Appendix 1: Economic analyses on Vattenfall’s lignite power plants offered for sale

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

DETERMINATION OF THE NET PRESENT VALUE FROM ELECTRICITY SALES

Berlin, October 19th, 2015

Greenpeace Nordic

Alexander Fernahl
Johannes Henkel
Thorsten Lenck

CONTENT

Energy Brainpool

LIST OF FIGURES

LIST OF TABLES

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).

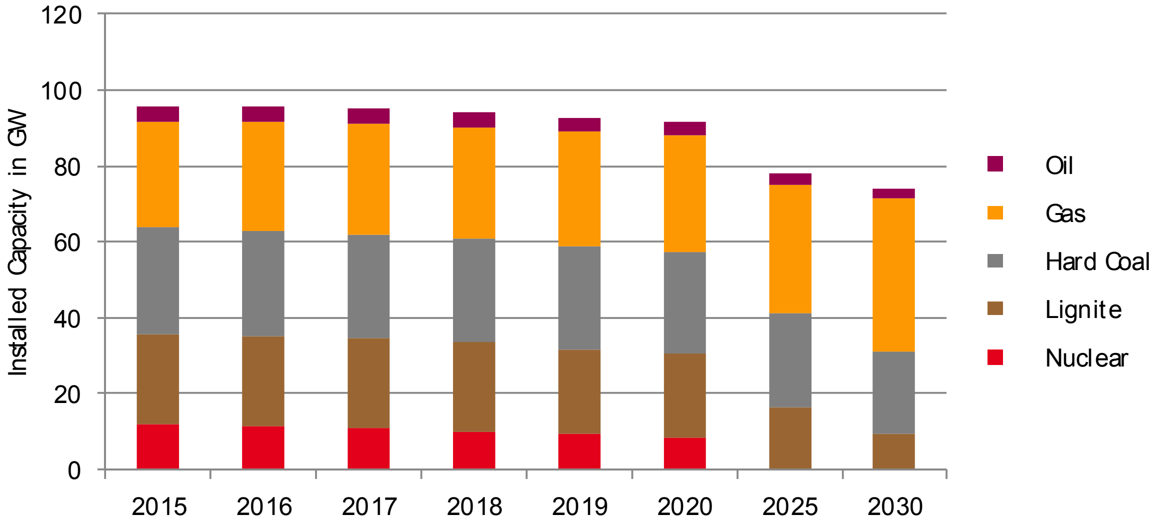


Figure 1: Installed capacity of modelled power plant park (Germany) by fuel

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.

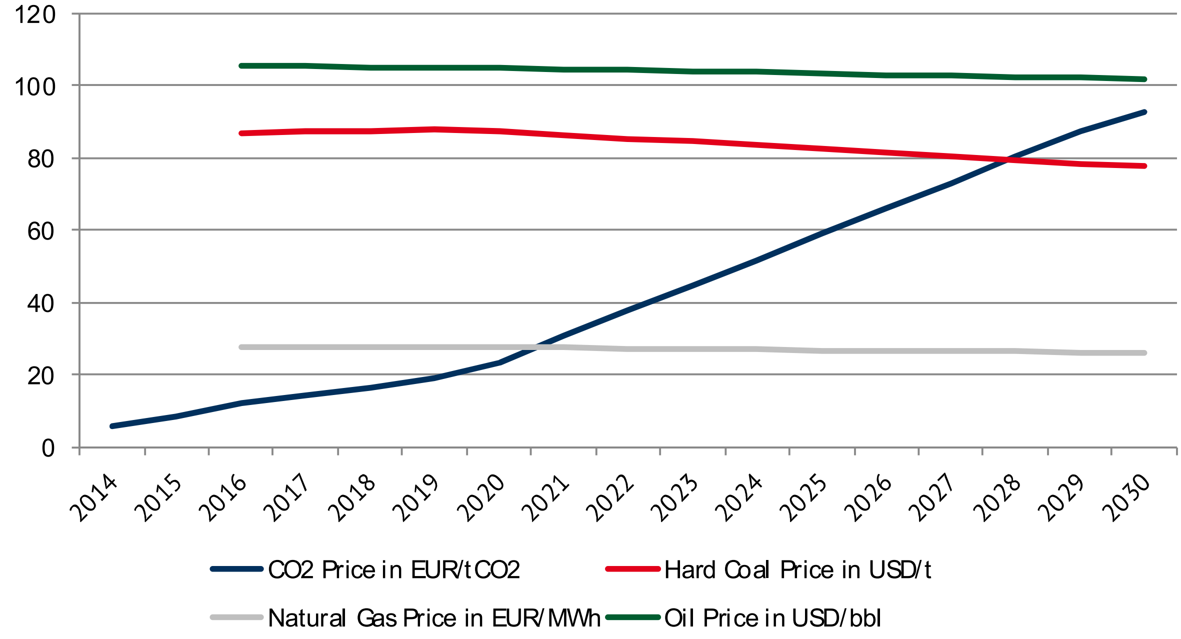


Figure 2: Modelled fuel and CO_2 emission price development

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 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.

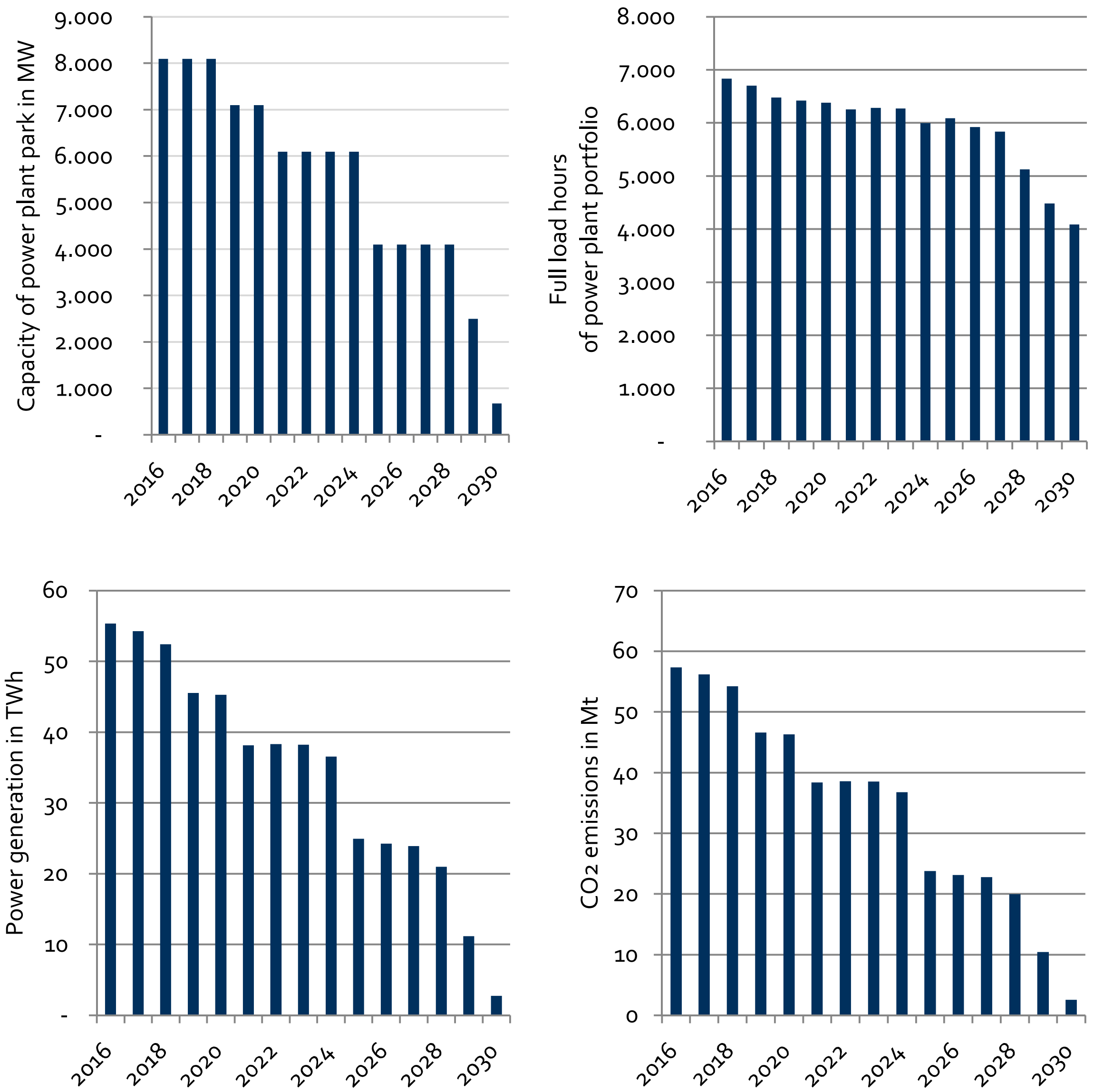


Figure 3: Capacity, full load hours, power generation and CO_2 emissions of the power plant park

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 electrici-

ty 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.

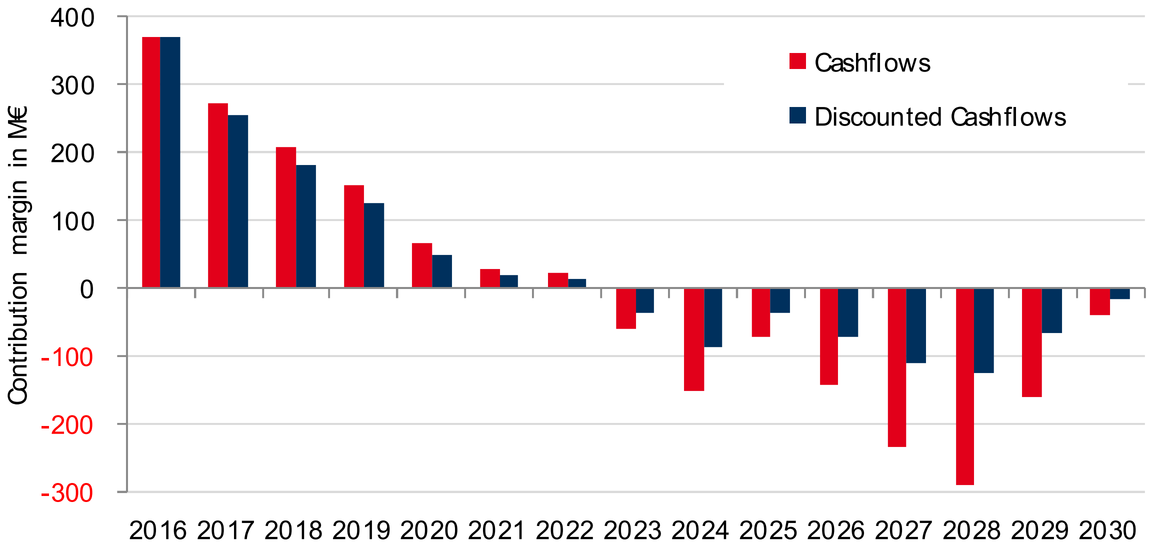


Figure 4: Yearly cash flows (contribution margins)

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

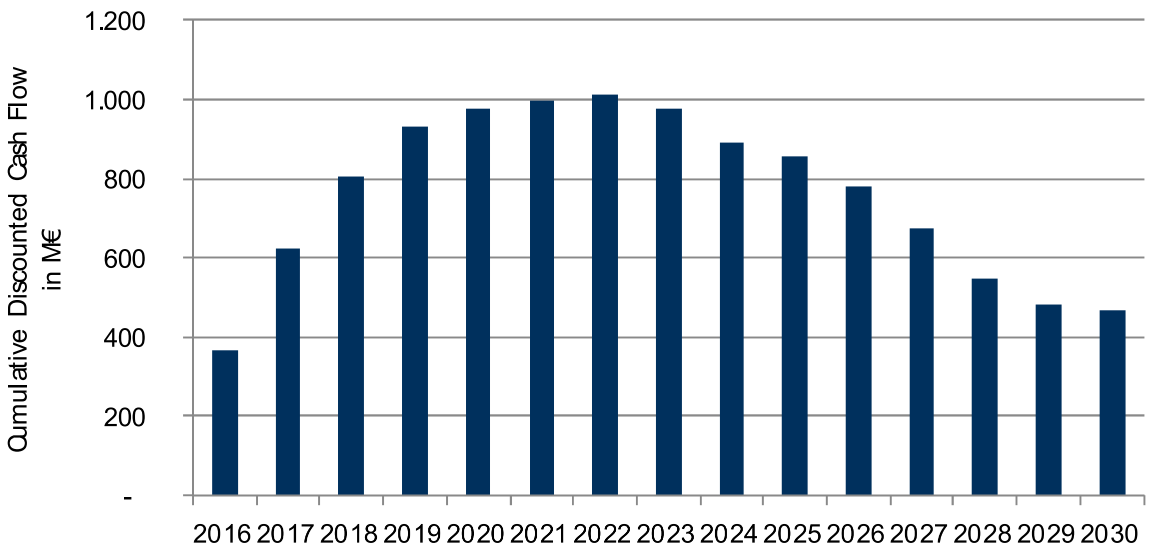


Figure 5: Development of the cumulated net present value over the time

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
- 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.

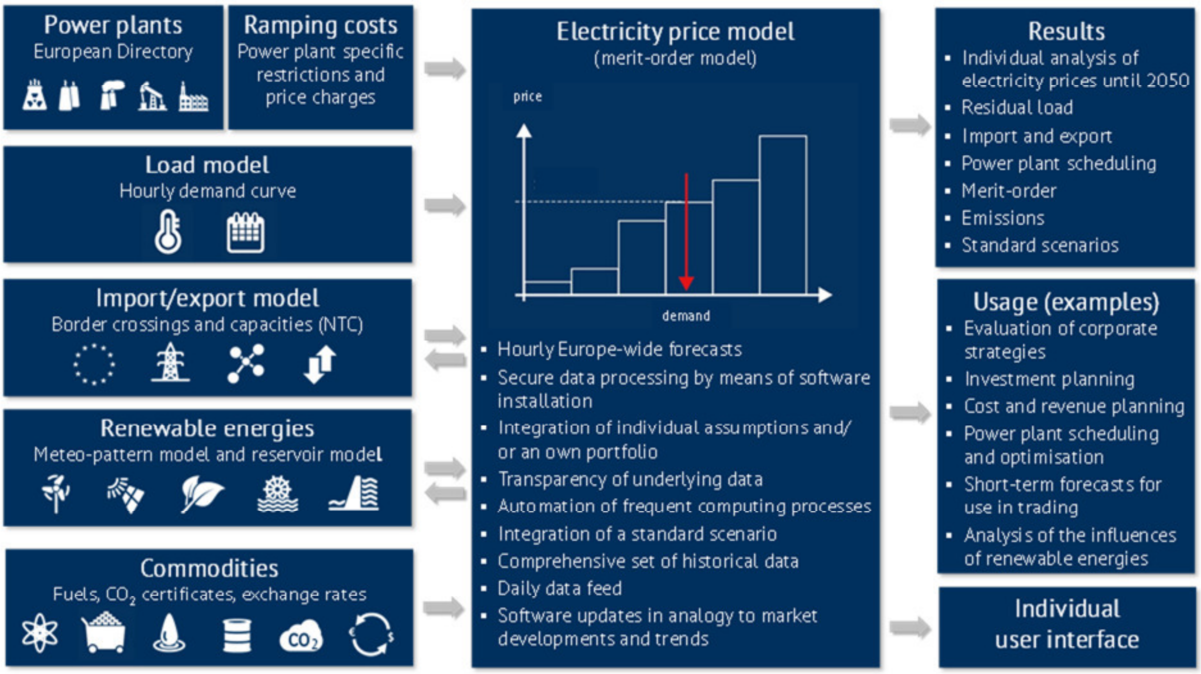


Figure 6: Schematic structure of Power2Sim

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.

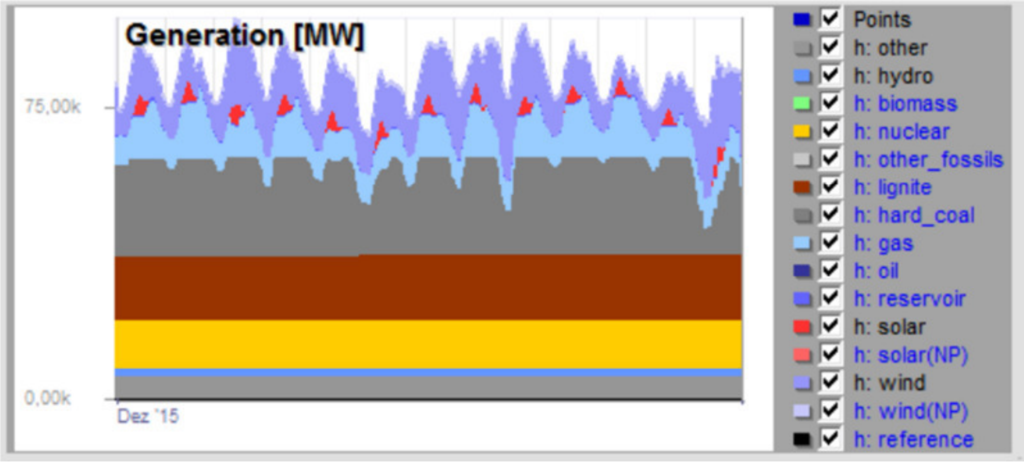


Figure 7: Modelled electricity generation by energy source

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.

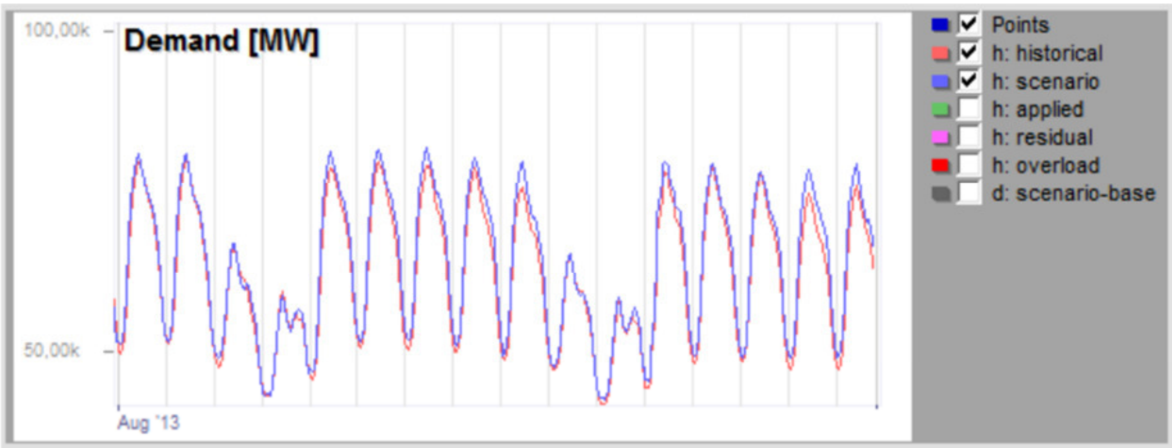


Figure 8: Historical (red) and modelled (blue) load

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.

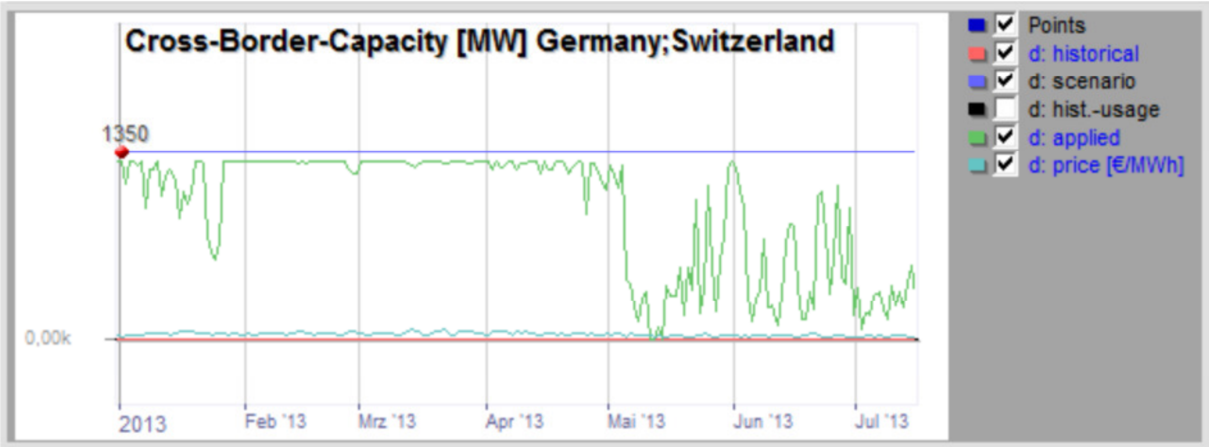


Figure 9: Cross-border import and export of electricity from Germany into Switzerland

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.

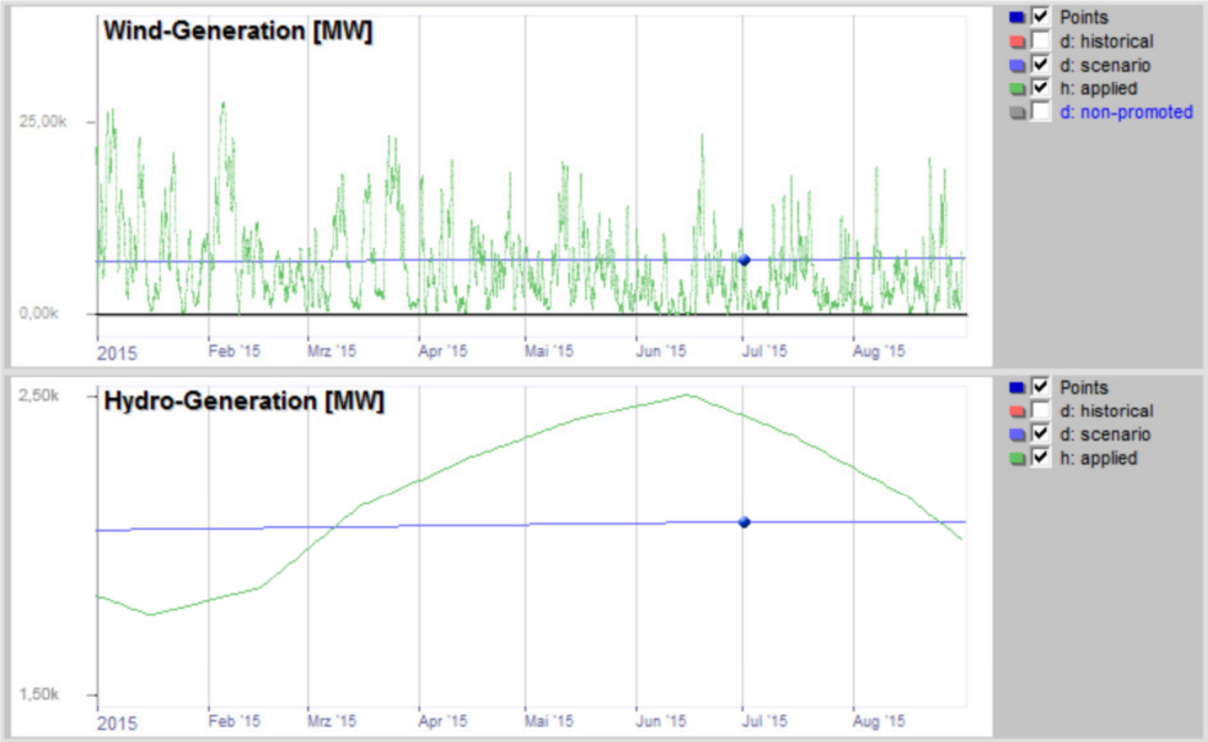


Figure 10: Modelled generation from wind and water power

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

Energy Brainpool

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
CO2 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
CO2 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

The net present value (NPV) is subject to numerous influences. 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 examined scenario above: Instead of primary energy and CO_2 prices from the World Energy Outlook 2014 (IEA 2014) current future market prices from EEX and ICE are taken into account as shown in Figure 11. The analysis includes the next few years only, because not all futures are traded longer than 2020.

