Lignite of the living dead

Below 2°C scenario and strategy analysis for EU coal power investors

Carbon Tracker Initiative

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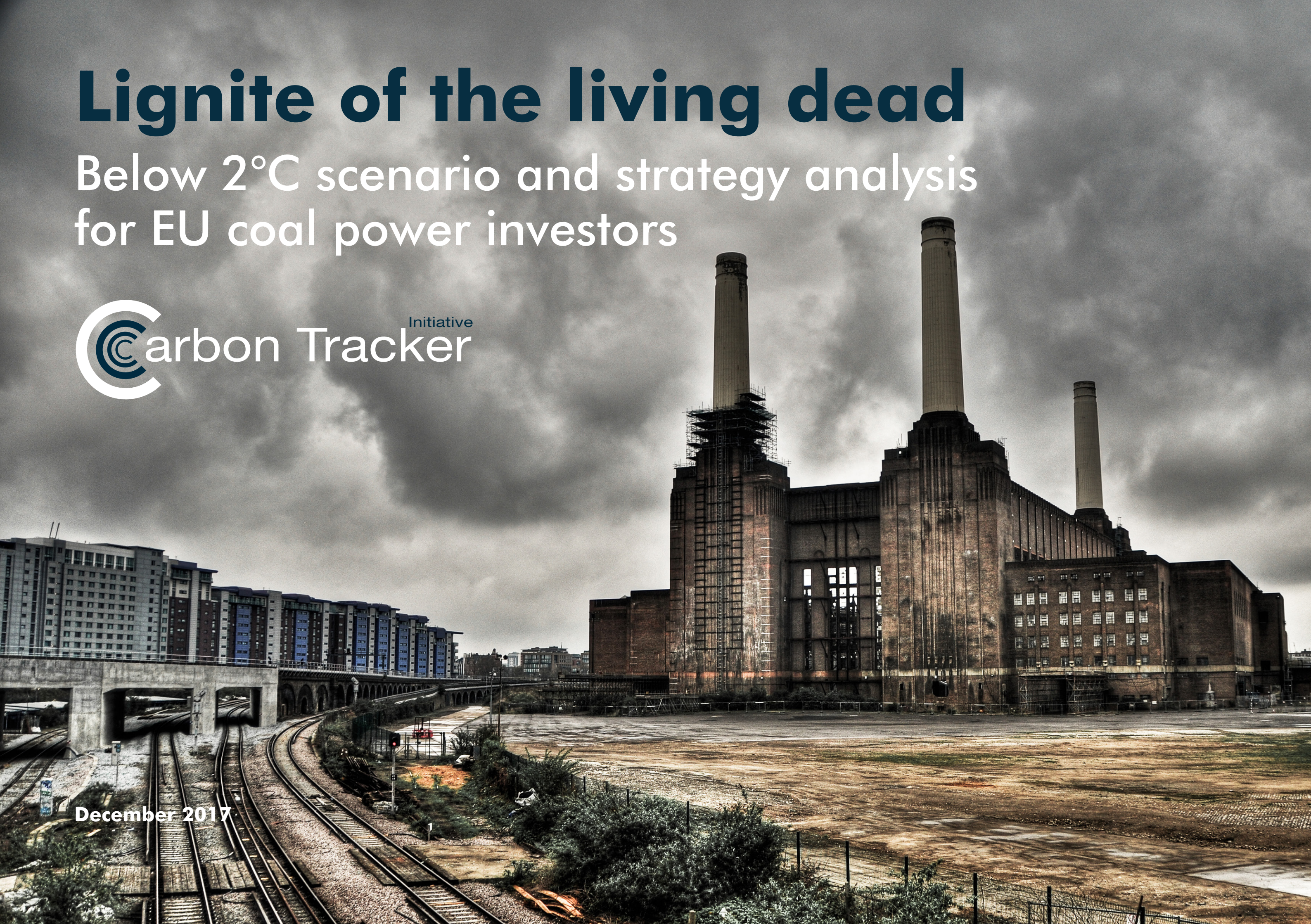

About Carbon Tracker

The Carbon Tracker Initiative is a team of financial specialists making climate risk real in today's financial markets. Our research to date on unburnable carbon and stranded assets has started a new debate on how to align the financial system in the transition to a low carbon economy.

