in the fields of policy, finance, strategy and organisation. We accompany our customers throughout all phases of the solution process – from scientific analysis, individual consulting and development of the ideal strategy and required tools to practical realisation as well as staff and management training.

Analysis

Our fundamental energy market model Power2Sim models energy prices and scenarios until 2050. Our spot price forecast serves as a short-term forecast for trading and dispatching. Constant observation of the market as well as inside knowledge of economics and politics help us to optimise our analysis models and project current trends.

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As market specialists we offer strategic and operative consulting for the energy sector.
Our strength lies in the areas of market transformation with increasing levels of renewables, in Germany's energy transition, as well as in trading, portfolio and risk management. We enable our customers to adapt and to grow in this changing market environment.

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In individual training, seminars and workshops, we deliver our manifold knowledge of and insights into the energy sector. We offer in-house seminars, e-learning courses, practice-oriented simulation games for the energy trade as well as specialised events and conferences.

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Publisher:

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October 2015