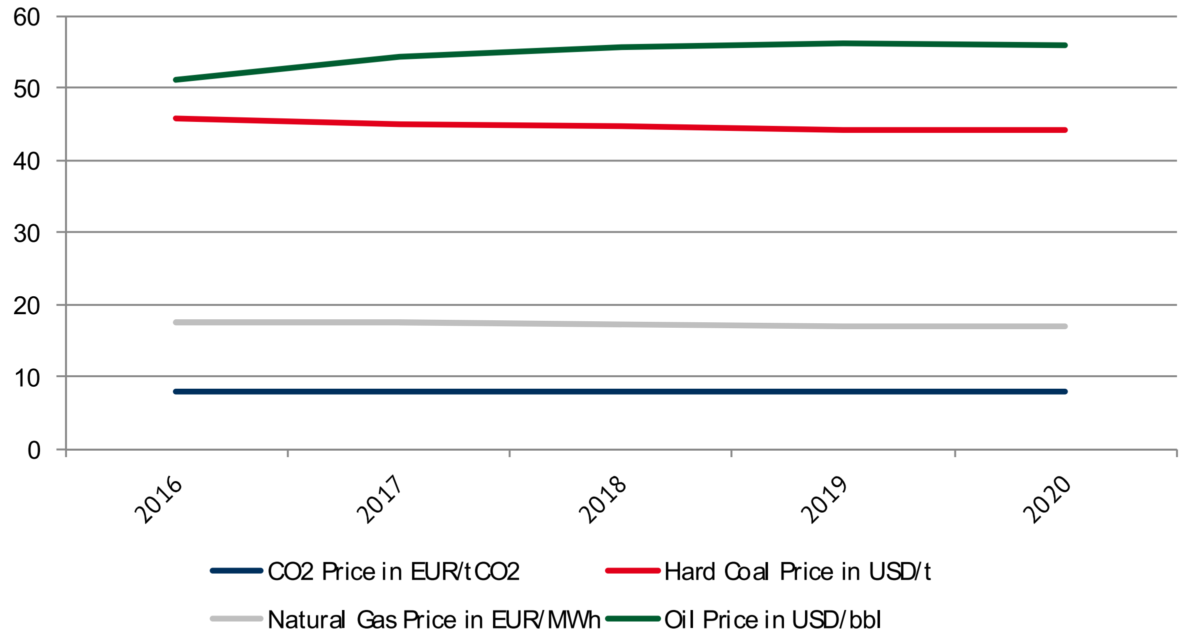


Figure 11: Modelled fuel and CO_2 emission price development (Scenario future market prices)

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 fall and, consequently, the contribution margins of lignite power plants. As shown in Figure 12 the yearly contribution margins from electricity sales are reversed into the negative.

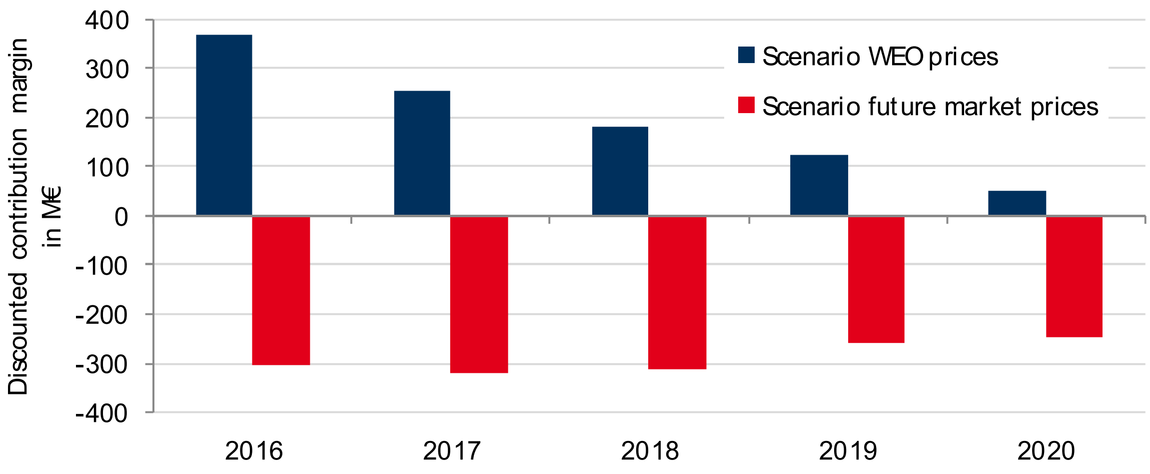


Figure 12: Comparison of yearly discounted cash flows (contribution margins)

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. Already, 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 these results 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

REFERENCES

Buttermann, H.-G. and Baten, T. (2013): Wirtschaftlichkeit des Neubaus von Braunkohlekraftwerken. In: Energiewirtschaftliche Tagesfragen 63 (2013), Heft 4.

EU (2013): EU energy, transport and GHG emissions trends to 2050, http://ec.europa.eu/energy/sites/ener/files/documents/trends_to_2050_update_2013.pdf [16.10.2015].

Eurostat (2015): Eurostat Database, nrg101a [online]. http://ec.europa.eu/eurostat/de/data/database [16.10.2015].

IEA (2014): World Energy Outlook 2014, IEA Publications 2014.

KPMG (2014): Kapitalkostenstudie 2014 [Online]. https://www.kpmg.com/DE/de/Documents/kapitalkostenstudie2014-de.pdf [16.10.2015].

MIBRAG (2015): Mitteldeutsche Braunkohlengesellschaft mbH [online]. http://www.mibrag.de [16.10.2015].

Umweltbundesamt (2013): Entwicklung der spezifischen Kohlendioxid-Emissionen des deutschen Strommix in den Jahren 1990 bis 2012 [online]. http://www.uba.de/uba-info-medien/4488.html. [16.12.2015].

Vattenfall Europe Mining AG (2014): Jahresabschluss zum Geschäftsjahr 1.1.2013 bis zum 31.12.2013.

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.

Consulting

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.

Training

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.

IMPRINT

Authors:

Alexander Fernahl

Dr. Johannes Henkel

Thorsten Lenck

Publisher:

Energy Brainpool GmbH & Co. KG
Brandenburgische Straße 86/87
10713 Berlin
Germany
www.energybrainpool.com
kontakt@energybrainpool.com
Phone: +49 (30) 76 76 54 - 10
Fax: +49 (30) 76 76 54 - 20

October 2015

Appendix 2: Estimates of closure costs and externalized costs

1. Closure costs

The closure costs can be very significant if we compare them with the NPV of the annual contribution margins (estimated in the Energy Brainpool report). These include at least land recultivation costs, power plant decommissioning costs and human resource-related costs.

1.1. Estimates of the **cost of land recultivation** showed significant additional recultivation costs.

- The analysis identified total recultivation costs amounting to EUR 2.4 billion for all current mining areas. Between 2006 and 2013, Vattenfall has spent close to EUR 0.7 billion on recultivating the area. This means that an additional EUR 1.7 billion will be needed for recultivation over the coming decades.
- The analysis is based on the recultivation costs of the German LMBV Foundation which is responsible for the land rehabilitation of 107,000 hectares of former mining landscape. For the period of 1991 to 2017, LMBV estimates costs of EUR 11.1 billion for the recultivation of 107,000 hectares; in other words more than 100,000 euros per hectare.

Type of cost	Assumptions and calculations	Estimated costs
Land recultivation costs after mine closures	Land recultivation costs are estimated for the next 25 years; without iron hydroxide deposition, impairments caused by sulfate, or any perpetual costs. **Mining Area[1]:** Nochten I (4,825 ha), Reichwalde (1,131 ha), Welzow Süd (9,000 ha), Cottbus-Nord (2,038 ha), Jänschwalde (6,015 ha) – **Total: 23,009 ha** **Land recultivation costs: EUR 104,000 per ha[2]**	EUR 1.7 billion

[1] Forum Ökologisch-Soziale Marktwirtschaft e.V. (2014): Kostenrisiken für die Gesellschaft durch den deutschen Braunkohletagebau. https://www.greenpeace.de/sites/www.greenpeace.de/files/publications/studie-folgekosten-braunkohle.pdf

[2] Based on the work of the German foundation LMBV responsible for the land rehabilitation of 107,000 ha of former mining land. This projection shows the amount of effort a new owner has to invest during the next 25 years for recultivation. Between 1991 and 2017, the LMBV estimates costs of 11.1 billion euros for the recultivation of 107,000 ha (this corresponds to EUR 103,738.32 per ha). http://www.lmbv.de/tl_files/LMBV/Publikationen/Publikationen%20Zentrale/Publikationen%20Diverse/Rekultivierung_2009.pdf. p7. Greenpeace does not expect these efforts to end after 25 years. There will be follow-up costs for decades to come because most of the area will not be fit for use after 25 years. Past

	TOTAL LAND RECULTIVATION COSTS: EUR 2.4 billion **Vattenfall** already spent EUR 681 million for land-recultivation (2006-2013); estimate based on the companies' liabilities related to recultivation (see the following table) **Estimated additional recultivation costs: EUR 1.7 billion**	

<u>Vattenfall's liabilities for recultivation</u>[3]

Year	Capital inflow (in millions of euros)	Capital outflow (in millions of euros)	Total liabilities (in millions of euros)
2005	56.5		868.4
2006	100.9	60.6	908.7
2007	148.7	39	1,018.4
2008	123	57.2	1,084.2
2009	96.8	75.5	1,105.5
2010	55.8	283.9	877.4
2011	122.2	44	955.6
2012	68.8	43.7	980.7
2013	94.8	77.3	998.2
Total outflow		**681.2**	

Because of the lack of transparency, Greenpeace has to assume that Vattenfall used any capital outflow for land recultivation purposes.

1.2. The analysis identified **total costs of EUR 0.4 to 0.85 billion for decommissioning** the Vattenfall coal-fired power plants

- The estimate assumes that the coal-fired power plants have a total capacity of eight gigawatts and EUR 50,000 to 105,000 per MW in demolition costs. This is based on EPRI's *Decommissioning Handbook for Coal-Fired Power Plants*.

experience shows that even after 50 to 60 years, many areas are still no-go areas affected by landslides and other problems.

[3] Based on several annual balance sheets issued by Vattenfall Europe Mining Aktiengesellschaft

Type of cost	Assumptions and calculations	Estimated costs
Costs of decommissioning coal-fired power plants	Installed capacity of Vattenfall's lignite power plants: 8,095 MW Range of benchmark costs for decommissioning coal power plants: EUR 50,000 – 105,000 per MW Expected total costs for demolition: EUR 404 – 850 million	Between EUR 404 and 850 million

Summary of benchmark coal plant decommissioning costs

(Source: *Decommissioning Handbook for Coal-Fired Power Plants*[4])

Plant	MW	Minimum costs (in thousands of USD/MW)	Maximum costs (in thousands of USD/MW)	Minimum costs (EUR[5]/MW)	Maximum costs (in thousands of EUR/MW)
Arkwright	160		19		105
Watts Bar	240	17	25	62	92
Port Washington	341	19.4	34.4	50	89
Range (Euro/MW)				50	105

Additional risks not considered:

- Further costs due to partial asbestos contamination of the power plants
- Further costs due to chemical contamination of the power plant site (especially Lippendorf)

1.3. The analysis also estimated costs of EUR 25 million to EUR 76 million for **indemnity or human resources support.**

- The calculation used an estimated number of employees in 2030 (3,900 employees), the average expected monthly salary (at today's prices) of EUR 2,618 and a very conservative average job tenure between 5 and 15 years.

[4] Decommissioning Handbook for Coal-Fired Power Plants, 1011220
Final Report, November 2004, EPRI Project Manager A. F. Armor
http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000000001011220

[5] Exchange rate: 1 USD = EUR 0.88

- These are very conservative assumptions, especially regarding job tenure and the factor of “monthly gross salary per year of job tenure”.

Type of cost	Assumptions and calculations	Estimated costs
Costs for **indemnity** or costs of financial support for a transfer company (50 percent of monthly gross salary per year of job tenure)	Average assumed job tenure: 5-15 years Average monthly gross salary: EUR 2,618 Estimated number of employees in 2030[6]: 3,900 TOTAL ESTIMATED COSTS: 3,900 employees x EUR 2,618 x 50 percent of 5 years or 15 years <u>Database:</u> total personnel costs in Lusatian lignite industry: EUR 342.3 million (2009)[7]; cumulated gross salaries in 2009 (76.8 percent of personnel costs[8]): EUR 262.9 million; number of employees in the Lusatian lignite industry: 8,369 (2013)[9]; average monthly gross salary per employee: EUR 2,618.	**EUR 25 to 77 million**

2. Current externalised costs

Further costs to reduce the environmental, health and social impact of the lignite industry amount to tens of billions of euros.

---

[6] Institut für ökologische Wirtschaftsforschung (2015): Vattenfalls Chance. Eine Zukunft für die Lausitz ohne Braunkohle. https://www.greenpeace.de/sites/www.greenpeace.de/files/publications/vattenfalls-chance-roadmap-150424.pdf

[7] EEFA – Energy Environment Forecast Analysis (2011): Die Rolle der Braunkohlenindustrie für die Produktion und Beschäftigung in Deutschland. Untersuchung im Auftrag des DEBRIV. http://www.braunkohle.de/61-0-EEFA-Studie-Beschaeftigungseffekte-2011.html

[8] Statistisches Bundesamt (2012): Arbeitskostenerhebung, https://www.destatis.de/DE/ZahlenFakten/GesamtwirtschaftUmwelt/VerdiensteArbeitskosten/ArbeitskostenLohnnebenkosten/Tabellen/StrukturKostenart.html

[9] http://www.braunkohle.de/126-0-Beschaeftigtenzahlen.html

2.1 Health costs

Health costs from air pollution related to lignite power plants are estimated at between EUR 7.1 and 21 billion[10] for 2016 to 2030. This estimate is based on approximately 512 TWh additional electricity production until 2030, accounting for declining capacity utilization as projected in the Energy Brainpool report (see Appendix 1), European Environment Agency damage cost values per tonne of SO2, NOx, PM2.5 and mercury emissions from the power sector in Germany[11], and the reduction of emission levels to comply with the Industrial Emissions Directive's emission limits from 2016 onwards and with the new Large Combustion Plants Best Available Technology Reference Document's emission levels from 2020 onwards[12].

Type of cost	Assumptions and calculations	Estimated costs
Health costs from air pollution related to lignite power plants	See tables for detailed calculations	**Between EUR 7 and 21 billion**

Damage costs of air pollution emissions in Germany (EUR/t, 2005 prices)

Pollutant	Low	High	Sector adjustment factor for power generation	Premature deaths (cases/t)
SO2	18,956	57,524	0.86	0.0188
NOx	6,817	19,059	0.80	0.0064
PM2.5	47,310	147,553	0.51	0.0285
Hg	2,860,000	2,860,000	1.00	

Average emissions 2010-2012, t/year

Facility	CO2	SO2	NOx	PM10	PM2.5	Hg
Boxberg	15,733,333	10,303	11,067	348	104	0.245
Lippendorf	11,400,000	12,300	7,680	143	43	0.763
Jänschwalde	24,300,000	22,367	19,400	617	185	0.482
Schwarze Pumpe	11,900,000	8,060	5,007	84	25	0.247

[10] Costs are expressed in 2014 prices and discounted to present value using a social rate of time preference of 3 percent.
[11] European Environment Agency (2014): Costs of air pollution from European industrial facilities 2008-2012, Tables A2.7-A2.9, A3.5 and A4.1-A4.3. http://www.eea.europa.eu/publications/costs-of-air-pollution-2008-2012
[12] Emission reductions associated with compliance with the IED and BREF limits have been projected in Holland et al (2015): Health and economic implications of alternative emission limits for coal-fired power plants in the EU.
http://www.greenpeace.de/sites/www.greenpeace.de/files/publications/report_health_and_economic_implications_of_alternative_emission_limits_coal_plants_eu.pdf

Estimated annual average stack emission concentrations from 2010 to 2012, mg/m3

Facility	SO2	NOx	PM	Hg (ug/Nm3)
Boxberg	183.8	197.4	9.2	4.4
Lippendorf	302.8	189.1	5.2	18.8
Jänschwalde	258.3	224.0	10.6	5.6
Schwarze Pumpe	190.1	118.1	2.9	5.8
IED emission limits (2016)	200.0	200.0	20.0	-
BREF emission limits (~2021)	130.0	180.0	10.0	10.0

Projected emissions (tonnes per year)

Pollutant	2010-2012 average	2016	2020	2025	2030	Cumulative 2016-2030
SO2	53,030	39,383	31,658	11,025	1,158	296,772
NOx	43,153	37,112	29,565	13,223	1,604	314,828
PM2.5	358	331	256	101	17	2,729
Hg	1.74	1.38	1.14	0.53	0.04	11.8

Damage costs, million EUR (in 2014 prices)

	2010-2012 average	Cumulative 2016-2030
Damage cost from air pollution, low	1,288	7,087
Damage cost from air pollution, high	3,832	21,003
Premature deaths, cases	1,284	7,674

2.2. Internalization of CO2 costs

Germany's Federal Environment Agency estimates the damages caused by CO2 emissions to be between EUR 80/t CO2 in the short term and EUR 145/t CO2 in the mid-term; we used an average of EUR 90/t CO2. We expect more than 500 million tonnes of additional CO2 emissions by 2030 even in our phaseout scenario. Based on these considerations, we calculated the differences between the IEA WEO 450 ppm scenario for CO2 prices and EUR 90/t CO2 damage estimations and came to a value for damages of around EUR 28 billion.

Type of cost	Assumptions and calculations	Estimated costs
(extended) Internalization of CO2 costs (difference between price of allowances in EU ETS and real environmental costs)	See table for detailed calculation	EUR 28 billion

Year	CO2 costs (in EUR / t CO2)[13]	Difference to the real environmental costs of EUR 90 / t CO2[14]	Total yearly CO2 emissions (in t CO2)[15]	Total yearly CO2 costs (in EUR)
2016	12.25	77.25	57,344,451.31	4,429,858,863.70
2017	14.46	75.54	56,185,616.43	4,244,261,465.12
2018	16.68	73.32	54,249,127.22	3,977,546,007.77
2019	18.89	71.11	46,574,531.96	3,311,914,967.68
2020	23.54	66.46	46,296,771.98	3,076,883,465.79
2021	30.64	59.36	38,380,957.67	2,278,293,647.29
2022	37.72	52.28	38,581,856.45	2,017,059,455.21
2023	44.80	45.20	38,504,431.05	1,740,400,283.46
2024	51.90	38.10	36,747,663.46	1,400,085,977.83
2025	58.99	31.01	23,758,863.28	736,762,350.31
2026	66.08	23.92	23,120,266.01	553,036,762.96
2027	73.16	16.84	22,781,069.95	383,633,217.96
2028	80.25	9.75	19,945,335.96	194,467,025.61
2029	87.35	2.65	10,439,086.57	27,663,579.41
2030	92.71	-	-	-
Total				28,371,867,070.10

This calculation is a extended internalization of CO2 costs and based on the difference between the price of allowances in EU ETS in the particular year, which are included in the NPV

[13] See Appendix 1: Energy Brainpool (2015): Economic analyses on Vattenfall's lignite power plants offered for sale. Determination of the net present value from electricity sales.
[14] Own calculation.
[15] See Appendix 1: Energy Brainpool (2015): Economic analyses on Vattenfall's lignite power plants offered for sale. Determination of the net present value from electricity sales.

calculated by Energy Brainpool (see attachment), and real environmental costs amounting to EUR 90 /t CO2[16]

Calculation: Difference to the real environmental costs of EUR 90 / t CO2 x total yearly CO2 emissions in t = total yearly CO2 costs (in EUR).

2.3. Mineral royalties

As currently the Vattenfall lignite plants are exempt from paying any **mineral royalties**, the actual mineral royalties were also estimated. Based on 508 million tonnes of lignite consumption in the next 15 years, and a 10 percent royalty rate, mineral royalties would be close to EUR 0.8 billion from 2016 to 2030.

Type of cost	Assumptions and calculations	Estimated costs
Costs for mineral royalties (the current legal situation grants total exemptions from paying mineral royalties for lignite mining)	Consumption rate (from 2016 to 2030 in tonnes): 508,310,000[17] Market price of lignite[18]: EUR 15.50 /t Mineral royalties[19]: 10 percent of market price Calculation: 508,310,000t x EUR 15.50/t x 0.1	**EUR 800 million**

3. Further risks posed by lignite activities

In addition to serious uncertainties regarding further liabilities, there are a great number of additional technical, economic and legal risks that cannot be seriously quantified. A major risk for any coal company in the Western world is the trend of phasing out coal from the energy mix. The main western countries pursuing climate policies are turning away from coal and lignite, due

[16] The German Federal Environment Agency (UBA) numbers the damage caused by CO2 emissions between EUR 80 /t CO2 (short term, 2010) and EUR 145 /t CO2 (mid-term, 2030). This calculation is based on an average amount of EUR 90/t CO2.
Umweltbundesamt (2012): Schätzung der Umweltkosten in den Bereichen Energie und Verkehr. Empfehlungen des Umweltbundesamtes.
https://www.umweltbundesamt.de/sites/default/files/medien/378/publikationen/hgp_umweltkosten.pdf
[17] See appendix 1: Energy Brainpool (2015): Economic analyses on Vattenfall's lignite power plants offered for sale. Determination of the net present value from electricity sales.
[18] Forum Ökologisch-Soziale Marktwirtschaft e.V. (2014): Kostenrisiken für die Gesellschaft durch den deutschen Braunkohletagebau.
https://www.greenpeace.de/sites/www.greenpeace.de/files/publications/studie-folgekosten-braunkohle.pdf
[19] ibid.

to climate change, high environmental costs and uncertain economic prospects. Especially at the G7 summit in Elmau 2015, the heads of states in attendance decided to achieve the decarbonisation of the energy sector by 2050. So there will be no further place for coal-fired power plants, in particular because the previous hope of “clean coal” raised by CO2 capture, transport, and storage technology (CCTS) has failed and is no longer an option in the foreseeable future.

Another major risk is the inconsistency of further lignite operations in view of the objectives of the German energy transition, which consists of, among other things, a nuclear power phaseout by 2022, greenhouse gas emissions reduced by 80 to 95 percent by 2050 (baseline: 1990), at least 80 percent renewables-based electricity by 2050, as well as efficiency targets. Therefore, the continuation of German lignite operations contradicts both the German energy transition and the 100 percent renewables strategy proposed by the State of Brandenburg. At the federal level, there is intense debate on the further regulation of coal-fired power generation. Although a government plan is in place to take a first step towards reducing coal-fired power generation to achieve Germany’s climate targets in 2020, it is most likely that the German government will implement further instruments (besides a reform of EU ETS) to reduce coal-fired power generation to achieve climate targets for 2030 and beyond.

In 2015, hundreds of thousands of people signed a petition to phase out coal in Germany, mass demonstrations were held protesting Vattenfall’s plans for its new Welzow Süd II open pit mine, and acts of civil disobedience against lignite mines could be observed in other parts of the country. Legal steps were also taken against Vattenfall’s approval procedures for new pit mines, and the people’s resistance against coal and lignite in Germany is increasing and will continue to put pressure on the German government to act against the use of coal resources.

From a legal point of view, the opening of new mining sites represents a further risk. A verdict by the German constitutional court reached in December 2013 not only strengthened the rights of affected citizens, but made it much more difficult to expropriate landowners. At the same time, an analysis[20] shows that Vattenfall’s currently operating lignite plants (Jänschwalde, Schwarze Pumpe, Boxberg, Lippendorf, and Berlin-Klingenberg) can be supplied by existing mines, so that there is no need to open any of the new lignite mines under consideration. Since

[20] Deutsches Institut für Wirtschaftsforschung (DIW) (2014): Risks of Vattenfall’s German Lignite Mining and Power Operations –Technical, Economic, and Legal Considerations. Policy Report on Behalf of Greenpeace Germany.
http://nbn-resolving.de/urn:nbn:de:0084-diwkompakt_2014-0877

lignite will no longer be needed in the mid-term, there is no legal foundation for the expropriation of citizens in favour of unnecessary resources.