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Table of Contents

Executive summary	6
Introduction	10
From nirvana to disaster	14
Mistakes made, lessons unlearned	16
Methodology and assumptions	23
Results	27
Recommendations for investors and utilities	35
Conclusion	37
References	38
Appendix 1 – modelling assumptions	41
Appendix 2 – sensitivity analysis and scenarios	44

Executive summary

In this report, we look at how a scenario for the EU28 that is compliant with limiting the rise in global warming to below 2°C might affect the valuation of coal-fired power plants. The IEA's Paris-compliant scenario (termed beyond 2°C scenario – B2DS) is used as the basis of below 2°C demand, under which coal power in the EU is phased-out by 2030. We have developed an asset-level model to determine a retirement schedule and understand the financial implications for investors. This analysis follows on from our recent report No Country for Coal Gen, which focused on US coal power.

From nirvana to disaster

European utilities were once a darling of investors. From 2000 to 2010, utilities outperformed the market (Stoxx 600) by over 60% as investors gravitated towards the power sector for stability and income. The following decade was one of startling decline: from 2010 to 2016, the Stoxx 600 increased 40% while utilities lost around 20% of their value, as overinvestment coupled with a failure to understand policy, technology and business model changes impacted performance. As investors fled and rating agencies issued downgrades, utilities responded by acknowledging mistakes and restructuring their businesses.

Mistakes made, lessons unlearned

"I grant we have made mistakes. We were late entering into the renewables market – possibly too late." RWE's CEO, Peter Terium, 2014

Despite experiencing first-hand the financial consequences of ignoring the transition to a low carbon economy, several utilities appear to believe coal-fired generation will play an important role in the EU power mix for the foreseeable future. Based on company reports and including member state phase-out policies, only 27% of operating coal units in the EU are planning to close before 2030. We believe this view is based on a series of outdated and misguided assumptions about the economic viability of coal, the competitiveness of alternatives and security of supply concerns.

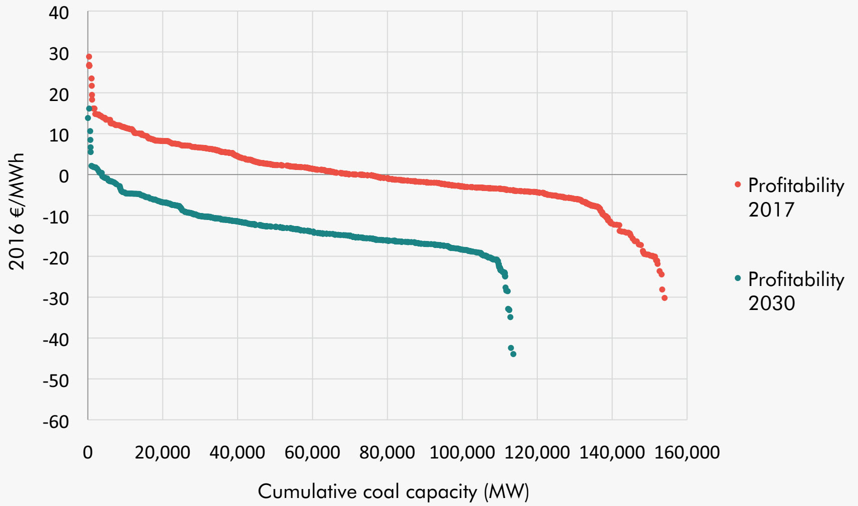
Lignite of the living dead

Confidence in coal-heavy utilities is returning as business restructurings, court rulings and power prices have revived balance sheets after years of huge impairments. For example, at the time of writing, RWE and Uniper have seen their share price increase by 64% and 79% respectively in 2017. However, we find that falling renewable energy costs, air pollution regulations and rising carbon prices will continue to undermine the economics of coal power in the EU, potentially making generation assets unusable by 2030.