Furthermore, there is the serious problem of the cost of reducing pollution in the rivers that feed Berlin's water supply, caused by Vattenfall's lignite assets, which can be assumed to amount to tens of millions of euros annually. Vattenfall's share of the sulphate load in Berlin is around 50 percent.

With the current German energy transition pushing toward a sustainable electricity supply based on a rapidly increasing share of fluctuating renewable energies, there is no place for inflexible and CO2-intensive lignite-fired power plants. Maintaining an energy system with lignite-fired power plants will only increase the number of hours that result in negative prices on electricity markets are, making the typical base load operation mode of lignite-fired power plants economically impossible. Furthermore, power prices on electricity markets are unlikely to increase in the near future. This means that power plant revenues will not increase either.

Appendix 3: Vattenfall’s opportunity. A future for Lusatia without lignite

Vattenfall’s opportunity

A future for Lusatia without lignite

GREENPEACE

www.greenpeace.de

This study was commissioned by Greenpeace Germany and executed by Institut für ökologische Wirtschaftsforschung.

Katharina Heinbach, Mark Bost, Steven Salecki, Julika Weiß

Berlin | April 2015

➡ Kein Geld von Industrie und Staat

Greenpeace ist international, überparteilich und völlig unabhängig von Politik, Parteien und Industrie. Mit gewaltfreien Aktionen kämpft Greenpeace für den Schutz der Lebensgrundlagen. Rund 590.000 Menschen in Deutschland spenden an Greenpeace und gewährleisten damit unsere tägliche Arbeit zum Schutz der Umwelt.

Impressum

Greenpeace e.V., Hongkongstraße 10, 20457 Hamburg, Tel. 040/3 06 18-0 **Pressestelle** Tel. 040/3 06 18-340, F 040/3 06 18-340, presse@greenpeace.de, www.greenpeace.de
Politische Vertretung Berlin Marienstraße 19–20, 10117 Berlin, Tel. 030/30 88 99-0 **V.i.S.d.P.** Gregor Kessler **Foto** Paul Langrock / Greenpeace
Zur Deckung unserer Herstellungskosten bitten wir um eine Spende:
GLS Bank, IBAN DE49 4306 0967 0000 0334 01, BIC GENODEM1GLS

Gedruckt auf 100% Recyclingpapier

Contents

List of Figures

List of Tables

1 Introduction

In view of the Swedish government's low-carbon objectives, Vattenfall is considering selling off its lignite (brown coal) operations in Germany. Any new owner would want this business to turn as high a profit for as long as possible and further expand surface mining in accordance with existing plans. Permits for these plans would commit the region to the environmentally damaging generation of electricity from coal until at least 2050. A possible alternative would be not to sell; instead Vattenfall could systematically stop generating electricity from brown coal while expanding renewable energies. This would make Vattenfall a pioneer in climate protection and drive forward the phaseout of environmentally damaging brown coal, as it is unlikely that third parties would continue coal mining operations once the existing coal-fired power plants were decommissioned and demolished.

This scenario brings up the question of what an appropriate climate-friendly and socially responsible **road map for transition** to be completed by 2030 would look like. Such a transition road map would need to pursue the following goals with a view to phasing out the generation of coal-fired electricity:

- No further open-pit mines to be opened up beyond those approved in late 2013 (this applies to any surface mines approved since then and any other potential sites).
- An end to the production and use of lignite in the Lausitz region by 2030.
- Vattenfall must adhere to its own CO_2 targets for 2020.
- The German state of Brandenburg must honor its CO_2 target for 2030.
- Vattenfall will make an appropriate contribution to Germany's national action program for climate protection.

Another goal would be to create opportunities for the brown coal regions through the active investment of Vattenfall. With this in mind, the transition road map also includes targets for the expansion of renewable energies by 2030 to counteract any loss of jobs in the area. In this short study, it is assumed that carbon capture, transport and storage (CCTS) technologies are not used in the power plants.

2 The Phaseout of Lignite

A road map for Vattenfall's exit from lignite-fired electricity will be laid out in this chapter. In order to provide a general framework, we will start by delineating Germany's most important climate protection goals, as well as those of Vattenfall and the German states in which Vattenfall operates lignite-fired power plants (Chapter 2.1). This will be followed by a brief outline of the significance of brown coal in the context of Germany's energy transition (Chapter 2.2). Building on this, a road map for the phaseout of lignite-fired electricity (Chapter 2.3) will be developed which will ensure that previously outlined climate protection goals are met and serve as the basis for a scenario of the expansion of renewable energies (Chapter 3).

2.1 Lignite in the context of low-carbon targets

The burning of fossil fuels such as coal, gas and oil to generate electricity and heat, and to power machinery, emits large amounts of greenhouse gases such as carbon dioxide (CO_2), resulting in a continuing increase in global temperatures since the beginning of the Industrial Revolution. The consequences of this human-induced climate change – an increasing number of droughts, more frequent floods, more severe storms and rising sea levels due to melting polar ice – can already be observed across the globe. Scientists predict that in coming decades these consequences could reach levels posing a threat to more and more people if we do not succeed in reducing greenhouse gas emissions. Since 2011, a total of 191 states and the European Union (EU) have been party to the United Nations Framework Convention on Climate Change of 1992 and the Kyoto Protocol of 1997, and are bound under international law to contain greenhouse gas emissions. In this context, the EU Member States committed themselves to the 20-20-20-targets to be met by 2020: a 20% reduction in greenhouse gas emissions from 1990 levels; a 20% increase in energy efficiency; and achieving a 20% share of renewable energies in total energy consumption.

From a historical point of view, industrial nations with high levels of fossil fuel consumption have already emitted a large amount of greenhouse gases and continue to do so today. They therefore have a special responsibility, prompting the German government and several German states to set particularly ambitious goals for the reduction of greenhouse gas emissions. Germany's, Brandenburg's, Berlin's and Vattenfall's greenhouse gas reduction targets are briefly outlined below to subsequently allow for a better understanding of the role Vattenfall's lignite operations play in meeting these targets. Any secondary goals (regarding energy efficiency or the share of renewable energies) will not be discussed here.

Although Vattenfall also operates lignite-fired power plants in Saxony, the state has not yet set specific greenhouse gas reduction targets, but it does refer to lignite in the context of the energy and climate program (2013) as a 'transitory technology'.

2.1.1 Germany's national targets

The German government formulated ambitious climate targets for Germany in its energy plan. Annual greenhouse gas emissions are to be reduced by 40% from 1990 levels to a maximum of 750 million tons of carbon dioxide equivalents by 2020. The German government and the Bundestag have repeatedly confirmed this goal. In addition, a reduction path ending in 2050 has been laid out: a reduction of 55% by 2030; a reduction of 70% by 2040; a reduction of 80% to 95% by 2050 (BMU and BMWi 2010, 4).

By the end of 2014, emissions had already been reduced by about 27% to 912 million tons, but it has been apparent for some time now that if additional measures are not introduced the 40% target will definitely not be met. Thus the German government's projection report of 2015 expects that the measures thus far adopted and implemented will only enable a reduction of 33% to 34% by 2020. On 3 December 2014, the German government therefore adopted the "Action Plan Climate Protection 2020", which aims for additional savings in the electricity sector to reduce CO_2 emissions by another 22 million tons.

To ensure this, in March 2015 the German Ministry for Economic Affairs and Energy (BMWi) proposed the introduction of a national '**Klimabeitrag**' [national climate contribution scheme] to take effect in 2017. This national climate contribution scheme specifically targets older fossil fuel

power plants with low efficiency and high CO_2 emissions per kWh of electricity generated; it is meant to induce them to reduce their electricity output and thus their CO_2 emissions. The measures apply to all fossil fuel power plants that are more than 20 years old, regardless of what kind of fuel they burn. Each power plant will receive an emissions allowance of 7 million tons of CO_2 per GW of installed capacity. This allowance will decrease linearly to 3 million tons per GW once the power plant reaches its forty-first year of operation and will then remain constant at this level. A climate contribution levy will have to be paid for every ton of CO_2 that exceeds the emissions allowance; the amount due is expected to be 18 to 20 euros per ton of CO_2. This is meant to deter power plants from exceeding emissions allowances.

2.1.2 Brandenburg

Brandenburg has also introduced ambitious low-carbon targets as part of its energy strategy. For instance, by 2020, energy-related CO_2 emissions are to be reduced by 40% from1990 levels and cut by 75% by 2030 (MWE 2012, 18). Brandenburg has already greatly expanded renewable energies in recent years, receiving three consecutive "*Leitstern*" (Guiding Star) awards from Germany's Renewable Energy Agency from 2010 to 2012. In the years following the reunification of Germany, shutdowns and modernization projects in the country's traditionally large and conventional power plant network had already resulted in a 36.5% reduction of greenhouse gas emissions by 2010, making the 40% target by 2020 look like it could be achieved without greater effort. However, since then, the utilized capacity of lignite-fired power plants has increased again so that the reduction achieved in 2012 amounted to only 34.6% (LUGV 2014, 7). CO_2 emissions therefore must still be reduced by about 4.9 million tons by 2020.

The target for 2030 is even more ambitious, as the CO_2 reduction the state is aiming for corresponds to the emissions of all of Brandenburg's lignite-fired power plants put together. However, to date, the state's energy strategy does not necessarily call for the phaseout of lignite-fired electricity to meet that target, but rather assumes that a reduction in emissions could be achieved mainly by capturing CO_2 from flue gas and storing it underground, or by using it in chemical industries to manufacture base materials. But safety and acceptance issues related to carbon capture, transport, and storage (CCTS) technology have made it highly controversial. The German Institute for Economic Research (DIW Berlin) stated in 2014 that there was not a single industrial-scale CCTS plant in operation worldwide and that nine of the 20 European CCTS projects had been abandoned and the rest postponed (Oei et al. 2014, XVII; von Hirschhausen et al. 2012). Moreover, DIW Berlin believes that the potential for the material utilization of CO_2 (carbon capture and use, CCU) in Germany is limited and concludes that "The development of lignite power plants that are low in CO_2 emissions due to CO_2 capture […] has thus far failed worldwide and does not offer any prospects for the sustainable use of lignite." (Oei et al. 2014, I) If Brandenburg wants to meet the targets of its own climate policy, it has no choice but to begin phasing out lignite-fired power plants.

2.1.3 Berlin

With the enactment of its state energy program (2006), Berlin committed to the reduction of greenhouse gas emissions by at least 40% from 1990 levels (13 million tons of CO_2) by 2020. Berlin reached a CO_2 emissions agreement in 2009 with Vattenfall, which operates practically all of the city-state's major combined heat and power (CHP) plants; the agreement stipulates that Vattenfall will reduce its greenhouse gas emissions in Berlin by 52% to 6.4 million tons by 2020. This corresponds to a reduction of 15% or 1 million tons of CO_2 compared to average levels from

2006 to 2008 (State of Berlin, Vattenfall 2009). The agreement provides for the shutdown of Reuter C, the oldest and most inefficient anthracite-fired combined heat and power plant, to ensure that targets are met. In addition, the lignite-fired Klingenberg CHP plant is to be replaced by an efficient gas and steam power plant by 2020 (Stroedter 2015). Klingenberg emits 1.4 to 1.7 million tons of CO_2 per year, making it the plant with the second highest CO_2 emissions in Berlin following Reuter West. The agreement also stipulated that the burning of anthracite to fuel the Lichterfelde CHP plant would be replaced by efficient gas combustion; this project has been nearly completed.

An energy and low-carbon target program is currently being developed for Berlin with the aim of making the city climate neutral by 2050.

2.1.4 Vattenfall

Vattenfall is an internationally active company owned by the Swedish government. In 2012, business operations carried out by the company generated a total of 85 million tons of CO_2 emissions, of which nearly 71% (60.3 million tons) were produced by the use of German lignite. The company's operations in Germany focus predominantly on conventional methods of power generation, which is unusual compared to its other operations and its own sustainability targets. Vattenfall plans to shift this focus and make operations more sustainable in coming years. To this end, it intends to reduce CO_2 emissions by 2020 to 65 million tons, and reduce them to half of 1990 levels by 2030. The company aspires to be totally CO_2 neutral by 2050 (Vattenfall 2009; Vattenfall 2014; Vattenfall 2013). As a state-owned company, Vattenfall is under no obligation to maximize profits for other shareholders and therefore has more leeway than other energy companies to achieve these targets.

The present study poses the question of how high the contribution of Vattenfall's brown coal sector should be to reduce overall emissions down to 65 million tons by 2020. Vattenfall already lists the contribution of various measures introduced to reduce CO_2 emissions by 2020 in its annual and sustainability reports of 2013; these measures also affect their lignite operations (Table 1). Taking these measures into account, Vattenfall believes that it needs to bridge an existing gap of 14.6 million tons to meet its sustainability targets. In the present study, the following changes in CO_2 emissions are taken into account based on the measures planned by Vattenfall:

– In addition to reductions, there are plans to **invest in replacement and growth**; these investments will initially result in an increase of 9.1 million tons in CO_2 emissions. Vattenfall specifically mentions the Moorburg anthracite-fired CHP plant and the Lichterfelde gas CHP plant, which would replace older anthracite CHP plants in Berlin and Hamburg. The company also plans to replace the Buggenum power plant in the Netherlands.

– On the other hand, a reduction will result through the **closure and decommissioning** of power plants that are no longer profitable or that have reached the end of their operating lives; these are not specifically mentioned. As power plants frequently continue to operate longer than originally planned, and we can expect that some of the reduction measures will affect lignite-fired power plants (the shutdown of the Klingenberg CHP plant, for example), it can be safely assumed that one-third of the CO_2 reductions listed by Vattenfall – amounting to 4 million tons – will be achieved by 2020 through the closure and decommissioning of operations that are not part of its brown coal division.

– The same applies to reductions amounting to 6.2 million tons expected by Vattenfall as a result of changes in the number of **operating hours;** this seems unlikely in view of the increase in the number of operating hours in recent years. Most of the fossil fuel power plants outside of

Vattenfall's brown coal division are thermal power stations whose output is used primarily to meet demand for heat. Since many urban energy and CO_2 programs are striving to expand district heating systems, there seems to be no reason to expect a decline in the number of their operating hours. At most, a lower number of operating hours could actually be expected in power plants fired by natural gas – a comparatively expensive fuel – that are not used primarily to supply heat. Most of these power plants are located in the Netherlands and in 2013 generated about 2.4 million tons of CO_2, which only accounts for roughly 2.8% of Vattenfall's greenhouse gas emissions. Their relevance to the Dutch energy system cannot be adequately addressed here. Overall, we do not expect to see substantial reductions outside of the brown coal division, so such reductions are not taken into consideration in this study, although they are expected by Vattenfall.

– **Other measures** such as the planned sale of facilities and operations that no longer belong to the company's core business (combined heat and power (CHP) plants in Denmark, CHPs in Sweden, engineering operations in Germany), and the co-firing of biomass in anthracite-fired power plants are however taken into account without deductions.

Based on the assumptions made here, we estimate that by 2020, Vattenfall must reduce its CO_2 emissions in its brown coal division by **23.5 million tons** from 2013 levels to be able to meet its low-carbon targets. Table 1 provides an overview that summarizes the above explanations and lists potential and expected emissions reductions in Vattenfall's other operations.

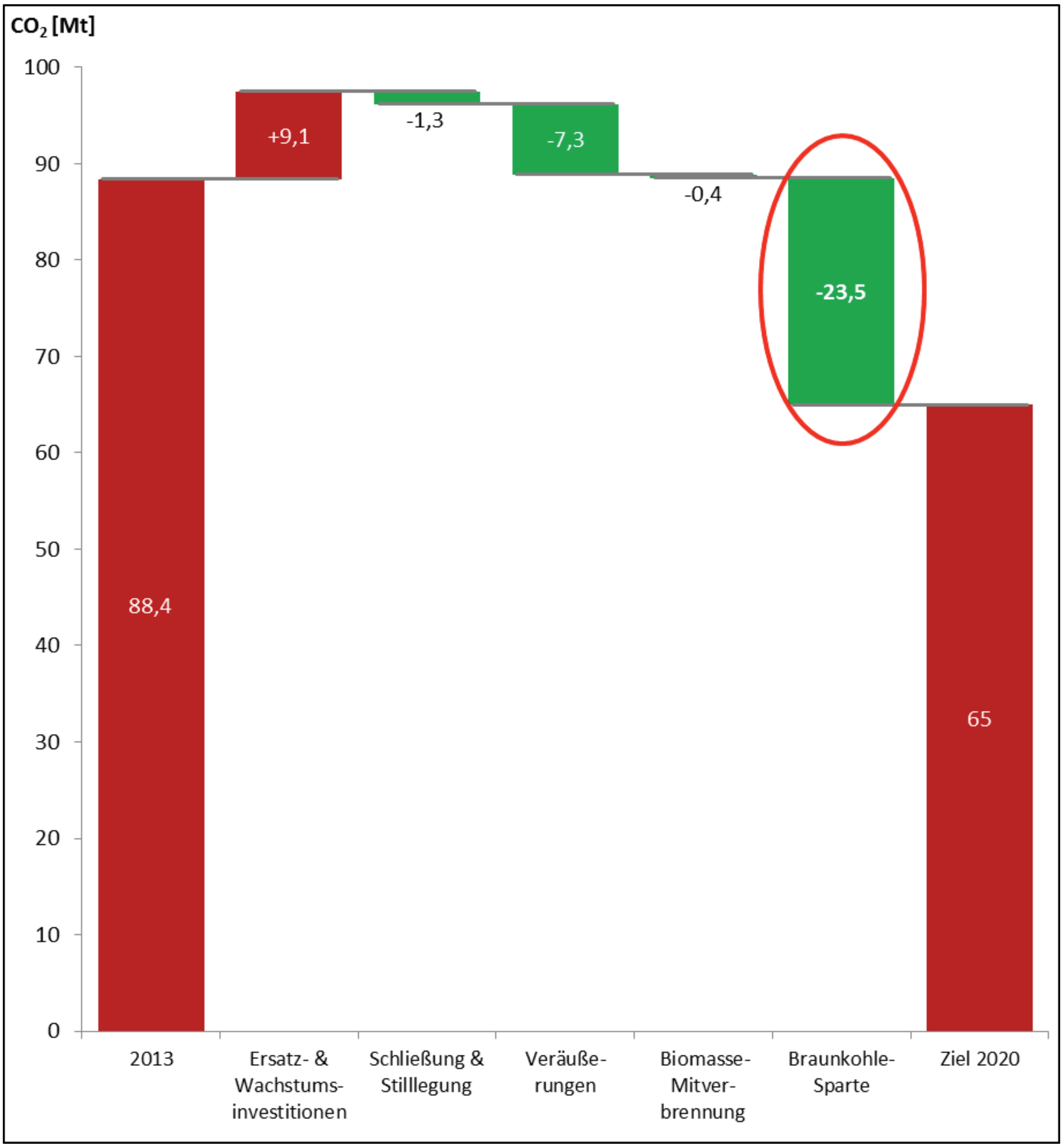
Table 1: The needed reduction in greenhouse gas emissions released by Vattenfall's lignite operations to achieve Vattenfall's own low-carbon targets by 2020

Benchmark data	**Mt CO_2**
Vattenfall's CO_2 emissions in 2013	88.4
Replacement and growth investments	9.1
Changes in the number of operating hours [A]	-
Closure and decommissioning [B]	-1.3
Sale of operations	-7.3
Measures to reduce CO_2	-0.4
Vattenfall's CO_2 emissions in 2020 (target)	65.0
Difference to target achievement	**-23.5**

A) Vattenfall uses a figure of 6.2 million tons; because these changes are uncertain and have already been taken into account to a certain extent in the phaseout road map, they are not taken into consideration here.
B) Vattenfall uses a figure of 4 million tons; only one-third of this has been taken into account here because it is uncertain and the Klingenberg plant has already been taken into consideration in the phaseout road map.

(Source: Vattenfall 2014, p. 22, supplemented with own assumptions)

Figure 1: The needed reduction in greenhouse gas emissions released by Vattenfall's lignite operations to achieve Vattenfall's own low-carbon targets by 2020



(Source: Vattenfall 2014, p. 22, supplemented with own assumptions)
(Translation of descriptions and numbers: Ersatz- & Wachstums-Investitionen = **Replacement & growth investments**; Schließung & Stillegung = **Closure & decommissioning**; Veräußerungen = **Sale of operations**; Biomasse Mitverbrennung = **Biomass co-firing**; Braunkohle-Sparte = **Lignite division**; Ziel 2020 = **2020 target**; +9,1 = **+9.1**; -1,3 = **-1.3**; -7,3 = **-7.3**; -0,4 = **-0.4**; -23,5 = **-23.5**; 88,4 = **88.4)**

2.2 The significance of lignite in the context of Germany's energy transition

Germany's energy transition means that the country's future will be dominated by fluctuating renewable energy sources such as wind and solar energy. In the future, conventional power plants will have to compensate even more for fluctuations inherent to renewable energies and must therefore say goodbye to profitable base-load operations in the long term. Thermal power plants should allow for the highest possible load gradients and require only low minimum load levels and rapid startup times to ensure that they provide the best possible support for fluctuating renewables (Brauner 2013; Pyc 2013; VDE 2012). Of all thermal power plants, lignite-fired power plants are the least capable of meeting these requirements; they also release the highest amount of intrinsic CO_2 emissions as well as numerous other air pollutants (Table 2). Thick-walled components of the steam generator may be subjected only to gradual changes in steaming rates, otherwise the allowable stress values of the material are exceeded and spontaneous failure or permanent damage to the material can be a result (NRW Energy Agency 2013). Moreover, as these power plants must operate at high minimum load rates, they require fuel from conventional energy sources that does not fluctuate, and they therefore stand in the way of a transition to an energy mix generated predominantly from renewable energy sources. Numerous studies by reputable institutes have come to the conclusion that lignite is no longer relevant to our energy system and will be of little importance to Germany's energy mix beyond the 2030s (Oei et al. 2014; Hilmes and Herrmann 2014; Kunz et al. 2013; Nitsch et al. 2012; Gerbaulet et al. 2012a).

Table 2: Characteristics of various types of fossil fuel-fired power plants

Type of power plant		Anthracite	Lignite	Gas & steam	Gas turbine only
Load gradient[A]	$\%P_N$/min	1.5 / **4** / 6	1 / **2.5** / 4	2 / **4** / 8	8 / **12** / 15
In the area of	$\%P_N$	40 – 90	50 – 90	40[B] – 90	40[B] – 90
Minimum load[A]	$\%P_N$	40 / **25** / 20	60 / **50** / 40	50 / **40** / 30*)	50 / **40** / 20 [B]
Start-up times:					
Hot (< 8 h) [A]	h	3 / **2.5** / 2	6 / **4** / 2	1.5 / **1** / 0.5	< 0.1
Cold (> 48 h) [A]	h	10 / **5** / 4	10 / **8** / 6	4 / **3** / 2	< 0.1
CO_2 emissions	g/kWh	750 – 1,100	850 – 1,200	400 – 550	

[A]) Order of values: common today / **best available technology** / optimization potential
[B]) due to the emission limits for NO_x and CO for continuous operation
(Sources: VDE 2012; Wagner et al. 2007)

Many different predictions have been made regarding the future utilized capacity of lignite-fired power plants (Table 3). While some authors consider a substantial reduction of capacity to be necessary due to the expansion of renewable energies (Nitsch et al. 2012; Oei et al. 2014; Gerbaulet et al. 2012b), other authors argue that the utilization of lignite-fired power plants will decrease only when all power plants with higher marginal costs (natural gas, anthracite, and so forth) have been largely replaced, or the cost of emissions allowances as determined by the European Emissions Trading System (ETS) is drastically increased (Erdmann 2013; Prognos 2012; IER 2012). Erdmann (2013) cites a CO_2 price of at least EUR 70 per ton. The decommissioning of power plants with higher marginal costs as described above (especially of gas-fired power plants) can currently be observed in Germany. Thus, CO_2 emissions released when

electricity is generated have recently increased despite the steady expansion of renewable energies; this is because the use of brown coal to generate electricity has also risen (BMWi 2014).

Lignite-fired power plants could continue to operate and squeeze out more expensive power plants in other countries even if at some point in the future the need for fossil energy in Germany no longer existed. This too is something that already happening today. The sharp drop in wholesale electricity prices in Europe caused by the German expansion of renewables in recent years is, for example, making it increasingly difficult for new efficient hydropower plants in Switzerland to compete. As a countermeasure, some Swiss energy economists are calling for a more complete calculation of lignite-generated electricity to reduce this type of power generation in Germany (Boulouchos 2014). In the medium to long term, these undesirable cross-border effects could intensify if countermeasures such as an effective Emissions Trading System (ETS) reform or additional instruments such as a German climate contribution were not taken.

As we can see, lignite cannot be referred to as a transitory technology because it hinders the continued expansion of renewable energies and is therefore incompatible with the energy revolution.

Table 3: Overview of various assumptions or forecasts regarding the development of the utilized capacity of lignite-fired power plants (full-load hours)

Source	2010	2012	2015	2020	2022	2030	2032	2040	2042	2050
Erdmann 2013			7,600	7,600	7,600	7,156	7,045	6,601	6,490	6,046
Gerbaulet et al. 2012					7,500	5,433	4,916	2,849	2,332	
DIW 2014: Phaseout scenarios: -2.2 % p.a.		7,500	7,016	6,277	6,004	5,025	4,807	4,023	3,848	3,221
BNetzA grid development plan 2012		7,500	7,037	6,329	6,066	5,119	4,906	4,140	3,968	3,348
Nitsch et al. 2012: Pilot study (fossil)				3,700	3,620	3,300	3,190	2,750	2,640	2,200
IER 2012						7,700				
Prognos 2012	7,000					6,000				5,000
Prognos 2010: Reference				6,900		6,594		6,244		7,221
Kost et al. / ISE 2013: low full-load hours			6,600	6,300		5,300		4,400		3,800
Kost et al. / ISE 2013: medium full-load hours			7,100	6,800		5,800		4,900		4,300
Kost et al. / ISE 2013: high full-load hours			7,600	7,300		6,300		5,400		4,800
Gray values: calculated assuming a linear decrease. **FLH =** Full-load hours (8,760 = 100%)										

2.3 Drawing up a road map for Vattenfall's phaseout of brown coal electricity

2.3.1 A review of power plants

Vattenfall operates six large lignite-fired power plants with a total of 15 power blocks. Table 4 below illustrates the most important technical data of these power plants. Boxberg III (1979/1980) and Jänschwalde (1981-89) are the oldest and most inefficient of these plants with a combustion efficiency of 35%. Correspondingly, they also have the highest intrinsic CO_2 emissions at around 1,150g CO_2/kWh. The newer power plants Schwarze Pumpe (1997/98), Lippendorf (1999), and Boxberg IV (2000/2012), have far higher combustion efficiencies ranging from 41.2% to 43.8%, and accordingly lower CO_2 emissions between 940 and 1,050g/kWh.

The Lippendorf plant is a special case because although Vattenfall operates both of the plant's power blocks, Block S is owned by EnBW. This is the only power plant that is not supplied from a Vattenfall-operated surface mine. Coal is supplied from the Vereinigtes Schleenhain open surface mine run by Mitteldeutschen Braunkohlengesellschaft (MIBRAG). All other Vattenfall-operated power blocks are owned by Vattenfall and supplied by Vattenfall-owned open-pit mines.

Another special case is the Klingenberg combined heat and power (CHP) plant in Berlin that is supplied by open-pit mines in Cottbus. Its primary role is to provide district heating. Supplying electricity has a secondary role, which is why its utilization varies enormously according to heating needs. In contrast, electricity generation is the main purpose of Vattenfall's other brown coal power plants, in which heat generation plays a comparatively small role.

In Brandenburg, there are two other lignite-fired CHP plants in Cottbus and Frankfurt/Oder. These are not owned or supplied by Vattenfall. With an electrical capacity of 74 and 45 MW respectively, they hardly compare with the other Brandenburg power plants. As with the Klingenberg power plant, they are fueled by a mix of lignite, natural gas, and heating oil. Since the focus of this study is on Vattenfall's power plants, the two above-mentioned plants will not be discussed in particular later, nor will other fossil-fueled Vattenfall power plants (using anthracite, natural gas, oil) because they do not burn brown coal.

Table 4: Overview of Vattenfall's lignite-fired power plants

Power plant	Power block	Net output [MWe]	Max. district heating output [MWth]	Com-mis-sioned in [year]	Retrofit [year]	Net com-bustion effi-ciency	Located in German state of	Owner
Lippendorf	[2]	1,750	460	1999	-	42.50%	Saxony	Vattenfall
	R	875	230	1999	-	42.50%	Saxony	Vattenfall
	S	875	230	1999	-	42.50%	Saxony	EnBW[1]
Jänschwalde	[6]	2,790	348			35.50%	Brandenburg	Vattenfall
	A	465	76.3	1981	1996; 2002-2006	35.50%	Brandenburg	Vattenfall
	B	465	76.3	1982		35.50%	Brandenburg	Vattenfall
	C	465	76.3	1984		35.50%	Brandenburg	Vattenfall
	D	465	76.3	1985		35.50%	Brandenburg	Vattenfall
	E	465	76.3	1987		35.50%	Brandenburg	Vattenfall
	F	465	76.3	1989		35.50%	Brandenburg	Vattenfall
Schwarze Pumpe	[2]	1,500	120			41.20%	Brandenburg	Vattenfall
	A	750	60	1997		41.20%	Brandenburg	Vattenfall
	B	750	60	1998		41.20%	Brandenburg	Vattenfall
Boxberg III	[2]	941	60			35.00%	Saxony	Vattenfall
	N	470	60	1979	1993; 2002-2006	35.00%	Saxony	Vattenfall
	P	470		1980		35.00%	Saxony	Vattenfall
Boxberg IV	[2]	1,486	65			42.95%	Saxony	Vattenfall
	Q	846	65	2000		42.30%	Saxony	Vattenfall
	R	640		2012		43.80%	Saxony	Vattenfall
Klingenberg		164	1,010	1981		35%	Berlin	Vattenfall
[1]) operated by Vattenfall								

(Sources: Oei et al. 2014; EC 2014b; EC 2014a; UBA 2014; BNetzA 2014)

2.3.2 An overview of surface mining

As a fossil fuel, raw lignite possesses a relatively low calorific value. Long transport routes are therefore uneconomical, and that is why most lignite-fired power plants are supplied from the immediate surroundings. The Vattenfall power plants in the Lausitz region are supplied from the open-pit mines in Jänschwalde, Welzow-Süd, Nochten, Reichwalde und Cottbus-Nord, despite the fact that the latter will be mined out in 2015. Vattenfall operates these mines themselves. In contrast, the central German open-pit mine of Vereinigtes Schleenhain (operated by MIBRAG) supplies the Vattenfall power plant in Lippendorf. The coal supplied from here has a higher heating value of 10,500 kJ/kg compared to Lausitz coal at an average of 8,800 kJ/kg. The lowest heating value is that of the coal from the open-pit mines at Reichwalde at 8,200 kJ/kg, which is why the power plant at Boxberg is especially set up to use this coal, yet still needs to rely by more than 70% on superior coal from Nochten to ensure the quality of coal needed. At the beginning of 2014, the reserves of the licensed open-pit mines in the Lausitz region and in central Germany amounted to 1,597 million tons of raw lignite. The total amount of technically minable reserves of raw lignite is about 4,985 million tons, which at current output would last until 2100 (Prognos 2012; Schuster 2007).

Table 5: Overview of surface mining in the Lausitz region and central Germany

Surface mines	Mining began in [year]	Reserves (2013) [Mt raw lignite]	Maximum annual mining [Mt raw lignite]	At maximum coal output, mined-out by [year]	German state	Power plants supplied
Lausitz: surface mines licensed early in 2013		**1,085**	**69**			
Cottbus-Nord	1981	11	6	2015	Brandenburg	Jänschwalde
Jänschwalde	1976	103	12	2020	Brandenburg	Jänschwalde, Klingenberg
Welzow-Süd I	1966	326	21	2027	Brandenburg	Schw. Pumpe, Jänschwalde, Boxberg, Klingenberg
Nochten	1973	301	20	2027	Saxony	Boxberg
Reichwalde	1987	344	10	2046	Saxony	Boxberg and others
Planned surface mines in the Lausitz region		**1,180**	**90**			
Welzow-Süd TF II (licensed in June 2014)	2025	200	21	2042	Brandenburg	Schw. Pumpe, Jänschwalde, Boxberg
Jänschwalde Nord	2025	270			Brandenburg	Jänschwalde, Klingenberg
Nochten II (licensed March 2014)	2025	300	69	2048	Saxony	Boxberg
Bagenz-Ost		230			Brandenburg	
Spremberg-Ost		180			Brandenburg	
Central Germany		**512**	**21**			
Vereinigtes Schleenhain (MIBRAG)	1949	292	11	2043	Saxony	Lippendorf (Vattenfall)
Profen (MIBRAG)	1941	220	10	2043	Saxony-Anhalt	Mumsdorf, Deuben, Wählitz, Schkopau

(Sources: Oei et al. 2014; Gerbaulet et al. 2012b; Schuster 2007)

To ensure both the mid-term and long-term operation of its power plants, Vattenfall (in cooperation with the state governments of Brandenburg and Saxony) strives to open up more surface mines. In March 2014, the Saxony state government approved the opening of the Nochten II mines, for which 1,640 people would have to be relocated. Three months later, Brandenburg agreed to the continuation of the brown coal plans for Welzow-Süd II, and here 810 people would have to lose their homes. For the intended development of the Jänschwalde-Nord mines, 900 people would also be affected. It is expected that a number of those who are affected will object to offers of compensation for relocation and take legal action. Such cases were previously solved by enforcing a statute on compulsory purchase for purposes of public utility set out in Germany's Basic Law which covers the compensation and forced relocation of those affected. Ziehm (2014) came to the conclusion in a judicial evaluation that both the licensing of operational mining plans and consequent expropriations for new brown coal open-pit mines was unconstitutional because, in the course of the energy revolution, expropriations could no longer be justified as being for the common good. It is also likely that the development of new open-pit mines (despite their licensing) will fail due to judicial hurdles. More importantly, several expert opinions by the DIW have come to the conclusion that this expansion is not necessary (Hirschhausen and Oei 2013a; Hirschhausen and Oei 2013b). By making use of maximum annual output, it would become necessary only from the mid-2020s. If we assume that power plant utilization will be reduced, there are already sufficient brown coal supplies to take us into the 2040s, using the mines that were licensed as of 2013 (Oei et al. 2014).

2.3.3 Assumptions and premises for phasing out lignite

The following premises and assumptions were used to develop a road map for phasing out brown coal:

1. There is compliance with the **climate protection objectives** of the German government, the state of Brandenburg, and Vattenfall.

2. The restrictions regarding **surface mines** (calorific values, reserves and maximum output) are taken into account. Apart from the surface mines that were licensed up until the beginning of 2013, no further mines are opened, not even the Nochten II and Welzow-Süd II mines that were licensed in 2014.

3. There is a gradual but **complete phaseout** by 2030 of brown coal being used to generate electricity. This is structured as evenly as possible to allow the expansion of renewable energy sources to continue at the same time and to enable a socially acceptable transformation in employment.

4. We assume that today's high **utilized capacity** of power plants remains constant at 72% to 92% until the end of 2016 because lignite-fired power plants sell a large share of their electricity up to four years in advance in the form of futures contracts, and because they are among the most economical power plants in Germany's "merit order" ranking. From 2017, we assume that the climate contribution proposed by the German Ministry for Economic Affairs and Energy (BMWi) is introduced, which according to the BMWi should come into force by 2020. For this "phasing in", we assume that the most seriously affected old power plants, Jänschwalde and Boxberg III, will not be able to stay within their emissions allowances immediately due to their futures contracts, and that their electricity production each year from 2017 until 2019 will correspond to the mean between that of the previous year and the emissions allowance. We also assume that from 2020, power plants will only generate electricity according to their emissions allowances, and that the climate contribution actually has the desired effect or that Vattenfall voluntarily stays within the emissions allowances.

2.3.4 The phaseout road map

The road map for phasing out lignite-fired electricity takes effect according to these assumptions and premises from 2017 onward, and leads to a gradual shutdown of all power plant blocks from 2019 to 2030. **Table 6** shows the utilized capacities of individual power plant blocks adapting to the emissions allowances for the climate contribution. The oldest power plants, Boxberg III and Jänschwalde, are the first to be gradually decommissioned. In comparison, newer power plants are decommissioned only towards the end of the 2020s.

Reducing utilized capacity below 50% does not necessarily imply that a power plant operating at partial load is inefficient and emissions-intensive. Just as well, power plants can also be on the grid temporarily but with a higher load during the winter and in seasonal transition times, for example, when only a low amount of photovoltaic energy is produced and there is also a need for district heating.

Table 6: Development of utilized capacity of Vattenfall power plants in phaseout schedule [%]

Power plant	Bl.	MW_e	Start	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Lippendorf	[2]	1,750	1999	72	72	72	72	72	72	72	72	70	67	65	63	61	59	56	27
	R	875	1999	72	72	72	72	72	72	72	72	70	67	65	63	61	59	56	
	S	875	1999	72	72	72	72	72	72	72	72	70	67	65	63	61	59	56	54
Jänschwalde	[6]	2,790		90	90	69	57	50	36	28	21	14	7						
	A	465	1981	90	90	65	51	44											
	B	465	1982	90	90	66	53	45	36										
	C	465	1984	90	90	68	56	49	40	38									
	D	465	1985	90	90	69	57	51	42	40	38								
	E	465	1987	90	90	71	60	54	46	44	42	40							
	F	465	1989	90	90	73	63	58	50	48	46	44	42						
Schwarze Pumpe	[2]	1,500		82	82	82	81	80	77	75	73	71	68	66	64	61	59	29	
	A	750	1997	82	82	82	81	79	76	74	72	69	67	65	62	60	58	0	
	B	750	1998	82	82	82	82	81	79	76	74	72	69	67	65	62	60	58	
Boxberg Werk III	[2]	941		90	90	63	49	41	16										
	N	470	1979	90	90	63	48	40											
	P	470	1980	90	90	64	50	41	31										
Boxberg Werk IV	[2]	1,486		91	91	91	91	91	91	87	85	84	83	82	81	79	78	77	44
	Q	846	2000	93	93	93	93	93	93	84	82	80	77	75	72	70	67	65	
	R	640	2012	89	89	89	89	89	89	89	89	89	89	89	89	89	89	89	89
Klingenberg		164	1981	54	52	49	47	44											

The phaseout road map allows the climate protection goals of Vattenfall and Brandenburg to be reliably achieved (**Table 7**). The same holds true for Berlin with the cessation of lignite-fired electricity at the Klingenberg power plant. The CO_2 reduction of 24.6 million tons also exceeds the total reduction foreseen in Germany's national action program for climate protection in the electricity sector of 22 million tons, and thus contributes to achieving national goals for an energy plan by 2020, provided that other measures in the national action program have the intended effect. However, if additional emissions from the new Moorburg and Lichterfelde power plants are taken into account, an overall CO_2 emissions reduction of only 15.5 million tons is reached at the federal level. Next to Vattenfall's large contribution, other power plants must also make a significant contribution to enable Germany to reach its low-carbon targets by 2020. This includes lignite-fired plants in North Rhine-Westphalia, Saxony, and Saxony-Anhalt, as well as older anthracite-fueled power plants.

Moreover, the phaseout of lignite-fired electricity allows Brandenburg to achieve its emissions reduction target for 2030. Nationwide, there is no clear goal for the electricity sector in 2030. In this respect, we cannot analyze goal achievement here.

Table 7: Benchmark data for phasing out lignite from 2015 to 2030

CO_2 reduction targets (2012 as base year)	2020		2030	
	Target	Present	Target	Present
Vattenfall	-23.4	-24.6	-	-59
Brandenburg	-4.9	-15.8	-36	-36
Germany’s national action program for climate protection	-22.0[A]	-24.6		

A) This is the CO_2 reduction goal in Germany’s national action program for climate protection that must be reached by 2020 in addition to existing measures and expected effects in Germany’s electricity sector.

In this scenario, lignite-fired power plants will continue to generate a total of 623 TWh of electricity until 2030, thereby emitting 641 million tons of CO_2 (Table 8). Concerning lignite reserves, it should be noted that the surface mines licensed at the beginning of 2013 will by 2030 be exploited only to about 56% (Table 8). Accordingly, no new surface mines would need to be opened – not even the Nochten II and Welzow-Süd II open-pit mines that were licensed and approved respectively in 2014. Next to the Cottbus Nord open-pit mine, which will be fully mined out in 2015, only the Jänschwalde open-pit mine will be fully exploited to the extent allowed by previous licensing.

Table 8: Benchmark data for phasing out lignite from 2015 to 2030

Benchmark data	2030
Cumulative CO_2 emissions [Mt]	641
Cumulative power generation [TWh]	623
Cumulative fuel use [Mt raw lignite]	764
Remaining lignite reserves [Mt raw lignite]	602

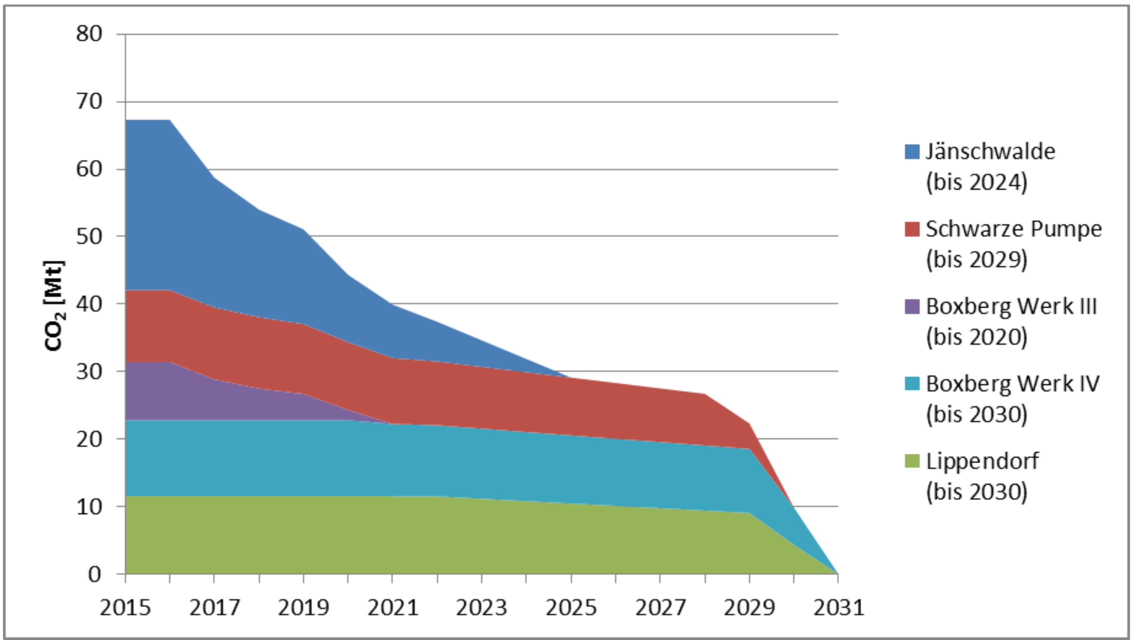
The following figures show the development of CO_2 emissions in the phaseout plan (Figure 2), power generation (Figure 3), installed capacity (Figure 4), lignite production rates (Figure 5), as well as the reduction in reserves in mines licensed by the beginning of 2013 (Figure 6). The last power plants will run until the end of 2030, so that electricity production and the emissions it generates will be down to zero starting in 2031.

The phaseout road map up to 2020 is largely determined by Vattenfall’s climate goals. Steep reductions in CO_2 emissions are required to achieve these goals by that time. Afterwards, the road map is characterized by reductions that are as even as possible until lignite-fired electricity is completely phased out in 2030. However, we can assume that the newer Boxberg IV and Lippendorf power plants will operate as long as possible, so that reductions in the last two years will be steep again. Licensed coal reserves will not have a limiting effect in this road map.

Without the climate contribution, power plant blocks would probably operate at a higher utilized capacity. In this case, individual power plant blocks would need to be decommissioned earlier in order for Vattenfall to achieve its 2020 goals, and for a steady phaseout. The development of installed capacity (Figure 4) would then be more strongly oriented towards CO_2 emissions (Figure 2) and power generation (Figure 3) than shown here. This would have only minor influence on the

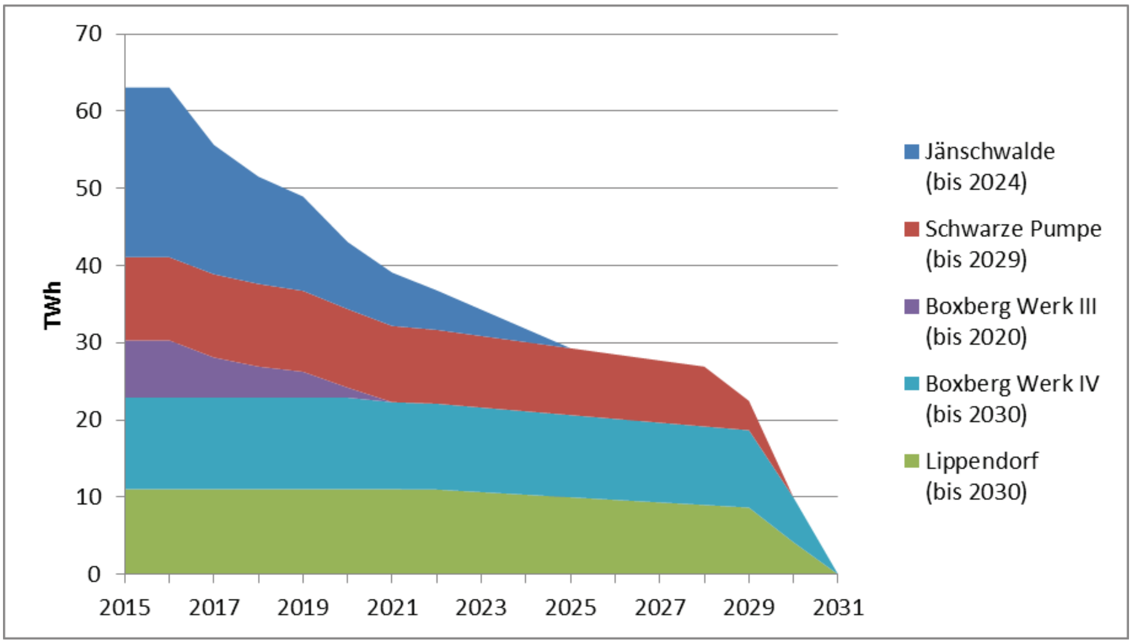
results shown in Table 8. Thus, CO_2 emissions (663 million tons) and electricity generation (644 TWh) would be higher by about 3.5% and 3.3% respectively over the entire period up to 2030. As a result, about 2.9% more coal would be consumed, so that the remaining lignite reserves of approximately 580 million tons would be about 3.7 % lower.