Specifically, this report finds:

- 54% of coal is cashflow negative today increasing to 97% by 2030 – making units reliant on lobbying to secure capacity market payments (which the European Commission wants to prohibit by 2025) and avoid air pollution regulations.
- The operating cost of coal could be higher than the LCOE of onshore wind by 2024 and solar PV by 2027, while battery storage and demand response increasingly provide auxiliary services and peak shaving.
- Since the majority of coal units are loss-making by 2030, the EU could avoid €22bn in losses by phasing out coal power in line with the Paris Agreement.

54% of operating coal capacity is cashflow negative today increasing to 97% by 2030



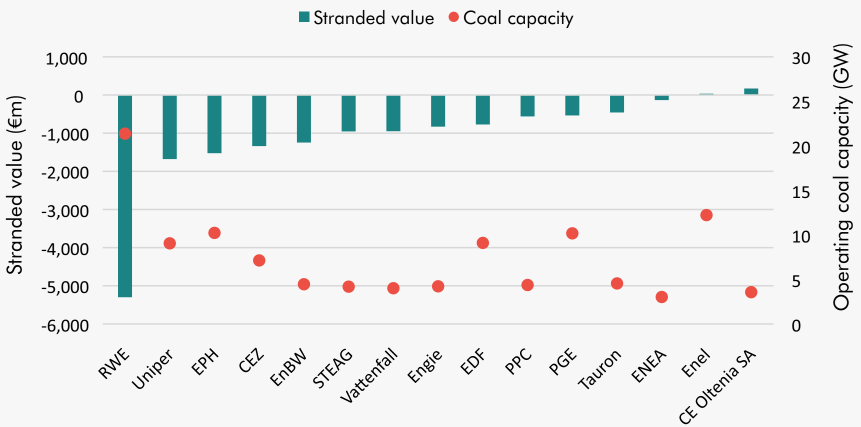
Below 2°C scenario analysis – the EU could avoid €22bn in losses by phasing out coal in line with the Paris Agreement

Our net present value (NPV) model seeks to replicate the real-world economic and investment decisions associated with a phase-out of coal-fired power in the EU. The model values every operating unit in the B2DS and a business as usual (BAU) scenario to understand stranded value. Stranded value is defined as the difference between the NPV of cashflow in the B2DS (which phases-out all coal power by 2030) and the NPV of cashflow in the BAU scenario (which is based on retirements announced in company reports). Both the B2DS and the BAU scenario acknowledge existing phase-out policies by member states. As most of the coal units are loss-making out to 2030, the total stranded value in the B2DS is negative – meaning the EU could avoid

€22bn in losses by phasing out coal power in line with the Paris Agreement. The utilities who have the most to gain from phasing-out coal by 2030 are RWE and Uniper who could avoid losing €5.3bn and €1.7bn, respectively. CE Oltenia SA and Enel are the only utilities surveyed in this report which stand to lose (€170 and €34m respectively) from retiring their coal units in a manner consistent with Paris.

The coal units operating in Germany could avoid losing €12bn by retiring early, while units in Poland could avoid losing €2.7bn. The UK has proportionally lower negative stranded value due to the fact it already has a phase-out policy. By phasing-out coal the UK is not only acting in the best interests of their citizens through improved air quality, but also the financial interests of utility shareholders through avoided value destruction. Italy and Slovenia have positive stranded value of €480m and €740m, respectively. To a much lesser degree, Portugal, Romania, Ireland and France also have positive stranded value and could lose a trivial amount if the EU complies with Paris.