Figure 2: CO_2 emissions from lignite-fired electricity in the phaseout road map



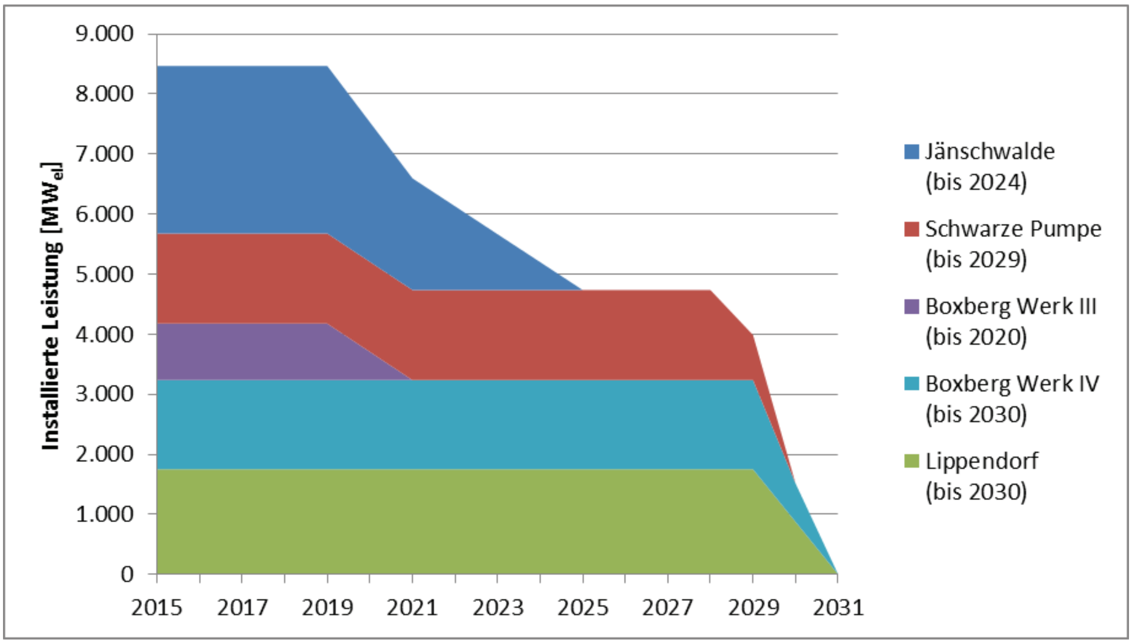
Sources: own computations

Figure 3: Lignite-fired electricity production in the phaseout road map



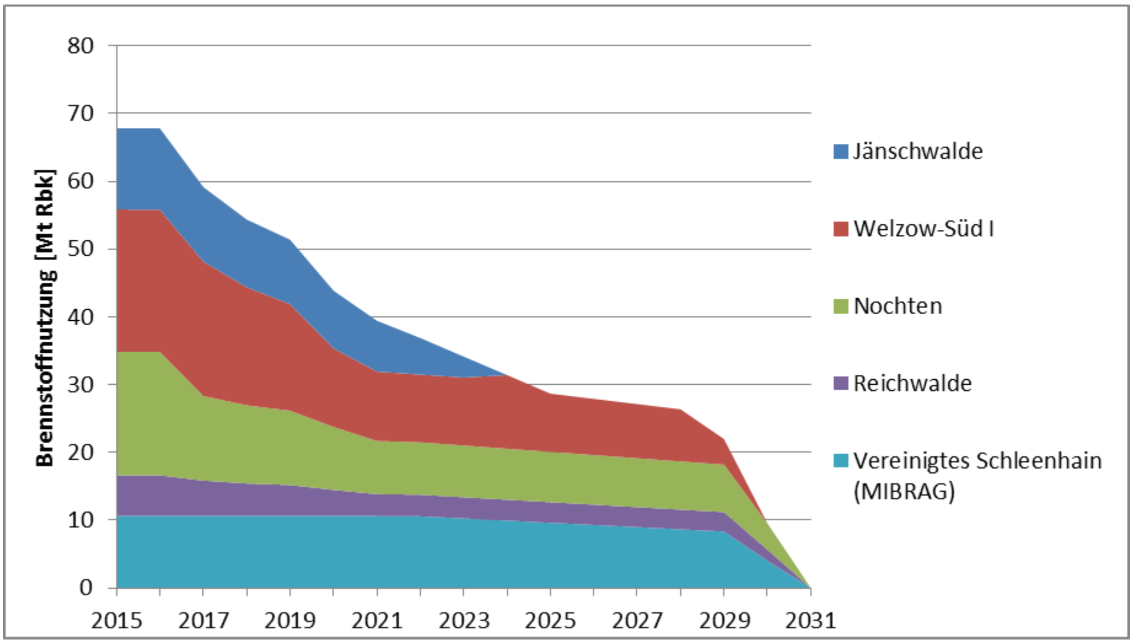
Sources: own computations

Figure 4: Reduction of installed capacity in the phaseout road map



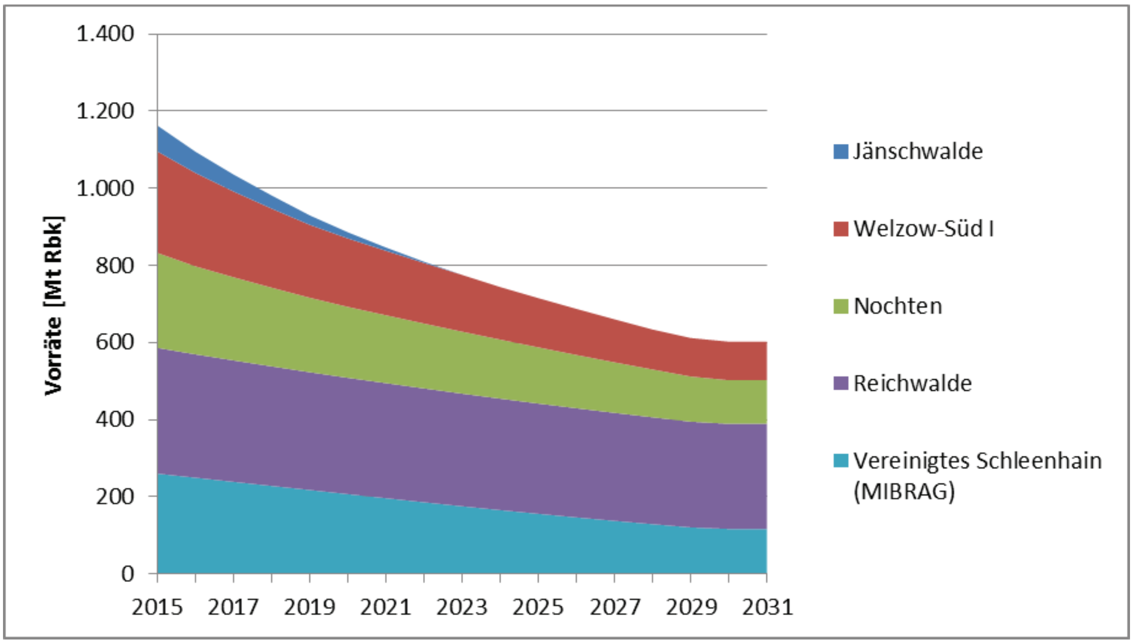
Sources: own computations
(Translation of descriptions and numbers: Installierte Leistung [MWe] = **Installed capacity [MWe]**; 9.000 = **9,000**; 8.000 = **8,000**; 7.000 = **7,000**; 6.000 = **6,000**; 5.000 = **5,000**; 4.000 = **4,000**; 3.000 = **3,000**; 2.000 = **2,000**; 1.000 = **1,000**)

Figure 5: Reduction in lignite production according to the phaseout road map



Sources: own computations
(Translation of description: Brennstoffnutzung [Mt Rbk] = **Fuel utilization [Mt raw lignite]**)

Figure 6: Reduction of lignite reserves in the surface mines licensed by the beginning of 2013



Sources: own computations
(Translation of numbers and description: 1.400 = **1,400**; 1.200 = **1,200**; 1.000 = **1,000**; Vorräte [Mt Rbk] = **Reserves [million tons of raw lignite]**)

2.4 Economic aspects

If, instead of selling its brown coal operations in the Lausitz region, Vattenfall were to phase out brown coal by 2030 as described in the road map above, it would, on one hand, affect the employment structure in the region. On the other hand, the phaseout would also have an effect on the development of the costs of climate change from surface mining and the use of lignite and the impact they both have on people and the environment. In the present study, selected economic aspects of such a development will be examined more closely. More specifically:

– The study will compare the consequences of expected job cuts as a result of the phaseout of surface mining and the use of lignite for electricity in the Lausitz region by 2030 to the consequences of continued mining activities and operation of lignite-fired power plants by potential buyers.

– It will also compare selected costs that could be avoided if Vattenfall were to systematically phase out lignite to the costs of continued lignite mining activities and the generation of electricity by potential buyers.

2.4.1 Employment

In 2010, Vattenfall employed nearly 8,200 people in its brown coal mining operations and lignite-fired power plants. That corresponds to about 7,800 full-time positions (Prognos 2011). If Vattenfall were to phase out brown coal operations in the Lausitz region as described in subsection 2.1, the **jobs** that depend on these activities would also be eliminated by 2030. A certain number of temporary jobs would be created because Vattenfall would have to dismantle power plants and rehabilitate brown coal mining sites. But it is difficult to quantify the effect these two activities would have on employment figures (Oei et al. 2014), making it impossible to include them in calculations in this study. However, current employment figures cannot be used as a benchmark for the comparison of the number of jobs lost to the phaseout of lignite with the employment situation created through the sale of Vattenfall's brown coal interests and their continued operation by potential buyers.

Even if coal-mining activities continue and power plants are kept in operation, **employment directly associated with the brown coal industry is expected to decline** by 2030. A study commissioned by Vattenfall came to the same conclusion (Prognos 2011). This is because a reduction in brown coal electricity and the CO_2 emissions it produces is absolutely necessary to ensure compliance with the German government's low-carbon targets, as stipulated in its energy plan of 2010, reaffirmed in its decision of 2011 to phase out nuclear energy, and in its Action Plan Climate Protection 2020 adopted in late 2014. The study carried out by Prognos shows what the development of employment figures up to 2030 could look like, taking into account the climate protection targets set by the German government. According to the study, some 11,180 people in eastern Germany were employed directly by the brown coal industry in 2010 (Prognos 2011). In the "Bundesregierung 2011" (German Government 2011) scenario, the German government's low-carbon targets correspond to the government's energy plan and its decision to phase out nuclear energy. In this scenario, the number of jobs will have decreased to 5,860 by 2030 (Prognos 2011), which corresponds roughly to a 48% drop in employment from 2010. Using the same target scenario for 2030, Prognos (2012) created a forecast for employment trends in the brown coal industry specifically tailored to the situation in the state of Brandenburg. The findings of the study

show that by 2030, the number of jobs will have decreased by about 50% from 2010. Based on these findings, the present study assumes that by 2030 – to comply with the German government's low-carbon targets – the current number of jobs at brown coal mining sites and lignite-fired power plants operated by Vattenfall in the Lausitz region will decline by half even if operations are sold and maintained. Increasingly ambitious targets – for instance, the introduction of the 'Klimabeitrag', the national climate contribution scheme currently under debate, could result in even lower employment rates by 2030. The Lausitz region would lose 4,100 jobs as a direct result of the phaseout of lignite; those jobs would be saved if the brown coal industry maintained mining operations and kept power plants in operation. If we assume that the distribution of full-time and part-time positions in **2030** is the same as today's, that figure would correspond to roughly **3,900** full-time positions. As already mentioned above, the dismantling of power plants and the rehabilitation of mining sites would create temporary jobs; these however cannot be readily quantified here.

Since there are no alternatives for the future development of the brown coal industry, this study relies on the employment figures from Prognos for estimating the number of jobs that will be lost in the brown coal industry. In so doing, consideration must be given to the fact that the underlying studies were commissioned by Vattenfall so that the independence of the figures computed is somewhat in doubt (Grüne Liga 2015). In particular, we question why two Prognos opinions (Prognos 2005; Prognos 2011) conclude that jobs increased in the eastern German brown coal industry between 2005 and 2011 while the "Coal Industry Statistics" for that timeframe indicate a reduction of employment numbers in eastern German mines (Coal Industry Statistics 2015). In addition, we note that the scenarios were produced in 2011 so they do not reflect current developments.

The report on the regional economic importance of lignite (see Prognos 2011; Prognos 2012) lists employment directly related to the brown coal industry (in other words, jobs in mines and lignite-fired power plants) as well as **indirect and induced employment effects**. The term indirect employment effect refers to employment created by intermediate products of the brown coal industry. Consumer spending by people directly and indirectly employed in the brown coal industry results in the creation of more jobs and is referred to as induced effects. The findings of the above-mentioned studies or the computational models they are based on (the underlying computational models) have been critically evaluated by Netzwerk Grüne Liga (Grüne Liga 2015) and others. It is also necessary to note that it is not clear to what extent jobs in upstream industries depend directly on the brown coal industry. According to Prognos (2011), a large proportion of indirect jobs are to be found in the following sectors: trade and repair services, construction, business-related services, construction, mechanical engineering and automotive construction. But these sectors also supply the renewables industry with goods and services. Should a transition toward an electricity industry based on renewable energy sources succeed in the region as outlined in Chapter 3, and a general diversification of the regional economic structure occur, the loss of jobs in coal mines and power plants would not necessarily lead to a decline in employment in upstream industries, as alternative business and trade opportunities would still exist.

2.4.2 Follow-up costs of lignite mining and electricity generation

Mining and generating electricity from brown coal are responsible for a number of **environmental, social and economic follow-up costs**. From the perspective of the regions affected, but also from the point of view of society overall, a positive effect of the transition road map is the avoidance of these follow-up costs. On one hand, these costs are incurred by earth movements due to surface

mining and their consequences – this includes costs of resettlement, large-scale draining of mines, soil degradation, acidification, the contamination of groundwater watercourses with iron ochre, and the cost of health care for people affected by noise and air pollution (Wronski and Küchler 2014). On the other hand, the generation of power from lignite releases greenhouse gases and other air contaminants responsible for follow-up costs caused by global warming and air pollution. Schemes do exist to internalize some of the follow-up costs: for example, an emissions trading system and an energy tax for brown coal electricity; and provisions for mining-related liabilities held by lignite mine operators to cover follow-up costs of surface mining. However, a large part of these follow-up costs are external costs, meaning costs not charged to the party responsible and must therefore be borne by society at large.

The German Environmental Agency (UBA) published a “Methodological Convention 2.0 for Estimates of Environmental Costs” that serves as a basis on which recommendations for best practice cost rates for **external costs incurred by air pollution and climate impacts** caused by the generation of electricity were valued (UBA 2012a; UBA 2012b). Compared with other fossil fuels, the use of lignite to generate electricity causes the highest environmental costs; however, the environmental cost of generating electricity from renewables is relatively low, making them the most environmentally-friendly source of energy (UBA 2012b) as shown in 9. Based on the UBA’s recommendations, an estimate was made of the environmental costs avoided by Vattenfall’s systematic phaseout of lignite in accordance with the road map developed (see subsection 2.3), compared to the costs of continuing to generate power from lignite. The development of power generation “Bundesregierung 2011” scenario used in the study “Importance of Lignite in Eastern Germany” (Prognos 2011) was used as a reference scenario for the continued operation of lignite-fired power plants. The generation of electricity by other power plant operators in eastern Germany was not included in the reference scenario; the generation of electricity by the new lignite-fired power plants, which according to Prognos (2011) will have gone online by 2050, was not taken into consideration either as they could not easily be assigned to the new owner of Vattenfall’s power plants. In calculating the avoided environmental follow-up costs, the period from 2015 to 2050 was examined. Environmental damages caused by greenhouse gas emissions and air contaminants produced by power plants in operation beyond 2050 were not considered. Since the use of renewables to generate electricity also involves environmental follow-up costs, in the scenario for Vattenfall’s phaseout of lignite power generation we also calculated how high the environmental costs incurred by the expansion of renewables in the states of Brandenburg and Saxony would be if the Alternative Road Map 2030 (see Chapter 3) were put into action.

Table 9: Environmental costs of electricity generation in Germany

	Air pollutants	Greenhouse gases	**Total environmental costs**
	[€-cents/kWh_e]		
Lignite	2.07	8.68	**10.75**
Anthracite	1.55	7.38	**8.94**
Natural gas	1.02	3.90	**4.91**
Oil	2.41	5.65	**8.06**
Hydroelectric	0.14	0.04	**0.18**
Wind energy	0.17	0.09	**0.26**
Photovoltaics	0.62	0.56	**1.18**
Biomass	1.07	2.78	**3.84**

Source: UBA (2012b); based on 2010 prices.

The calculations show that according to the reference scenario drafted by Prognos (2011), the continued operation of Vattenfall's lignite-fired power plants until 2050 by a potential buyer would involve a cumulative power generation of 1,458 TWh. If Vattenfall stops using lignite to generate electricity by 2030, as proposed in the road map, it would reduce the amount of electricity generated in the period from 2015 to 2030 to just under 664 TWh. That means that the phaseout of lignite power generation by 2030 would **amount to EUR 85.4 billion in avoided environmental costs.**[1] If the environmental costs caused by the expansion of the power generation capacity of renewables as proposed in the Alternative Road Map 2030 are taken into account, **savings would amount to about EUR 82.7 billion**.[2] The regional construction of additional renewable energy facilities in Saxony and Brandenburg as provided by the Alternative Road Map 2030 cannot completely compensate the amount of electricity generated by the lignite-fired power plants as described in the reference scenario. However, as the use of lignite to generate electricity produces the highest environmental costs (see Table 9), significantly lower environmental costs would result even if electricity were generated from a mix of renewables and fossil fuels based on gas and anthracite. So even in that case, the phaseout of lignite in the Lausitz region would result in lower external costs caused by air pollution and impacts.

The mining-related provisions made by mine operators in the lignite industry give an indication of how high the **follow-up costs resulting from lignite mining** are. According to the Federal Mining Law (BbergG), mining companies are legally bound to:

- to compensate people forced to abandon their property (§§ 84-90);
- to take precautions to prevent harm to people's health or lives, and to protect property, workers and other parties involved in operations against damages (§ 55);
- to ensure that adequate measures are taken to rehabilitate mining sites so that the surface may be used for other purposes (§ 55);
- to properly recycle or dispose of any waste generated (§ 55);
- to protect third parties against any hazards to health or life caused by mining operations even following the cessation of operations (§ 55);
- to reclaim the surface area of the mining site once mining operations have ended (§ 55).

---

1 Based on 2010 prices.

2 Based on 2010 prices.

Operators must make provisions for these (precautionary) measures. Mining-related provisions of Vattenfall's subsidiary Vattenfall Europe Mining AG amounted to roughly EUR 998 million in 2013 (Vattenfall Europe Mining Aktiengesellschaft 2014). The following chart shows the development of the company's mining-related provisions in the period from 2005 to 2013, as well as their annual deposits and withdrawals. In most years, deposits are higher than withdrawals so that the overall amount saved is higher than the amount paid out. It should be noted when reading the figures that the adoption of Accounting Law Modernization Law (BilMoG) in 2010 resulted in a change in the legal basis for the calculation of provisions, which explains the high amount of withdrawals in 2010.

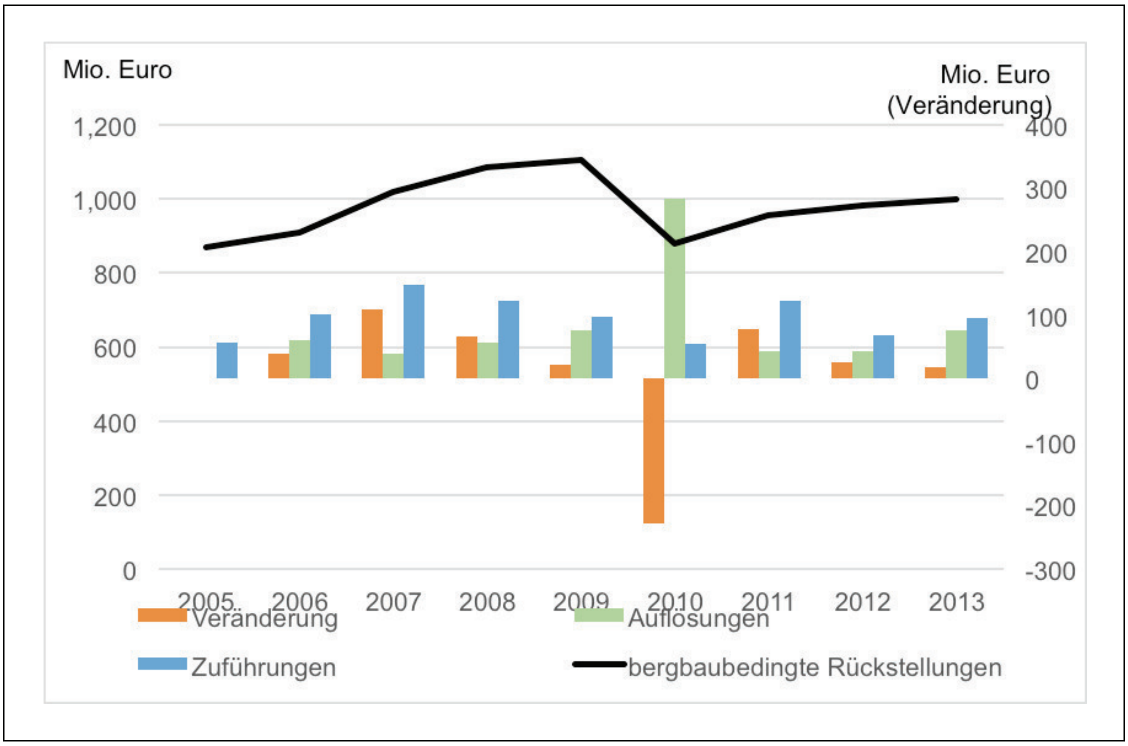


Figure 7: Mining-related provisions of Vattenfall Europe Mining AG from 2005 to 2013
Source: Evaluation of the annual financial statements of Vattenfall Europe Mining AG published on the www.bundesanzeiger.de website.

(Translation of descriptions and numbers: Veränderung = **Shift**; Zuführungen = **Deposits**; Auflösungen = **Withdrawals**; bergbaubedingte Rückstellungen = **Provisions for mining damage**

As the amount of EUR 998 million is the figure given for existing provisions in the fiscal year of 2013, we can assume that additional provisions related to the future commissioning of surface mines planned in the Lausitz region (see Table 5) have not yet been included. Deposits made by Vattenfall for mining-related provisions in recent years give an indication of what kind of additional costs could be expected, for example to finance resettlements, if Vattenfall went ahead and opened the planned lignite mines. Thus, in the past, disbursements for mining-related measures included the following: EUR 47 million for the partial resettlement of the village of Trebendorf/Schleife; EUR 9.4 million for rerouting the Weißer Schöps River; and costs amounting to EUR 4.5 million for the relocation of the Oberlausitz military training area (Vattenfall Europe Mining Aktiengesellschaft 2009). In the following years, disbursements for partial resettlements and river rerouting also

appear as a partial aspect of deposits for provisions made so that the figures listed above probably only reflect part of the disbursements made.

A study by FÖS on the “Cost Risks for Society Posed by German Lignite Mining” (Wronski and Küchler 2014) concludes that provisions mandated by the Federal Mining Law do not cover all aspects of follow-up costs of lignite mining. For example, the psychosocial costs of resettlement, of disease and illness caused by particulate matter emissions, of long-term disruptions to the water balance and the loss of biodiversity are not or only partly covered by the legally prescribed provisions and must therefore be classified as external costs of lignite mining. Secondly, due to the lack of transparency regarding the basis and models used by Vattenfall and other companies in the lignite business to calculate follow-up costs, there is the risk that the provisions made for the rehabilitation of mining sites will not be high enough to cover actual costs. The authors also criticized the fact that the prescribed discount rate seems too high in view of how low current real interest rates are on capital markets (Wronski and Küchler 2014).