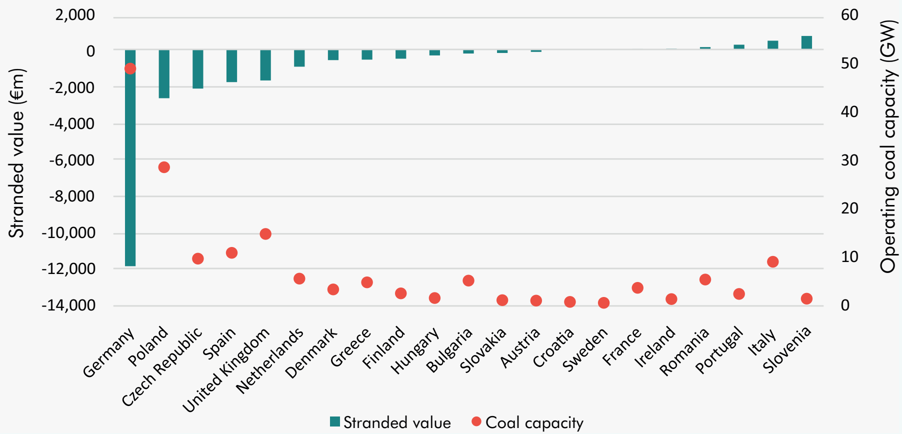
Below 2°C stranded value of the 15 largest EU utilities by coal capacity



Recommendations for investors and utilities

Utilities with exposure to coal power in the EU are at a strategic crossroads: continue to invest in coal and hope governments will allow rent-seeking in the form of capacity and retirement payments, or divest and prepare for a low carbon future. The recent announcement of more stringent air pollution limits and reforms to the EU emissions trading system highlight the risk in a pro-coal strategy. Moreover, low cost renewable energy, battery storage and demand response are energy sector mega trends which will change power systems in Europe and throughout the world. Those utilities that expect to run their coal units longer than evidence suggests are putting their assets on a collision course with these mega trends.

Below 2°C stranded value for the EU28 member states



Investors should adjust the valuation ascribed to coal generation assets held by utilities. This will involve using an asset-level model which provides a 2030 retirement schedule by dynamically determining which units close when. Utilities should acknowledge and prepare for coal to be phased-out by 2030 due to combination of policy commitments, technological progress and business model changes. Moreover, utilities should prepare for the reality that compensation may not get paid for early closure. The Netherlands' phase-out is a case in point: by incorporating a carbon price, the government has avoided paying compensation to asset owners.

Introduction

This report analyses the potential for European utilities to fail to learn from previous mistakes by assuming coal power will be an important source of power generation beyond 2030. In doing so, the report reviews the validity and implications of continuing to rely on coal power.

One or the other: coal power or Paris compliance?

The EU28 is still heavily reliant on coal-fired power. The EU is the third largest producer of power in the world, after China and the US. In 2014, annual production of power in the EU was over 3,000 TWh, or nearly 13% of the total world output[1]. Coal currently makes up 18% of total operating capacity and 26% of total generation in the EU. The EU's reliance on coal is at odds with the IEA's beyond 2°C scenario (B2DS), which sees the EU phase-out coal power by 2030. This analysis takes the coal-fired generation trajectory in the IEA B2DS, and develops a model to determine which units should close when based on the profitability and location of the unit. The detailed assumptions regarding future costs and prices are produced by Carbon Tracker.

Additional value destruction should be avoided

European utilities know the financial consequences of ignoring the transition to a low carbon economy. For example, as detailed in Coal: Caught in the EU Utility Death Spiral, the EU's five largest utilities lost over €100bn in value from 2008 to 2013 largely because of a failure to predict how policy would drive technology costs downwards and promote new business models. These utilities have since recognised that they entered the low carbon market 5-10 years too late.

[1] *Based on gross generation. See: IEA, (2017). Energy Technology Perspectives 2017: Catalysing Energy Technology Transformations. Available: http://www.iea.org/bookshop/758-Energy_Technology_Perspectives_2017*

Challenging the orthodoxy

The false comfort of the status quo has already cost European utilities dearly. Despite this, many utilities still expect coal to be part of the power mix towards the end of the first half of the century.[2] In our opinion this assumption runs the risk of overlooking influential changes in supply side inputs, such as continued technology cost reductions, and demand side fundamentals, including capital additions to meet air pollution regulations. Previous value destruction and fuel mix changes in the European power sector have occurred over a relatively short period – not the long timeframes often claimed by industry. For example, only 5 years ago, coal was generating more than 40% of the UK's power, but supplied just 2% of power in the first half of 2017.