In summary, we can conclude that although part of the follow-up costs of lignite mining and electricity generation must be paid for by Vattenfall or any other potential operator of the mines and power plants, a large share of the follow-up costs incurred by the adverse effects of lignite operations on people and the environment and the climate impact must be borne by society at large and not by the companies responsible. If Vattenfall undertakes a gradual phaseout of lignite and does not open any additional mines in the Lausitz region as planned, considerable savings in the follow-up costs of lignite operations would be achieved.

3. Alternative Road Map 2030: Investments in Renewable Energies

From the regional perspective, a transformation road map for Vattenfall's brown coal division in the Lausitz can be compensated for in various respects by expanding renewable energies and adding emphasis to future-oriented energy services. In drawing up an Alternative Road Map for the region we use the number of jobs lost from a brown coal phaseout as a reference number (see subsection 2.4).

At the end of 2013, 50% of the employees in the brown coal industry were older than 50 years of age, and even more employees, 65%, were over 45 (Coal Industry Statistics 2014). One can reasonably expect that a large number of these employees will have retired by 2030. In a comparable scenario without a phaseout, the employment numbers could be expected to fall by about half by 2030. The number of jobs created through the expansion of renewable energies according to this study is thus greater than the number of employees remaining in the brown coal industry by 2030. Even if for reasons of qualifications or locality, employees could not be taken on by other employers, it is reasonable to expect that a large number of now young employees could be retrained in the next decades to work in the field of renewable energy.

At this juncture we do not take into account the issue of energy security that has to be decided at a supra-regional level. However, more flexibly operated power plants will be needed in the future to compensate for fluctuating renewables and to ensure energy security. In addition, from the climate protection standpoint, we must reduce fossil fuel must-run capacities and maximize the efficient use of remaining fossil residual energy production through predominantly urban combined heat and

power (CHP) facilities. These factors also argue for a phaseout from this type of electrical power generation (see Chapter 2.2). The production of hydrogen or methane from excess green power that, with existing natural gas infrastructure, allows for easy storage, transport and flexible reconversion, heat production, or use as fuel in the transportation sector, may likewise enjoy increased significance in this connection. Vattenfall, together with the Brandenburg wind power specialist Enertrag, has already successfully realized a first demonstration system. However, since this technology is still in development, its potential value creation and employment effects in this area cannot be taken into consideration within the scope of this study.

The use of regionally available renewable energy can accompany diverse positive regional economic aspects. Besides the climate and environmental protective effects of a phaseout, the Alternative Road Map 2030 also demonstrates the economic alternatives for the region. A proposal for a green energy concept has been worked out for the Alternative Road Map 2030 for the Lausitz region and the affected states of Brandenburg and Saxony that will allow employment in the green energy area to compensate for jobs lost in the brown coal industry and shows what investment will be required in green energy technology. This study examines only the employment compensation that can be achieved through green energy expansion in electricity generation. Fundamentally, however, measures to expand activities in the area of green energy heat and efficiency measures also offer employment possibilities (see Hirschl et al. 2010; Aretz et al. 2013; Weiß et al. 2014).

In order to estimate the realization possibilities of this Alternative Road Map we must compare the green energy expansion needed to compensate for employment in the brown coal industry with regional green energy potential. In designing the Alternative Road Map 2030, it was assumed that Vattenfall would make a large part of the necessary investment and thus the focus of activities is expected to be on larger projects (e.g. wind farms and open array photovoltaic systems). Beyond that, the Alternative Road Map shows how value creation effects can be linked to an assumed green energy expansion in 2030.

To determine investment and job effects, the IÖW has recourse to a model for determining value creation and employment effects through renewable energy (called the WeBEE model) that has existed for several years and that has been used in a number of research projects (see in this connection Hirschl et al. 2010 and Aretz et al. 2013). In the following, we first briefly explain the WeBEE model and the procedure used for computing value creation and employment effects before we discuss green energy potential and the green energy expansion needed to compensate for the jobs lost in the brown coal industry in the region.

3.1 Methodology

As part of its study entitled "Community Value Creation through Renewable Energies", commissioned by the Agentur für Erneuerbare Energien (AEE) [Agency for Renewable Energies], the IÖW developed a model for computing value creation and employment effects at the community level (hereafter referred to as the WeBEE model) (Hirschl et al. 2010). The model, which has since been continuously developed, now encompasses over 50 green energy value creation chains including 19 green energy value creation chains in the area of power generation. Using the model for these value creation chains, it is possible to compute company profits, net income of employees, and tax income for the communities at the state and federal level. In addition, the model allows for the determination of employment effects in the form of full-time jobs.

The central basis for computing value creation using the WeBEE model is the analysis of the investment and operating costs of individual green energy technologies. These correspond to the specific implementations along the value creation chain of a given green energy technology and are related to installed system capacity.

The value creation chains are subdivided into four aggregate value creation stages and the cost positions included in them:

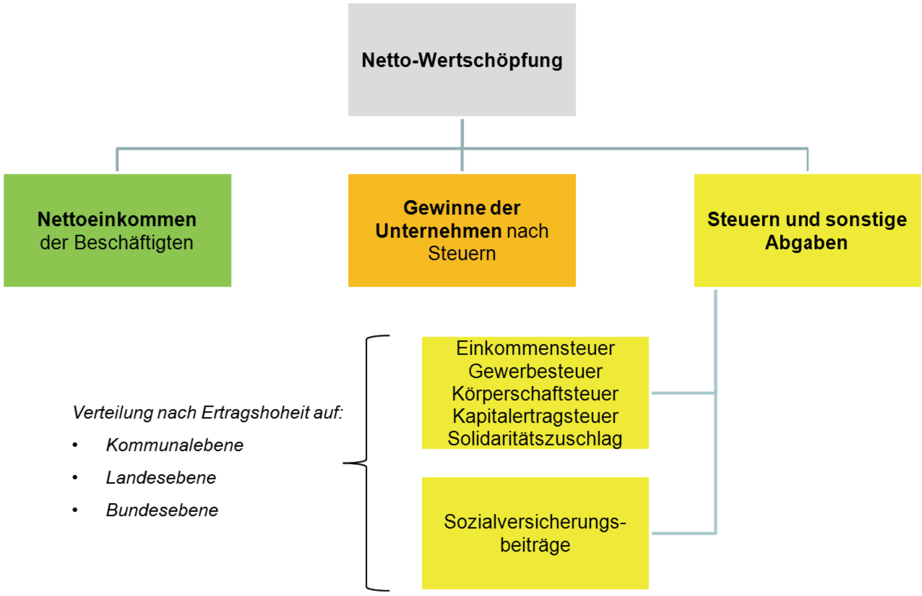
- **Facility manufacturing**
  (investment costs for green energy facilities and individual system components)
- **Planning and installation**
  (ancillary investment costs for planning offices, assembly, the purchase of real estate, and the like)
- **Facility operation and maintenance**
- (operating costs for maintenance, fuel and energy costs, insurance, third-party debt interest, and to a certain extent operating personnel and lease payments, etc.)
- **Operator profits**
  (profits of the facility operator and taxes paid on profits).

The methodology described subsumes trade in facility components or installation and maintenance material in the four value creation stages referenced above. Depending on the value creation chain, each of the value creation stages above can in turn be subdivided into various value creation steps that can differ between various green energy technologies. For example, the facility manufacturing value creation stage includes the value creation steps of individual system components. In the system operation stage, the value creation steps include, for example, facility maintenance, insurance premiums, or where appropriate, personnel costs. Individual or multiple typical business branches are assigned to the individual value creation steps for which statistical data sources for economic figures are available. Revenues in the individual stages are computed by assigning individual investment and operating cost positions to the corresponding value creation steps. In academic literature, cost structures are predominantly described relative to investment costs or in part are shown relative to ancillary investment costs. This percentage structure allows the application of cost structures to the specific investment costs that are derived from the current literature (market analyses, evaluation reports, and the like). The costs or revenues in the value creation stages of "facility manufacturing" and "planning and installation" accrue on a one-time basis through investment in a green energy system. On the other hand, the costs and revenues for the operation are generated annually over the entire operating life of the green energy facility.

Generally speaking, value creation is a combination of the following three components:

1. The **profits** of the participating company net of income taxes.
2. The **net income** of the participating employees.
3. The **taxes** paid on company profits and gross income.

Figure 8: Defining value creation in the IÖW's WeBEE model



Source: Own presentation
(Translations: Netto-Wertschöpfung = **net value added**; Nettoeinkommen der Beschäftigten = **net income of employees**; Gewinne der Unternehmen nach Steuern = **corporate profits after tax**; Steuern und sonstige Abgaben = **taxes and other charges**; Verteilung nach Ertragshoheit auf = **breakdown into sovereign tax authorities**; Kommunalebene = **local level**; Landesebene = **state level**; Bundesebene = **federal level**; Einkommsteuer = **income tax**; Gewerbesteuer = **business tax**; Körperschaftssteuer = **corporation tax**; Kapitalertragssteuer = **capital gains tax**; Solidaritätszuschlag = **solidarity surcharge**; Sozialversicherungsbeiträge = **social security contributions**

In the following we will briefly describe the underlying procedure for computing value creation and employment effects. For computing **pre-tax profits** of companies in the respective value creation steps, each position is assigned a return on sales figure that expresses the annual pre-tax profits of a company relative to sales during that period. Return on sales is a statistic of the Deutsche Bundesbank [German Central Bank] that lists data from the annual financial statements of German companies for the years 2006 to 2010 (Bundesbank 2012). The average return on sales of the various industries is computed as an average value for the years 2006 to 2010. The determination of profits of system operators deviates from the procedure described. Here, pre-tax profits are computed using an average return on equity of respective green energy technologies that is taken from the progress report on Germany's Renewable Energies Act (BMU 2011) and updated where applicable.

Income effects are computed depending on sales for the individual positions of the value creation stages. Besides income, this methodology also shows the effects on employment. Employment effects are first computed as a number of employed persons. In this regard, data on the number of employees contributing to social security insurance by industry is extracted from publications of the Federal Labor Agency (Bundesagentur für Arbeit 2012). In addition, specific industry revenues are taken from the Federal Statistics Office (2012a). These permit an indication of the number of employees paying into social security per euro of sales which, multiplied by sales per kilowatt of installed capacity, makes it possible to arrive at a specific figure of employees (head count) per kilowatt of electric power. Then, using the special data analysis of the Federal Statistics Office, these data are converted into full-time equivalents (VTE). The special analyses come on the one hand from the quarterly salary survey in the manufacturing industry and services area and on the other from data in the "RS 3.8 Employment by Economic Subcategories" micro census. Based on the average

gross annual income in the business branch of the respective value creation steps, the wages and salaries paid in euro per kilowatt can be computed from sources provided by the Federal Statistics Office (2012b).

Tax receipts and income from other levies come from taxing company income and the income of employees. Within the framework of taxes and other levies on company profits at the company level, this also includes consideration of the taxation of distributed profits. The model includes the trade tax, individual income tax, corporate income tax and the tax on investment income as well as the solidarity surcharge, church taxes and, where applicable, health insurance fund contributions. Generally speaking, the company's choice of legal entity governs the computation of its tax rate. Therefore, the companies participating in the value creation process on the basis of WZ-08 are subdivided into corporate and partnership entities in order to take into consideration the differences in company taxation (Federal Statistics Office 2012c). In order to model after-tax profits one must first estimate the taxable income which is the basis upon which income and corporate income taxes are assessed. Taxable income is computed using Bundesbank (2012) data on taxes paid on pre-tax profits and an ideally typical company taxation of corporate and partnership taxation. For the sake of simplicity, trade taxes are computed on the basis of pre-tax profits. In the case of corporate entities (Corp.), the trade tax, and corporate income tax plus the solidarity surcharge on corporate income tax, are due at the corporate level. With the exception of the trade tax, taxation of partnership entities (Part.) takes place at the partner level.

In the case of distributed profits we assume in the case of corporations that 50% of shares are owned by private persons and 25% each by corporations and partnerships. In addition, we assume 50% of after-tax profits are distributed. Private persons as investors pay the investment tax on their distributed profits, corporations pay corporate income tax and the solidarity surcharge, and partnerships pay income tax, church tax and the solidarity surcharge. The taxation of partnerships is done by dividing the partners into private persons, corporations and partnerships using a 2008 special analysis by the Federal Statistics Office of statistics on partnerships/associations. Corporations must pay corporate income tax and the solidarity surcharge, and partnerships and private persons must pay the individual income tax, church tax and solidarity surcharge; private persons, in addition, have to pay contributions to their health insurance fund.

For taxes and other levies on the income of employees, the previously computed gross annual wages govern. Here the corresponding payments of income tax, church tax, solidarity surcharge and social levies (employer and employee) are taken into consideration.

Using this method, the scope of tax and levy payments can be computed as well as after-tax profits or net income.

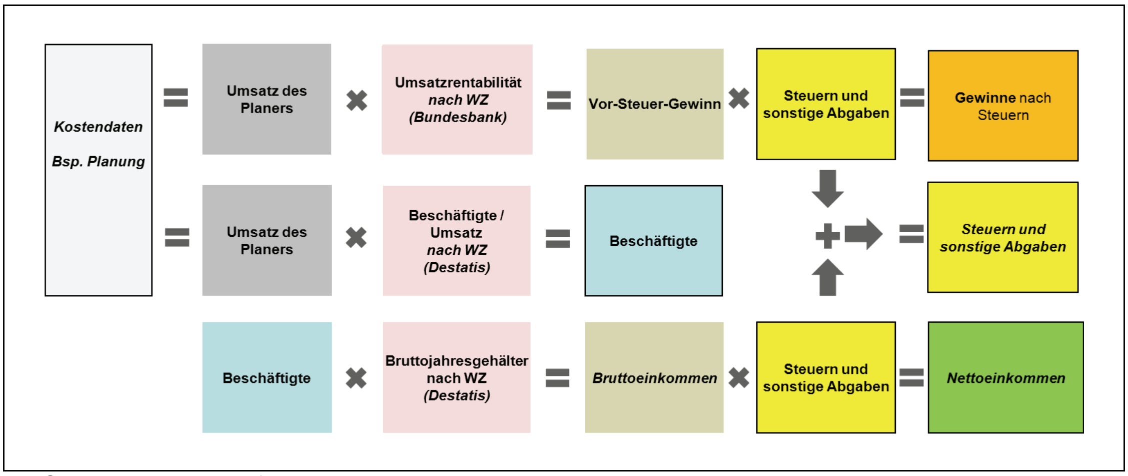
Besides the indirect effect of profits and income, communities profit directly from the value creation process in two ways. First, they receive almost all of the trade tax. Only a small amount goes to the federal government (3.72%) and the states (13.23%). In addition, the communities participate proportionally in the assessed individual income tax (15%) as well as the investment income tax (12%).

Moreover, in addition to the community-relevant gross value creation components, the WeBEE model can be used to compute the gross value creation effects at the state and federal levels. At the state level, income from corporate income, individual income, investment income and trade taxes are considered. At the federal level, the respective shares of the corporate income tax, individual income, investment income and trade taxes, as well as income from the solidarity surcharge, and the social

levies of employers and employees, are included. This allows for a Germany-wide quantification of value creation effects at each of these three levels; i.e. a determination of what value creation in German communities, states, or in Germany as a whole are generated through the green energy technologies reflected in the model.

In conducting analyses with the model described above, the value creation chains are limited to revenues that are directly related to green energy. Thus, for example, the production of facility components is included in the analysis of direct effects. Under this methodology, the indirect effects of upstream sales and their associated value creation effects are not considered. However, these effects can be likewise computed by coupling the WeBEE model with an expanded, statistically open I/O model (Aretz et al. 2013).

Figure 9: Presentation of an example of value creation computation in the WeBEE model of IÖW



Sources: own presentation
(Translations: Kostendaten Bsp. Planung = **cost data for planning (as an example)**; Umsatz des Planers = **revenue of planner**; Beschäftigte = **employees**; Umsatzrentabilität nach WZ (*Bundesbank*) = **sales profitability in industry (*German Bundesbank*)**; Beschäftigte/Umsatz nach WZ = **employees/sales in industry**; Bruttojahresgehälter nach WZ = **gross annual salaries in industry**; Vor-Steuer-Gewinn = **pre-tax profit**; Bruttoeinkommen = **gross income**; Steuern und sonstige Abgaben = **taxes and other charges**; Gewinne nach Steuern = **profits after taxes**; Nettoeinkommen = **net income**)

3.2 A scenario-based estimate for 2030: methodology and assumptions

To compute value creation and effects on employment at the level of a German state, the figures upon which the WeBEE model is based can be adjusted to the state under examination. This region-specific adjustment within the model includes state-specific gross annual salaries by business industry, the average rate of trade tax, and the proportion of church membership in the states as parameters for calculating church tax.

Using the WeBEE model, the specific value creation and employment effects relative to one unit of installed green electricity capacity is computed for each of the value creation chains. This allows for an estimate of effects at the regional or national level using the power capacity of the green energy generation systems

installed and added within a region, a state, or in Germany[3]. In the context of this study, this means that value creation and employment effects at the value creation stages of “planning and installation”, “facility operation and maintenance” as well as “operator profits” can be computed on the basis of assumed added construction of installed green energy system capacity through 2030 needed to compensate for the jobs lost in the brown coal industry. Assuming there is potential for the additional expansion of renewable energies in states, computations for Saxony and Brandenburg are done separately to compute the effects with the model adjusted for the specific state.

In addition to the inventory and expansion of installed green energy capacity in 2030 that is being analyzed, assumptions must be made concerning the residence of green energy companies and green energy employees in the two states because, in the normal case, not all value creation steps along the green energy value creation chains can be performed entirely by actors residing in the state. Including the factor of the regional residency of companies and employees along the individual green energy value creation chains in a state requires comprehensive research and empirical data gathering. Such a detailed analysis was not possible within the scope of this brief study, so the effects on the value creation stages of “planning and installation” as well as “facility operation and maintenance” were computed assuming an 80% regional residency. Already today there are companies resident in the states of Brandenburg and Saxony that are active in the green energy sector. Under the assumption that green energy service providers will continue to expand their competencies in those regions affected by the phaseout from brown coal, a percentage of 80% regional residency is deemed realistic or realizable.

In some value creation steps, regional residency of 100% was assumed since in this case at the state level it can be assumed that these steps will be covered by local actors. This affects personnel for operating systems and rental payments or real estate purchases.

Regional residency of the operator company and the shareholders is dispositive of the question as to what portion of the value created will remain in the region or leave the state. Here we have created three scenarios with different assumptions concerning the residence of the operator and investors in green energy systems:

- Scenario 1: less local content relative to the regional residency of the operator companies and shareholders (overall 20% assumption)
- Scenario 2: medium local content relative to the regional residency of operator companies and shareholders (overall 50% assumption)
- Scenario 3: higher local content relative to regional residency of the operator companies and shareholders (overall 80% assumption).

The effects of manufacturing green energy facilities and components cannot be computed within the scope of the study because the economic activities of the manufacturers of green energy facilities and components in individual states are very independent of the capacity added to and installed within the state. Also, it is possible to estimate value creation and employment only on the basis of economic figures (revenues, employees) from firms resident in the states. This, too, requires comprehensive research and empirical data gathering which could not be done within the scope of this study. However, trading in facility components was taken into account and included in computations at the systems manufacturing stage.

---

[3] In this regard it should be observed that the estimate is done on the basis of green energy technologies that are reflected in the IÖW model. Thus, it covers a large part of the green energy capacity installed in Germany but does not include the entire range of technologies.

For the scenario-based estimate, we must also take into account that by 2030 the investment costs in most cases will be reduced because of learning curve effects. Thus, the specific investment costs of green energy technologies will necessarily be subject to a degressive effect. The cost degression through 2030 was computed on the basis of assumed cost developments in long-term scenarios by the BMU [Germany's environment ministry] (Nitsch et al. 2012a; Nitsch et al. 2012b). For simplification, we have assumed no changes in the remaining cost structure.

Tax computations for 2030 are made on the basis of tax legislation existing in 2012. The computation of operator profits is done on the basis of a technology-specific return on equity. The required information on this point is derived from the literature, including the progress report on Germany's Renewable Energies Act (BMU 2011). Against the background of profitability reductions in the photovoltaic industry in past years, we have reduced the return on equity from photovoltaic roof systems to 6% for 2030.

3.3 Renewable energy potential in Brandenburg and Saxony

An Alternative Road Map to possibly compensate for the loss of jobs at Vattenfall in the brown coal industry through further expansion of renewable energies in the affected regions can only be drawn up on the basis of existing green energy potential. A detailed or up-to-date analysis of green energy potential could not be done within the scope of a brief study so we analyzed the data on potential that had already been gathered. For simplicity, green energy potential for the Alternative Road Map 2030 is viewed at the level of the states affected by phaseout from the brown coal industry. It was not possible to make a clear geographical assignment of green energy added capacity and the associated employment potential within the green energy section for the Lausitz region. It can, however, be assumed that upon phaseout from the brown coal industry by 2030, additional potential, in particular for wind energy and photovoltaics, will be available in the Lausitz when the recultivated areas of former surface mines become available. In addition, region-specific studies such as, for example, the " Lausitz-Spreewald Regional Energy Plan" (RPG Lausitz-Spreewald 2013)[4] show that there is considerable potential for further expansion of renewable energies in the region. The following subsection provides an overview of green energy potential in Brandenburg and Saxony in the power generation sector.

3.3.1 Brandenburg

In 2012, as part of a study commissioned by Greenpeace entitled "Renewable energy potential in Brandenburg 2030: technical developmental potential and value creation and employment effects - a scenario-based analysis" (Bost et al. 2012a), the IÖW investigated the developmental green energy potential in the state of Brandenburg through to 2030. The study showed that there was still

[4] Although the Lausitz-Spreewald Regional Planning Association (RPG) is one of a total of five planning associations in Brandenburg, the regional wind potential in a time horizon through to 2030 is about one-third of the wind power potential according to Bost et al (2012a) that can be developed in the EE-0BK scenario in Brandenburg by 2030. In the case of photovoltaics, the demonstrated potential in the energy plan has the same dimension as the photovoltaic potential for all of Brandenburg portrayed by Bost et al. (2012a) in the EE-OBK scenario.

considerable potential both in the area of wind and solar energy as well as with regard to green thermal energy. The analysis of potential was done for two scenarios: in the scenario of a 50% reduction in lignite by 2030, called “EE 50 BK" it was assumed that electricity generated from brown coal would fall by 50% by 2030; in the scenario of a complete phaseout of lignite by 2030, called “EE 0BK”, the assumption was a complete phaseout of lignite-fired electricity by 2030. What developmental potential would look like through 2030 in the electricity sector in the latter case is discussed below.

Bost et al. (2012a) analyzed various studies to compute **wind power potential** in Brandenburg. Accordingly, the usable unrestricted wind power potential in the state lies between 34.5 GW to 55.3 GW. The EE 0BK scenario assumed that by 2030, 15 GW of wind power would be installed, of which about 5.4 GW would be attributable to repowering old facilities. As of 2014, there were wind turbines with about 5.5 GW of capacity installed in the state (AEE 2015) so that currently there remains considerable potential for the further expansion or repowering of wind turbines.

According to Bost et al. (2012a), in the area of solar energy there is a total potential of 3,561 MWp for **photovoltaic arrays** on roof surfaces. In addition, depending on the study, anywhere from 2,190 MWp to 6,667 MWp could be installed in open spaces available for photovoltaics. Thus for Brandenburg this equates to photovoltaic potential totaling between 5,751 MWp and 10,228 MWp. In the EE 0BK scenario, it was assumed for photovoltaic expansion that 6,113 MWp of photovoltaic capacity would be installed by 2030, of which 36% would be on roof surfaces and 64% in open arrays. As of 2015, there were photovoltaic systems in Brandenburg with about 2.9 GW connected to the grid (AEE 2015).

The study by Bost et al. (2012a) limits the analysis of potential in the area of **biomass** to its endogenous potential. That is because biomass imports are not part of Brandenburg's green energy potential and should be viewed critically from a socio-ecological standpoint. Since the expansion of biomass conversion to electricity in the state is already well advanced, the IÖW study assumed a complete development of biomass potential by no later than 2020 (Bost et al. 2012b). Additional potential is found in biogas. Bost et al. (2012a) assumed an installed capacity of just under 400 MW by 2030. According to the Biogas Professional Association (2014), biogas facilities with a total of 192 MW capacity were installed in Brandenburg at the end of 2013.

According to Bost et al. (2012 b), the potential for **hydropower** in Brandenburg is relatively low because of the lack of altitude variation and the slow rate of flow of existing flowing waters. In the EE 0BK scenario, the assumption is that existing potential would be completely developed by 2030 (about 14 MW).

There are currently no deep geothermal projects in Brandenburg for generating electricity. However, according to the analysis of green energy potential for Brandenburg prepared by Bost et al. (2012 a), there is potential in the state for power generation from **deep geothermal sources**. For the time horizon until 2030, a possible expansion of 850 MW is mentioned. In the EE 0BK scenario, the authors assumed a 10% (85 MW) development of this potential in Brandenburg by 2030

The following table (Table 10) provides an overview of the status of current green energy expansion in Brandenburg, the potential in green power generation discussed above, the degree of expansion by 2030 assumed in the EE 0BK scenario, and the unused potential that is available for the future expansion of green energy in the state.

Table 10: Renewable energy potential for power generation in Brandenburg

Renewable energy technology	Technical potential for renewable energies	Renewable energy expansion in the EE-0BK scenario	Utilized renewable energy potential (as of 2013/2014)	Unused renewable energy potential	Unused potential vs. renewables expansion in the EE-0BK scenario
	[MW]	[MW]	[MW]	[MW]	[MW]
Wind energy on land	55,000.0	15,079.0	5,456.6	49,543.4	9,622.4
Wind energy (new facilities)	n.s.	9,666.1	5,314.8	n.s.	4,351.3
Wind energy (repowering)	n.s.	5,412.4	141.8	n.s.	5,270.7
Photovoltaics	10,228.0	6,112.5	2,921.0	7,307.0	3,191.5
Photovoltaics (on roofs)	3,561.0	2,216.5	689.2	2,871.8	1,527.4
Photovoltaics (open arrays)	6,667.0	3,896.0	2,231.8	4,435.2	1,664.2
Biomass (biogas)	359.0	359.0	370.0	16.3	167.0
Hydropower	n.s	13.9	5.0	n.s.	9
Deep geothermal	850.0	85.0	0.0	850.0	85.0

Sources: See source references in the text.
n.s. = not specified

3.3.2 Saxony

There were no current studies or potential surveys with a comparable degree of detail available for the state of Saxony. Accordingly, the green energy potential could only be roughly estimated on the basis of available documents and sources that are listed as follows:

- Daniels et al. (2008): Green Expansion Study 2020: Perspectives for renewable energies in Saxony. An investigation of the technical potential of renewable energy sources in Saxony as well as their economic implementation possibilities for electrical power generation through 2020.
- The Saxony State Ministry for Environment and Agriculture (2009): Background paper concerning the goals of future climate protection and energy policies of the state of Saxony.
- The Saxony State Ministry for Economics, Labor and Transportation and the Saxony State Ministry for Environment and Agriculture (SMWA and SMUL 2013): Energy and climate program in Saxony.
- Bofinger et al. (2012): Study of the potential of wind energy usage on land.

- AEE (2015): www.foederal-erneuerbar.de. State portal of the Agency for Renewable Energies concerning renewables.

According to a study commissioned by the German Wind Energy Association (Bofinger et al. 2012) concerning the potential for wind energy usage on land, there is a maximum potential (i.e. potential for wind energy on unrestricted spaces) of about 24 GW in Saxony. At 2,027 full-load hours (Bofinger et al. 2012), this corresponds to the possible electricity generation of just under 48,650 GWh/year. At a usage rate of 1% of the land area in Saxony, this works out to a potential of 4.9 GW of installed wind capacity according to Bofinger et al. (2012). The targeted goal of the Saxony government in its energy and climate program of 2012 provides for an increase in electricity generation to 2,200 GWh/year by 2022 (SMWA and SMUL 2013) which corresponds to an installed capacity of about 1.09 GW. With an installed capacity of 1.07 GW (AEE 2015) already attained in 2014, the goal has been almost reached. Since the goals of the Saxony government have a time horizon only to 2022, the Alternative Road Map 2030 relies on the potential according to Bofinger et al. (2012).

In 2008, the Bundnis 90/Die Grünen [The Greens] party’s state parliamentary group commissioned a study by the Vereinigung zur Förderung der Nutzung Erneuerbarer Energien VEE Sachsen [Association for the Promotion of the Use of Renewable Energies VEE Saxony] entitled "Investigating the technical potential of renewable energy sources in Saxony and the economic feasibility of green electricity generation until 2020". Since no potential analyses of a more current date could be identified for the state of Saxony, the estimate of the potential for photovoltaics and biomass has been based on this study. It may be assumed that a current evaluation of green energy potential, given the current state of technology, might lead to somewhat different potential estimates, so that potential values for photovoltaics and biomass set forth in the following can be regarded only as points of orientation.

Daniels et al. (2008) show a "technically realistic solar potential" totaling 5,360 MWp for **photovoltaic roof systems and photovoltaic open arrays** of which, according to the authors of the study, 3,680 MWp could be installed on open spaces and 1,680 MWp on roof surfaces. According to the Saxony government, about 1,800 GWh/year of electricity could be supplied by radiant solar energy by 2022 (SMWA and SMUL 2013) which corresponds to a capacity of 1,800 MWp, assuming a full capacity per hour of 1,000 h/a (Kost et al. 2013). In 2014, photovoltaic systems with a total capacity of 1,574 MWp were already connected to the grid (AEE 2015). In the case of photovoltaic potential, the Alternative Road Map 2030 also uses the data from Daniels et al. (2008), since the goals under the SMWA and SMUL (2013) relate only to 2022.

The study commissioned by The Greens from 2008 (Daniels et al. 2008) shows a potential of around 2500 GWh/year (not including sludge from water treatment plants) for biogas and 2,700 GWh/year from solid biomass (without straw from grain crops). Thus there is a total of possible power generation from solid and gas-producing **biomass** of just under 5,180 GWh/year or an installed capacity of 660 MW.[5] Against the background of existing usage competition and the limitations of the availability of existing agricultural areas for the production of biomass, the Saxony government believes that by 2022 an increase in power generation from biomass to 1,800 GWh/year is realistic (SMWA and SMUL 2013). At the end of 2013, there were biogas facilities in Saxony with a total capacity of 92.2 MW and biomass (thermal) power plants with a cumulative capacity of 95 MW in operation on the grid (AEE 2015). In its energy and climate program, the Saxony government has already noted the limitation on areas for biomass crops and existing usage competition. For that reason, the Alternative Road Map gives no consideration to biomass potential, in other words, it assumes no further expansion of biomass in the state.

[5] biogas systems: assumption of 7,500 h/a, biomass(thermal) power plants: assumption of 8,000 h/a

As of 2014 there were hydropower plants in Saxony with a total capacity of just under 130 MW (DGS 2015). In the view of the Saxony government, the potential for hydroelectric power is already exhausted for hydro-ecological reasons (SMWA and SMUL 2013).

With a view to the future usage of **deep geothermal** for power generation, Daniels et al. (2008) explains that all of Saxony sits on a geothermally usable cushion of heat whose depth and content however cannot be quantified. In a similar vein, the Saxony government has stated that it is currently not foreseeable when and to what extent power from deep geothermal sources can be generated in Saxony (SMWA and SMUL 2013).

Table 11: Renewable energy potential for power generation in Saxony

Renewable energy technology	Technical potential for renewable energies	Exploitable potential for renewable energies by 2030	Utilized renewables potential (as of 2013/2014)	Unused renewable energy potential	Unused renewables potential vs. exploitable potential by 2030
	[MW]	[MW]	[MW]	[MW]	[MW]
Wind energy on land	24,000.0	4,900.0	1,066.0	22,934.0	3,834.0
Wind energy (new facilities)	n.s.	5,360.0	1,574.0	n.s.	3,786.0
Wind energy (repowering)	n.s.	1,680.0	798.4	n.s.	881.6
Photovoltaics	n.s.	3,680.0	775.6	n.s.	2,904.4
Photovoltaics (on roofs)	n.s.	667.7	187.2	n.s.	480.5
Photovoltaics (open arrays)	n.s.	328.8	92.2	n.s.	236.6
Biomass (biogas)	n.s.	338.9	95.0	n.s.	243.9
Hydropower	n.s.	127.5	127.5	0.0	0.0
Deep geothermal	n.s.	0.0	0.0	n.s.	0.0

Sources: See source references in the text.
n.s. = not specified

3.4 Conclusions under the Alternative Road Map 2030

The Alternative Road Map 2030 for the expansion of renewable energies and competency expansion for energy services was prepared against the background of the green energy potential in

the states of Saxony and Brandenburg, discussed above, that are affected by a phaseout from brown coal. It provides a possible variant for the further expansion of renewable energies and the investments needed to compensate through employment in the renewable energy sector for the jobs lost from the brown coal industry.

According to the discussion in Chapter 2.4, it is assumed that if surface mining and power plants in the Lausitz region continue operations, about 4,100 employees (or 3,900 full-time employees) would have work in the brown coal industry in 2030. Of these, about 60% can be allocated to the power plants and mining areas in the state of Brandenburg and about 40% to those in the state of Saxony. Given these numbers, employment alternatives in renewable energies must be created. If the national climate contribution is implemented beginning in 2017, as proposed by the German Ministry for Economic Affairs and Energy (BMWi), and if open pit mining and power plants continue operations by new owners, then, compared with the "German Government 2011" scenario based on the "Significance of brown coal in eastern Germany" study (Prognos 2011), a further reduction in power generation from brown coal and thus a further reduction in jobs might occur. In that case, the expansion of renewable energies and the investment needed for that would be much lower than that indicated in the following subsection.

As Table 10 and Table 11 show, particularly in the case of wind and photovoltaics, there is still potential for further expansion up to the year 2030. Table 12 and Table 13 show the expansion of renewable energies in Brandenburg and Saxony needed to compensate for lost jobs in the brown coal industry through 2030, and the percentage of green energy potential discussed above that can be exploited for that purpose.

Table 12: Renewable energy expansion in Brandenburg under the Alternative Road Map 2030

Renewable energy technology	Unused potential vs. renewables expansion in the EE-0BK scenario	Exploitation needed to compensate for lost lignite jobs	Expansion needed from 2015 to 2030 to compensate for lost lignite jobs
	[MW]	[%]	[MW]
Wind energy on land	9,622.4		7,216.5
Wind energy (new facilities)	4,351.3	75%	3,263.5
Wind energy (repowering)	5,270.7	75%	3,953.0
Photovoltaics	3,191.5		1,290.8
Photovoltaics (on roofs)	1,527.4	14%	209.1
Photovoltaics (open arrays)	1,664.2	65%	1,081.7
Biomass (biogas)	167.0	0%	0.0
Hydropower	8.9	0%	0.0

Deep geothermal	85.0	5%	4.3

Sources: Own computations

Table 13: Renewable energy expansion in Saxony under the Alternative Road Map 2030

Renewable energy technology	Unused renewables potential vs. exploitable potential by 2030	Exploitation needed to compensate for lost lignite jobs	Expansion needed from 2015 to 2030 to compensate for lost lignite jobs
	[MW]	[%]	[MW]
Wind energy on land	3,834.0	80%	3,067.2
Photovoltaics	3,786.0		2,442.8
Photovoltaics (on roofs)	881.6	30%	264.5
Photovoltaics (open arrays)	2,904.4	75%	2,178.3
Biomass (biogas)	480.5	0%	0.0
Hydropower	0.0	0%	0.0
Deep geothermal	0.0	0%	0.0

Sources: Own computations

Table 14 shows what employment effects (full-time equivalents) will be generated by the expansion of renewable energies under the Alternative Road Map in 2030, and the associated investment required for the assumed renewable energy expansion under the Alternative Road Map 2030. The computations for the Alternative Road Map 2030 show that assuming the exhaustion of potential in Brandenburg and Saxony, and assuming regional residence of companies along the green energy value creation chain (see subsection 2.4.1), the renewable energy sector can compensate for 3,900 full-time employees whose jobs would be lost through the phaseout from brown coal by 2030. As the technology-specific expansion figures would lead one to expect, most of the positive employment effects in 2030 would fall within the technology sectors of wind and photovoltaics.

As previously explained in subsection 3.3, despite regional potential for renewable energy expansion, it is not possible to compensate for the entire number of lost jobs through green energy expansion directly in the Lausitz region but these losses can be compensated within the affected states themselves on a broader level. In Brandenburg, about half of the wind turbines and all of the photovoltaic capacity was

installed as required to take advantage of the Lausitz-Spreewald region's potential for expansion of renewables as laid out in the Regional Energy Program (RPG Lausitz-Spreewald 2013).

The investment required for renewable energy expansion in the 2015 to 2030 timeframe is just under €16 billion with the largest amount, €12.7 billion, allocated to investment in wind turbines (new facilities and repowering). Another focus is investments in photovoltaic systems (€3.3 billion), of which the major share would go to the additional construction of photovoltaic arrays in open spaces.

Table 14: Investment in renewable energy technologies in the Alternative Road Map 2030 and the effect on jobs in 2030, by technology area

	Employment effects in 2030 from renewable energy expansion under the Alternative Road Map 2030		Required investment 2015-2030 under the Alternative Road Map 2030		
	Brandenburg	**Sachsen**	**Brandenburg**	**Sachsen**	**Total**
Green energy technology	[FTE]		[Mio. Euro]		
Wind energy on land	1,906	828	8,904.2	3,784.6	12,688.8
Photovoltaics	409	772	1,131.7	2,134.7	3,266.4
Biomass (Biogas)	0	0	0.0	0.0	0.0
Hydropower	0	0	0.0	0.0	0.0
Deep geothermal	2	0	11.2	0.0	11.2
Total	**2,318**	**1,600**	**10,047.17**	**5,919.2**	**15,966.4**

Source: Own computations.
FTE = Full Time Equivalent

The following tables (Tables 15, 16, and 17) show what value creation effects can be associated with the expansion of renewable energies assumed in the Alternative Road Map 2030. As discussed in subsection 3.2, three different scenarios are shown for the residence of operator companies and their shareholders to illustrate the regional economic significance of high local content from these actors.

Table 15: Direct value created and employment effects in 2030 from renewable energy expansion in the Alternative Road Map – lower local content

	After-tax earnings	Net employment income	Total community taxes	**Value created at community level**	Total state taxes	**Value created at state level**
	[Mio. Euro]					
Wind energy on land	122.7	77.7	64.3	264.7	27.0	291.7
Photovoltaic	33.4	31.8	6.1	71.4	7.3	78.6
Biomass (Biogas)	0.0	0.0	0.0	0.0	0.0	0.0
Water power	0.0	0.0	0.0	0.0	0.0	0.0
Deep geothermal	0.2	0.1	0.0	0.3	0.0	0.3
Total	**156.3**	**109.6**	**70.5**	**336.4**	**34.3**	**370.6**

Source: own computations that assume 20% regional residence for operating companies and shareholders and straight-line/steady added construction from 2015-2030.

Table 16: Direct value created and employment effects in 2030 from renewable energy expansion under the Alternative Road Map – medium local content

	After-tax earnings	Net employment income	Total community taxes	**Value created at commu-nity level**	Total state taxes	**Value created at state level**
	[Mio. Euro]					
Wind energy on land	212.6	77.7	87.2	377.5	34.5	412.0
Photovoltaic	59.5	31.8	11.3	102.6	10.5	113.1
Biomass (Biogas)	0.0	0.0	0.0	0.0	0.0	0.0
Water power	0.0	0.0	0.0	0.0	0.0	0.0
Deep geothermal	0.3	0.1	0.0	0.5	0.0	0.5
Total	**272.4**	**109.6**	**98.6**	**480.6**	**45.1**	**525.7**

Source: own computations that assume 50% regional residence for operating companies and shareholders and straight-line/steady added construction from 2015-2030.

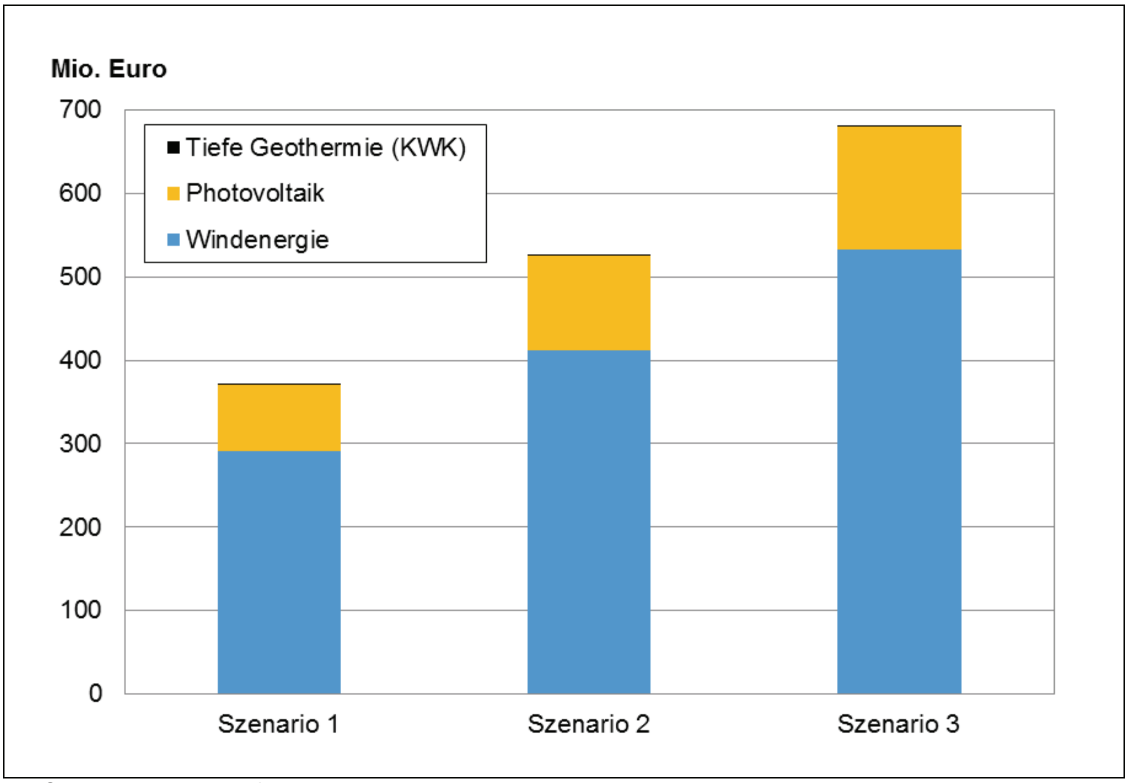
Table 17: Direct value created and employment effects in 2030 from renewable energy expansion under the Alternative Road Map – higher local content

	After-tax earnings	Net employment income	Total community taxes	**Value created at community level**	Total state taxes	**Value created at state level**
	[Mio. Euro]					
Wind energy on land	302.5	77.7	110.1	490.3	42.0	532.3
Photovoltaic	85.6	31.8	16.5	133.9	13.7	147.6
Biomass (Biogas)	0.0	0.0	0.0	0.0	0.0	0.0
Water power	0.0	0.0	0.0	0.0	0.0	0.0
Deep geothermal	0.5	0.1	0.1	0.7	0.1	0.7
Total	**388.6**	**109.6**	**126.7**	**624.8**	**55.8**	**680.7**

Source: own computations that assume 80% regional residence for operating companies and shareholders and straight-line/steady added construction from 2015-2030.

In Scenario 1 (low local content), a direct value creation of €360 million in the states of Saxony and Brandenburg can be achieved with the expansion of renewables assumed under the Alternative Road Map 2030. Of that, 42% would come from company profits after taxes, 30% from net employment income, and 28% from the taxes that would flow into the budgets of communities and states. Assuming an 80% regional residency of operator companies in Scenario 3, the value creation effects at the state level add up to about €681 million and thus are about 90% above the effects in Scenario 1. Company after-tax income in this case would comprise 57% of value creation at the state level, net after-tax income 16% and taxes to the communities and states 27%. The results for Scenario 2 (medium local content) are as would be expected between Scenarios 1 and 3. A comparison of the results for the scenarios makes it clear what significance the residency of the operators and their shareholders has for retaining the value creation created in the region. The involvement of local actors - above all the local citizenry - is thus of essential importance not only with regard to the acceptance of renewable energies but also from the regional economic point of view.

Figure 10: Direct value creation effects at the state level in 2030 from renewable energy expansion under the Alternative Road Map 2030, by technology area and local content scenarios



Sources: own computations
Translation: Tiefe Geothermie (KWK) = **geothermal energy (CHP)**

Considerable investment is needed by 2030 for expanding renewable energies in the Alternative Road Map that must come from Vattenfall and other actors in the region. If as far as possible, components and/or renewable energy facilities are purchased from manufacturers in Brandenburg and Saxony, or the planning and installation work is done by companies that are resident there, this will simultaneously benefit the regional economy. In addition, it is worth considering that even if new owners continue to operate the power plants and develop surface mines as planned, this and the maintenance of lignite power plants will also necessitate investment.

The development and expansion of renewable energies can bring about a shift in priorities, allowing the Lausitz region to find new perspectives. The entire region could thus succeed in maintaining a strong economy, and retain its attraction as a livable community. A study by the Dresden branch of the Ifo Institute of Economic Research believes that action is urgently required to bring about this indispensable structural change. The study concludes that “the longer the necessary changes are delayed, the less opportunity there will be.” (Ragnitz et al. 2013).

4 Conclusions

The aim of this short study was to demonstrate what a climate-friendly and socially responsible road map for transition for Vattenfall's phaseout of lignite in Germany by 2030 could look like. To this end, the report first outlined a road map for the phaseout of lignite and compared its (regional) economic advantages and disadvantages. Then, to ensure a socially responsible phaseout, and in particular to provide for the loss of jobs, an alternative road map was drafted that showed how this loss of jobs could be compensated by the expansion of renewable energies, at least in terms of numbers.

The road map for transition until 2020 was determined largely by Vattenfall's own climate targets. High reductions in emissions of CO_2 are necessary if these targets are to be met. They could in fact be met by reducing the installed capacity of the power plants in accordance with the national '**Klimabeitrag**' [national climate contribution scheme] proposed by Germany's Ministry for Economic Affairs and Energy and by decommissioning two power plant units. Secondly, the road map calls for a constant and steady reduction in lignite-fired electricity until the complete phaseout of lignite power generation is completed in 2030. We can however assume that the newer power plants Boxberg IV and Lippendorf are meant to continue operating as long as possible so that a particularly sharp decline in emissions can be expected in the last two years. Without CCTS and/or CCU technologies, the use of which currently seems unlikely, Brandenburg's low-carbon targets for 2030 could probably only be met by phasing out the use of lignite to generate electricity. At the same time, the road map for transition plays an important role in meeting the German government's climate protection goals. Coal reserves that were approved and earmarked for exploitation by the beginning of 2013, do not at any time have a limiting influence on this road map.

Economic aspects were taken into consideration, and job losses expected in the region as a result of the phaseout were examined, as well as the follow-up costs of lignite mining and power generation. The reduction of selected follow-up costs should a phaseout be carried out were also calculated. If a phaseout takes place, we can expect the loss of all jobs in Vattenfall's mines and in the lignite-fired power plants by 2030. But Prognos (2011; 2012) calculates that if the operation of power plants and lignite mines continues, direct employment in the lignite industry will decline by 50% by 2030. Due to the demographics of employees, we assume that a higher number of employees would be retired by 2030, so that the loss of jobs would be managed in a socially responsible way.