Downside from ignoring or upside from divesting?

This report uses conservative assumptions (see Box 1) to model the financial risks associated with ignoring the EU's arguably inevitable transition away from coal-fired power. Consequently, this study reveals the stranded value that can result from pursuing expensive business as usual (BAU) strategies. In doing so, this analysis also highlights the financial benefits from embracing a B2DS.

[2] RWE, for example, recently stated in their latest annual report: "… the most modern lignite-fired power plants are taken offline around the middle of the century, when opencast mining comes to an end in Hambach and Garzweiler." See: RWE, (2016). Annual report. Available: http://www.rwe.com/web/cms/mediablob/en/3688522/data/2957158/7/rwe/investor-relations/reports/2016/RWE-annual-report-2016.pdf

Box 1. Key modelling assumptions used in this analysis

The modelling in this report is based on a series of reasonable assumptions about commodity prices (fuel, power and carbon), asset operating costs (variable and fixed) and policy outcomes (out of market revenues and control technologies costs).

Fuel costs include the expenses incurred in buying, transporting and preparing the coal. For hard coal we assume a price of €70/t with transport costs of €2-7/t depending on the location of the unit. For lignite we assume €15/t. Both hard coal and lignite prices are unchanged out to 2030. A 2017 average of year-ahead power contracts is used, which is unchanged out to 2030. We apply a simple power optimisation to account for the delta between peak and baseload prices. Another influential factor is carbon pricing, which has a major impact on the relative costs of using different fuels. We use a linear carbon price scenario increasing from €7.5/t in 2017 to €20/t by 2030 (see Box 3).

The variable costs we used depend on the size of the unit: 0-100 MW (€5.42/MWh), 100-300 MW (€4.34/MWh) and 300 MW or more (€4.07/MWh). Fixed costs include the costs incurred at a power plant that do not vary significantly with generation and include: staffing, equipment, administrative expenses, maintenance and operating fees. The fixed cost assumptions included in this report depend on the size of the unit and whether it is burning coal or lignite: 0-100 MW (€33/kW for hard coal and €58/kW for lignite), 100-300 MW (€23/kW for hard coal and €48/kW for lignite) and 300 MW or more (€20/kW for hard coal and €45/kW for lignite).

A significant anticipated cost for the EU coal units is compliance with the Industrial Emissions Directive's (IED) best available techniques reference (BREF) for large combustion plants (see Box 4).[3] Compliance with BREF impacts both capital costs (from investing in control technologies) and operations costs (from using the control technology). The control technologies we consider are wet flue gas desulphurisation (capex of €44/kW and opex of €0.72/kW) and selective catalytic reduction (capex of €78/kW and opex of €1.15/kW).

Box 1 continues overleaf

[3]*European Commission, (2016). Best Available Techniques (BAT) Reference Document for Large Combustion Plants. Available: http://eippcb.jrc.ec.europa.eu/reference/BREF/LCP_FinalDraft_06_2016.pdf*

Out of market revenues include: balancing services of €2,000/kW and ancillary services of €2,000/kW for all units, as well as capacity payments for existing markets in accordance with the European Commission proposal 2016/0379, which excludes coal from 2025.[4] The modelling also takes into consideration the following member state phase-out policies: Denmark (2025), Finland (2030), France (2022), Italy (2025), Netherlands (2030), Portugal (2030) and UK (2025). Appendix 1 has further information on operating cost and revenue assumptions.

The B2DS applied is Carbon Tracker's interpretation of the IEA's Energy Technology Perspectives 2017. This scenario is consistent with a 50% probability of achieving anthropogenic warming of 1.75°C, and a 66% probability of an outcome of 2°C of warming.

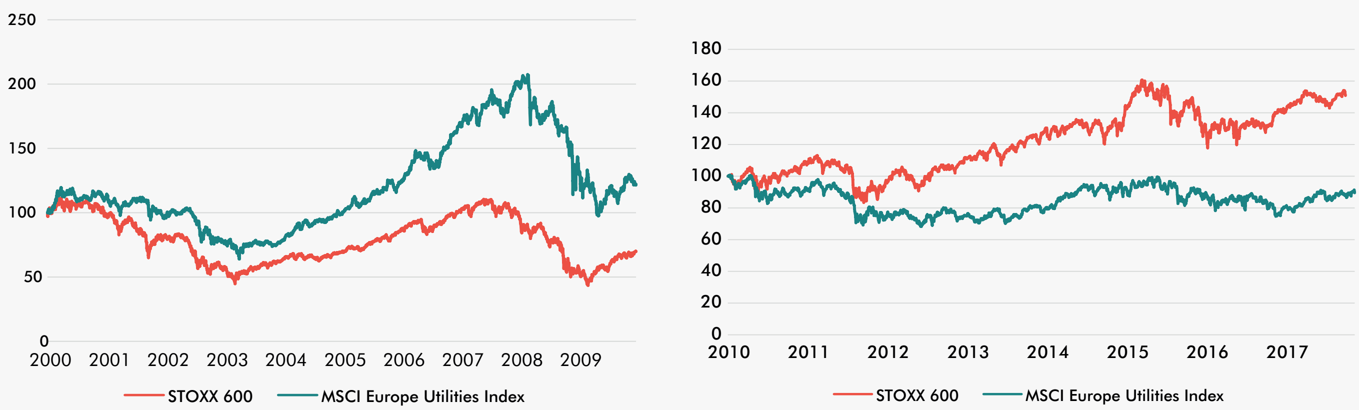
[4] *Article 23: "Generation capacity for which a final investment decision has been made after entry into force shall only be eligible to participate in a capacity mechanism if its emissions are below 550g CO_2/kWh. Generation capacity emitting 550g CO_2/kWh or more shall not be committed in capacity mechanisms 5 years after the entry into force of this Regulation." See: European Commission, (2016). Regulation of the European Parliament and of the Council on the internal market for electricity. Available: http://eur-lex.europa.eu/resource.html?uri=cellar:9b9d9035-fa9e-11e6-8a35-01aa75ed71a1.0012.02/DOC_1&format=PDF*

From nirvana to disaster

Prior to 2010, investors were attracted to European utility stocks for stability and income. Power utilities were typically seen as safe stock as they often operate with the protection of longstanding regulations, which can act as a barrier to market entry for new entrants. Moreover, prior to the rise of energy efficiency investing, power utilities have also been resistant to economic cycles. With low-demand elasticity and reliable revenues, utilities have traditionally paid consistently high dividends. From 2000 to 2010, the stock prices of European utilities outperformed the Stoxx by over 60%.

From 2010 onwards, it became clear how unprepared European utilities were for the transition to a low carbon economy. Years of overinvestment coincided with the beginnings of structural changes in the production and consumption of power.

Figure 1. MSCI Europe Utilities Index and Stoxx 600 performance from (2000-10) and (2010-17)



Source: Bloomberg LP, Carbon Tracker analysis

This brave new world of technology and efficiency mandates, as well as business model changes created a virtuous circle which destroyed the value of conventional thermal generation. From 2010 to 2016, the trend over the previous decade reversed as the value of European utilities decreased around 20%, while the Stoxx increased 40% over the same period.

As detailed in Coal: Caught in the EU Utility Death Spiral, the five largest utilities in terms of power generation – EDF, GDF Suez, Enel, E.ON and RWE – were all downgraded by S&P, as a result of challenges faced by pressured profitability.