Should a phaseout take place, about 4,100 jobs would be lost. The computed ecological follow-up costs are incurred by lignite mining and power generation. Even if measures are in place to internalized these costs (for example, follow-up costs are at least partially covered by provisions made by the companies responsible), a large part of the follow-up costs are externalized and must be paid for by society. The phaseout could significantly reduce external costs. In the event of such a phaseout, alone the environmental cost of emissions released when lignite is used to generate electricity, would be EUR 82.7 billion less than if lignite operations were to continue – that is, if a shift to renewable energies is carried out as recommended by the Alternative Road Map 2030.

There are different ways of responding to job losses resulting from the phaseout of lignite operations. In the present study, we examined to what extent the regional use of renewable energy sources to generate electricity could replace those jobs. Findings show that there is sufficient potential for a further expansion of renewable energies to compensate for job losses in the German states concerned. In fact, regional studies show that there is considerable potential for the

expansion of renewable energies in the Lausitz region in particular. Even though other opportunities for investment in sustainable energy industries and the creation of jobs in areas such as renewable heat, the expansion of heat networks, energy efficiency, energy services and new technologies such as power to heat, power to gas, and power to X were not taken into account in this study.

Vattenfall's close collaboration with the various groups and initiatives committed to change in the energy industry and a phaseout of lignite in the Lausitz region is desirable so that in future, they can work together to bring about an energy transition in the region. The citizen's groups *Bürger für die Lausitz - Klinger Runde* and the *Lausitzer Allianz* – the latter represents the interests of the Sorbs – explicitly advocate structural change in the Lausitz region. Local initiatives that actively promote the expansion of renewables as an alternative to lignite, and work to bring about change in the country's energy policies are, for example, *Pro Guben e.V.*, *KRABAT - Energiepark Proschim* as well as *Bündnis Heimat* and *Zukunft* in Brandenburg. Communities and counties in the Lausitz-Spreewald planning region have united and created the Lausitz Energy Region. They too are committed to the expansion of renewable energies and sustainable development in the region – without however questioning the use of lignite power generation.

The study "*Industrial and Economic Lausitz Region: Current Situation and Perspectives*" compiled by the Ifo Institute for Economic Research in Dresden in 2013 concludes that concerted efforts are necessary to secure the economic future of the Lausitz region (Ragnitz et al. 2013). Although individual players are already active in this area, there is no specific plan to date for an ecological and socially responsible industrial transition for the Lausitz region, which also envisions an end of the lignite industry. The present report succeeds in developing a framework for the development of such a transition plan. It shows that jobs that are still expected to exist in the lignite industry in 2030 can also be secured through the widespread expansion of renewable energies (without taking other future technologies into account). Investments made by Vattenfall and other regional players could contribute to a climate-friendly and socially responsible shift in the energy industry of the Lausitz region. That would make the company a pioneer of the energy revolution and would contribute to a socially responsible and ecologically acceptable alternative for the region and the people who currently work there. The Lausitz region has potential, but the longer it holds on to structures dependent on the old lignite industry, the lower its chances of bringing about change will be.

5 Literature

AEE [Agentur für Erneuerbare Energien] (2015): Bundesländer mit neuer Energie. In: *Föderal erneuerbar*. http://www.foederal-erneuerbar.de/startseite (Zugegriffen 20. März 2015).

Aretz, Astrid, Katharina Heinbach, Bernd Hirschl und André Schröder [Institut für ökologische Wirtschaftsforschung] (2013): *Wertschöpfungs- und Beschäftigungseffekte durch den Ausbau Erneuerbarer Energien*. Hamburg. http://www.greenpeace.de/fileadmin/gpd/user_upload/themen/energie/20130902-Greenpeace-Studie-Wertschoepfung.pdf.

BMU [Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit] (2011): Erfahrungsbericht 2011 zum Erneuerbare-Energien-Gesetz. http://www.erneuerbare-energien.de/files/pdfs/allgemein/application/pdf/eeg_erfahrungsbericht_2011_entwurf.pdf (Zugegriffen 8. Juli 2011).

BMU und BMWi (2010): *Energiekonzept für eine umweltschonende, zuverlässige und bezahlbare Energieversorgung*. Berlin: Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (BMU); Bundesministerium für Wirtschaft und Technologie (BMWi). http://www.bundesregierung.de/ContentArchiv/DE/Archiv17/_Anlagen/2012/02/energiekonzept-final.pdf?__blob=publicationFile&v=5.

BMWi [00000] (2014): Energiedaten (Stand: August 2014). http://www.bmwi.de/BMWi/Redaktion/Binaer/energie-daten-gesamt,property=blob,bereich=bmwi,sprache=de,rwb=true.xls (Zugegriffen 19. August 2014).

BNetzA [Bundesnetzagentur] (2014): *Kraftwerksliste Bundesnetzagentur (bundesweit; alle Netz- und Umspannebenen)*. 29. Oktober.

Bofinger, Stefan, Doron Callies, Michael Scheibe, Yves-Marie Saint-Drenan und Kurt Rohrig (2012): *Potenzial der Windenergienutzung an Land*. Kurzfassung. Berlin.

Bost, Mark, Timo Böther, Bernd Hirschl, Sebastian Kreuz, Anna Neumann und Julika Weiß (2012a): *Erneuerbare Energien Potenziale in Brandenburg 2030*. Berlin: Institut für ökologische Wirtschaftsforschung (IÖW). http://www.ioew.de/publikation_single/Erneuerbare_Energien_Potenziale_in_Brandenburg_2030/.

Bost, Mark, Timo Böther, Bernd Hirschl, Sebastian Kreuz, Anna Neumann und Julika Weiß [00002] (2012b): *Erneuerbare Energien Potenziale in Brandenburg 2030*. Berlin: Institut für ökologische Wirtschaftsforschung (IÖW). http://www.ioew.de/publikation_single/Erneuerbare_Energien_Potenziale_in_Brandenburg_2030/.

Boulouchos, Konstantinos (2014): Verzerrter Strommarkt: Sind die Erneuerbaren daran schuld? Zukunftsblog Energie. In: *ETH Zürich*. 8. Juli. https://www.ethz.ch/de/news-und-veranstaltungen/eth-news/news/2014/07/verzerrter-strommarkt-sind-die-erneuerbaren-dara-schuld.html.

Brauner, Günther (2013): Flexibilisierung der thermischen Kraftwerke für die Energiewende. Netzregelung uns Betriebsführung, 11. Juni, München. http://publik.tuwien.ac.at/files/PubDat_225342.pdf.

Bundesagentur für Arbeit (2012): Arbeitsmarkt in Zahlen - Beschäftigungsstatistik: Sozialversicherungspflichtig Beschäftigte nach Wirtschaftszweigen (WZ 2008) Deutschland.

Bundesbank (2012): Hochgerechnete Angaben aus Jahresabschlüssen deutscher Unternehmen von 2006 bis 2011.

Daniels, Wolfgang, Hans-Peter Grafe, Antje Koppen, Eckhard Kreibich, Uwe Mixdorf, Hans-Jürgen Schlegel, Peter Volkmer, Volkmar Weise, Dieter Winkler und Gerd Wolf (2008): *Ermittlung der technischen Potenziale der erneuerbaren Energieträger in Sachsen sowie deren wirtschaftliche Umsetzungsmöglichkeiten für die Stromerzeugung bis zum Jahr 2020*. Dresden: Vereinigung zur Förderung der Nutzung Erneuerbarer Energien VEE Sachsen.

DGS [Deutsche Gesellschaft für Sonnenenergie] (2015): EnergyMap - Bundesland Sachsen. In: *EnergyMap.info*. http://www.energymap.info/energieregionen/DE/105/121.html (Zugegriffen 15. April 2015).

EC [European Commission] (2014a): List of Stationary Installations in the Union Registry. In: *Emissions Trading System (EU ETS)*. 27. Februar. http://ec.europa.eu/clima/policies/ets/registry/documentation_en.htm.

EC [European Commission] (2014b): Verified Emissions for 2013. In: *Emissions Trading System (EU ETS)*. 1. April. http://ec.europa.eu/clima/policies/ets/registry/documentation_en.htm.

EnergieAgentur NRW (2013): Flexibilität von Kraftwerken. Für Netzstabilität und Versorgungssicherheit. April. https://broschueren.nordrheinwestfalendirekt.de/herunterladen/der/datei/bro-kwt-flexibilitaet-final2-pdf/von/flexibilitaet-von-kraftwerken-fuer-netzstabilitaet-und-versorgungssicherhei/vom/energieagentur/1405.

Erdmann, Georg (2013): Kurzgutachten zur energiewirtschaftlichen Planrechtfertigung im Entwurf des Braunkohlenplans „Tagebau Welzow-Süd räumlicher Teilabschnitt II".

Fachverband Biogas (2014): Branchenzahlenprognose für die Jahre 2014 und 2015.

Gerbaulet, Clemens, Jonas Egerer, Pao-Yu Oei und Christian von Hirschhausen (2012a): *Abnehmende Bedeutung der Braunkohleverstromung: Weder neue Kraftwerke noch Tagebaue benötigt*. DIW Wochenbericht. Berlin: DIW, 28. November. http://www.diw.de/documents/publikationen/73/diw_01.c.412252.de/12-48-4.pdf.

Gerbaulet, Clemens, Jonas Egerer, Pao-Yu Oei, Judith Paeper und Christian von Hirschhausen (2012b): *Die Zukunft der Braunkohle in Deutschland im Rahmen der Energiewende*. Politikberatung kompakt. Berlin: DIW.

Grüne Liga (2015): *Arbeitsplatzeffekte der Lausitzer Braunkohlewirtschaft*. Hintergrundpapier. http://www.lausitzer-braunkohle.de/Texte/hintergrund_arbeitsplaetze.pdf (Zugegriffen 12. April 2015).

Hilmes, Uwe und Nicolai Herrmann (2014): *Der „ideale Kraftwerkspark" der Zukunft; Flexibel, klimafreundlich, kosteneffizient – Maßstab für einen optimierten Entwicklungspfad der Energieversorgung bis 2040; Energiewirtschaftliche Untersuchung*. Berlin: enervis energy advisors GmbH.

Von Hirschhausen, Christian, Johannes Herold und Oei, Pao-Yu (2012): CCTS-Technologie ein Fehlschlag: Umdenken in der Energiewende notwendig. In: *DIW-Wochenbericht* 6/2012: 3–9.

Hirschhausen, Christian von und Pao-Yu Oei (2013a): *Gutachten zur energiepolitischen Notwendigkeit der Inanspruchnahme der im Teilfeld II des Tagebau Welzow-Süd lagernden Kohlevorräte unter besonderer Berücksichtigung der Zielfunktionen der Energiestrategie 2030 des Landes Brandenburg*. Politikberatung kompakt. Berlin: DIW.

Hirschhausen, Christian von und Pao-Yu Oei (2013b): *Gutachten zur energiewirtschaftlichen Notwendigkeit der Fortschreibung des Braunkohlenplans „Tagebau Nochten"*. Gutachten. Berlin: DIW.

Hirschl, Bernd, Astrid Aretz, Andreas Prahl, Timo Böther, Katharina Heinbach, Daniel Pick und Simon Funcke [00040] (2010): *Kommunale Wertschöpfung durch erneuerbare Energien*. Schriftenreihe des Instituts für ökologische Wirtschaftsforschung (Hrsg.). Nr. 196/10. Berlin. http://www.ioew.de/uploads/tx_ukioewdb/IOEW_SR_196_Kommunale_Wertsch%C3%B6pfung_durch_Erneuerbare_Energien.pdf.

IER (2012): *Energiewirtschaftliche Bedeutung der Braunkohlenutzung in Deutschland*. Stuttgart: Institut für Energiewirtschaft und Rationelle Energieanwendung der Universität Stuttgart.

Kost, Christoph, Johannes N. Mayer, Jessica Thomsen, Niklas Hartmann, Charlotte Senkpiel, Simon Philipps, Sebastian Nold, Simon Lude und Thomas Schlegl (2013): *Stromgestehungskosten Erneuerbare Energien*. Studie. Freiburg: Fraunhofer Institut für solare Energiesysteme. http://www.ise.fraunhofer.de/de/veroeffentlichungen/veroeffentlichungen-pdf-dateien/studien-und-konzeptpapiere/studie-stromgestehungskosten-erneuerbare-energien.pdf (Zugegriffen 3. April 2014).

Kunz, Friedrich, Gerbaulet, Clemens und Christian von Hirschhausen (2013): Mittelfristige Strombedarfsdeckung durch Kraftwerke und Netze nicht gefährdet. In: *DIW Wochenbericht* (18. September).

Land Berlin und Vattenfall (2009): Klimaschutzvereinbarung zwischen dem Land Berlin und Vattenfall. 8. Oktober. http://www.stadtentwicklung.berlin.de/umwelt/klimaschutz/aktiv/vereinbarung/download/vattenfall-ks_senguv.pdf.

LUGV [Brandenburgisches Landesamt für Umwelt, Gesundheit und Verbraucherschutz] (2014): *Klimagasinventur 2013 für das Land Brandenburg*. Oktober. http://www.lugv.brandenburg.de/media_fast/4055/klimagas_2013.pdf.

MWE [Ministerium für Wirtschaft und Europaangelegenheiten des Landes Brandenburg] (2012): Energiestrategie 2030 des Landes Brandenburg. 21. Februar. http://www.energie.brandenburg.de/media/bb1.a.2865.de/Energiestrategie_2030.pdf.

Nitsch, Joachim, Thomas Pregger, Tobias Naegler, Dominik Heide, Diego Luca de Tena, Franz Trieb, Yvonne Scholz, et al. (2012a): *Langfristszenarien und Strategien für den Ausbau der erneuerbaren Energien in Deutschland bei Berücksichtigung der Entwicklung in Europa und global*. Schlussbericht. Stuttgart, Kassel, Teltow.

Nitsch, Joachim, Thomas Pregger, Tobias Naegler, Dominik Heide, Diego Luca de Tena, Franz Trieb, Yvonne Scholz, et al. (2012b): *Langfristszenarien und Strategien für den Ausbau der erneuerbaren Energien in Deutschland bei Berücksichtigung der Entwicklung in Europa und global*. Datenanhang II zum Schlussbericht. Stuttgart, Kassel, Teltow.

Oei, Pao-Yu, Claudia Kemfert, Felix Reitz und Christian von Hirschhausen (2014): *Braunkohleausstieg – Gestaltungsoptionen im Rahmen der Energiewende*. Politikberatung kompakt. Berlin: DIW. http://www.diw.de/documents/publikationen/73/diw_01.c.471589.de/diwkompakt_2014-084.pdf.

Prognos (2005): *Energie- und regionalwirtschaftliche Bedeutung der Braunkohle in Ostdeutschland*. Endbericht. Berlin.

Prognos (2011): Bedeutung der Braunkohle in Ostdeutschland. http://www.prognos.com/fileadmin/pdf/publikationsdatenbank/Prognos_Studie_Braunkohle_Ostdeutschland_2011_Langfassung.pdf.

Prognos (2012): *Untersuchung der energiestrategischen und regionalwirtschaftlichen Auswirkungen der im Rahmen der systematischen Weiterentwicklung der Energiestrategie des Landes Brandenburg untersuchten Szenarien in zwei Leistungspaketen*. Berlin.

Pyc, Ireneusz (2013): VDE-Studie: Erneuerbare Energie braucht flexible Kraftwerke – Szenarien bis 2020 22. November. https://www.vde.com/de/regionalorganisation/bezirksvereine/suedbayern/facharbeit%20regional/akenergietechnik/documents/vortrag%2021-11-2013%20flexible%20kraftwerke.pdf.

RPG Lausitz-Spreewald [Regionale Planungsgemeinschaft Lausitz-Spreewald] (2013): *Regionales Energiekonzept Lausitz-Spreewald*. Kurzfassung. Cottbus.

Schuster, René (2007): *Zur Zukunft der Lausitzer Braunkohle: Kohlebedarf des konventionellen Kraftwerkparks sowie Folgen für den Klimaschutz und die Inanspruchnahme von Siedlungen*. Cottbus: Fraktion die Linke.

SMUL [Sächsisches Staatsministerium für Umwelt und Landwirtschaft] (2009): Hintergrundpapier zu den Zielen der künftigen Klimaschutz und Energiepolitik des Freistaates Sachsen.

SMWA und SMUL [Sächsisches Staatsministerium für Wirtschaft, Arbeit und Verkehr, Sächsisches Staatsministeriumfür Umwelt und Landwirtschaft] (2013): *Energie- und Klimaprogramm Sachsen 2012*. Dresden.

Statistik der Kohlenwirtschaft (2014): Altersgliederung der Belegschaft. Stand 4/14. http://www.kohlenstatistik.de/19-0-Braunkohle.html (Zugegriffen 17. April 2015).

Statistik der Kohlenwirtschaft (2015): Beschäftigte im Braunkohlenbergbau. Stand: 03/15. http://www.kohlenstatistik.de/19-0-Braunkohle.html (Zugegriffen 17. April 2015).

Statistisches Bundesamt (2012a): Statistisches Jahrbuch - Deutschland und Internationales.

Statistisches Bundesamt (2012b): Verdienste und Arbeitskosten - Arbeitnehmerverdienste 2011.

Statistisches Bundesamt (2012c): Finanzen und Steuern - Umsatzsteuerstatistik (Voranmeldungen) 2010.

Stroedter, Jörg (2015): *Zwischenbericht der Enquete-Kommission „Neue Energie für Berlin – Zukunft der energiewirtschaftlichen Strukturen“*. Abgeordnetenhaus von Berlin, 9. Februar. http://www.parlament-berlin.de/ados/17/IIIPlen/vorgang/d17-2100.pdf.

UBA [Umweltbundesamt] (2012a): *Ökonomische Bewertung von Umweltschäden: Methodenkonvention 2.0 zur Schätzung von Umweltkosten (inklusive Anhang A und B)*. Dessau-Roßlau.

UBA [Umweltbundesamt] (2012b): *Schätzung der Umweltkosten in den Bereichen Energie und Verkehr. Empfehlungen des Umweltbundesamtes*. Dessau-Roßlau.

UBA [Umweltbundesamt] (2014): *Kraftwerke in Deutschland (ab 100 Megawatt elektrischer Leistung)*. August.

Vattenfall (2009): *24/7/365*. Vattenfall Europe AG. http://corporate.vattenfall.de/globalassets/deutschland/finanzberichte/vattenfall_europe_24_7_365.pdf.

Vattenfall (2013): *Eine neue Energielandschaft. Geschäftsbericht 2012 inklusive Nachhaltigkeitsbericht*.

Vattenfall (2014): *Fortgesetzte Positionierung für den Energiemarkt von morgen. Geschäfts- und Nachhaltigkeitsbericht 2013*.

Vattenfall Europe Mining Aktiengesellschaft (2009): Jahresabschluss zum Geschäftsjahr vom 01.01.2008 bis zum 31.12.2008.

Vattenfall Europe Mining Aktiengesellschaft (2014): Jahresabschluss zum Geschäftsjahr vom 01.01.2013 bis zum 31.12.2013. Bericht über das Geschäftsjahr 2013 vom 1. Januar bis 31. Dezember 2013.

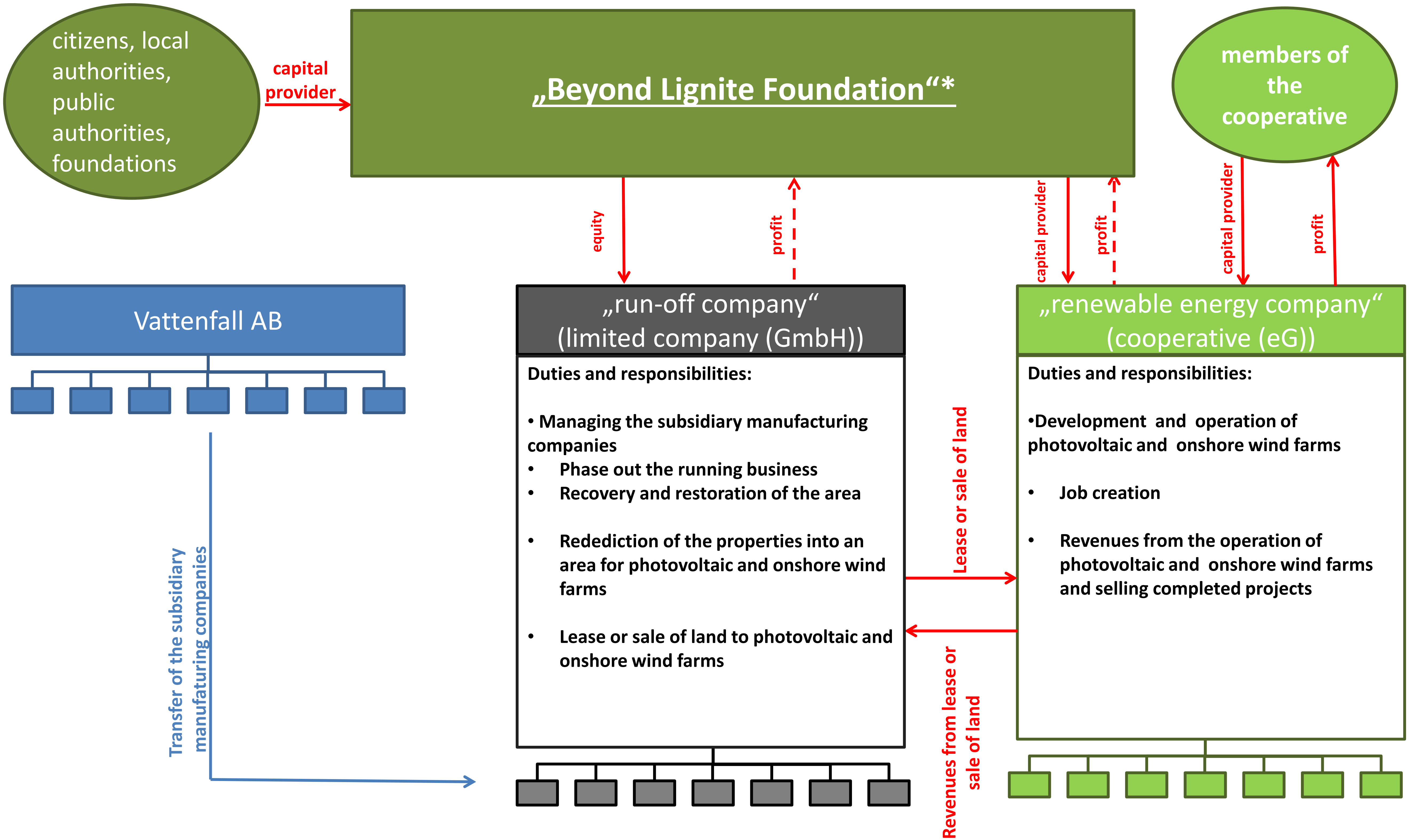
VDE (2012): *Erneuerbare Energie braucht flexible Kraftwerke – Szenarien bis 2020*. ETG - Energietechnische Gesellschaft im VDE.

Wagner, Hermann-Josef, Marco K. Koch und Jörg Burkhardt (2007): CO2-Emissionen der Stromerzeugung. Ein ganzheitlicher Vergleich verschiedener Techniken. In: *BWK* 59, Nr. 10: 44–52.

Wronski, Rupert und Swantje Küchler (2014): *Kostenrisiken für die Gesellschaft durch den deutschen Braunkohletagebau*. Berlin.

Ziehm, Cornelia (2014): *Neue Braunkohlentagebaue und Verfassungsrecht – Konsequenzen aus dem Garzweiler-Urteil des Bundesverfassungsgerichts*. Deutsche Umwelthilfe (DUH).

Appendix 6: Beyond Lignite Foundation



*Purpose of the foundation:

Keep the lignite resources in the mining field in the ground

Terminate the operations the mining areas as well as the coal-fired electricity plants as soon as practically feasible