Figure 2. S&P credit ratings of major European utilities in 2010 compared to 2017

S&P Ranking	EDF		RWE		GDF Suez/Engie		E.ON/Uniper		Enel	
	2010	2017	2010	2017	2010	2017	2010	2017	2010	2017
A+	A+									
A			A		A		A			
A-		A-				A-			A-	
BBB										BBB
BBB-				BBB-				BBB-		

Source: Bloomberg LP (2017)

Mistakes made, lessons unlearned

Confidence in coal-heavy utilities is returning as business restructurings, court rulings and power prices have improved company finances (see Box 2). These utilities expect to operate their coal units well beyond 2030. Based on company reports and including member state phase-out policies, only 27% of operating coal units in the EU are planning to close before 2030.[5] The coal industry's rhetorical playbook regarding the ongoing need for coal power boils down to three main arguments: coal is the most viable form of generation; renewables and other low carbon alternatives require subsidies; and coal is needed to keep the lights on because renewable energy is intermittent. These arguments are being used to justify the continued use of coal in the EU beyond 2030.[6] We believe these arguments are both outdated and misguided.

Box 2. 2017: a good year for coal-heavy German utilities

Over the past year, wholesale power prices in Germany have increased by around 20% due to a combination of nuclear outages, weak hydro, cold weather, maintenance outages and higher carbon prices. The recent rise in power prices has lifted dark and spark spreads across Europe. These price rises coupled with business restructurings and court rulings have improved the finances of coal-heavy German utilities. RWE and Uniper, for example, saw their share prices increase by 64% and 79% respectively in 2017. These rises need to be put in context: RWE's share price is still down 70% since the start of 2009. While there are concerns that renewed nuclear safety investigations from French regulators and lower-than-normal seasonal gas capacity may keep power prices high for the next 6-12 months, there is widespread recognition that prices will remain supressed over the long-term due to low marginal cost renewables and continued advancements in energy efficiency.[7] The CEO of Engie, for example, recently stated that low electricity prices are here to stay.[8] Low power prices coupled with BREF and higher carbon prices will increase operating costs and likely keep dark spreads prohibitively low. Appendix 2 includes a sensitivity analysis of our modelling assumptions, including power prices.

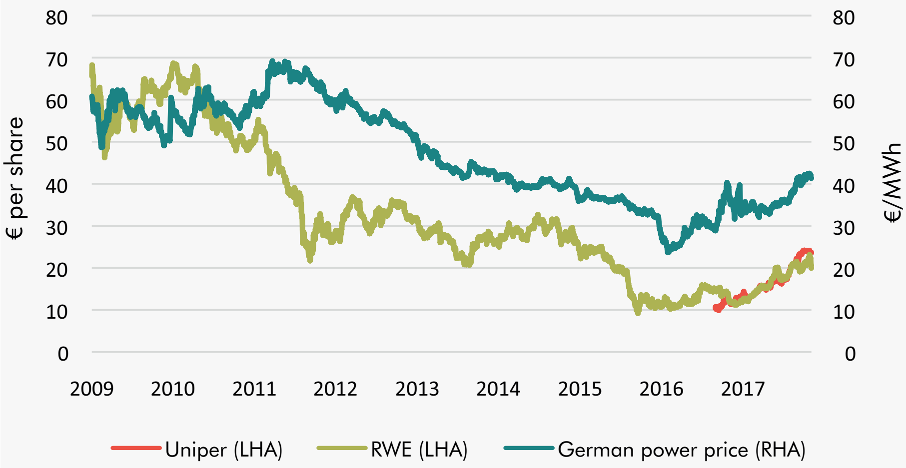
[5] *Based on company reports alone, only 5% of operating coal units in the EU are planning to close before 2030.*

[6] *See for e.g., Sandbag (2017). Eurelectric: Let's copy-paste Poland's coal strategy across Europe. Available: https://sandbag.org.uk/2017/09/25/eurelectric-lets-copy-paste-polands-coal-strategy-across-europe/*

[7] *BNEF, (2017). EU Power Weekly: Power Prices May Scale New Heights. Unavailable without subscription.*

[8] *Financial Times, (2016). Low European power prices here to stay, says utility CEO. Available: https://www.ft.com/content/4bdf5a4e-1a84-11e6-8fa5-44094f6d9c46*

Figure 3. RWE and Uniper share price performance versus German wholesale power price in 2017



Source: Bloomberg LP, (2017)

Coal industry argument: coal is the most economically viable form of generation

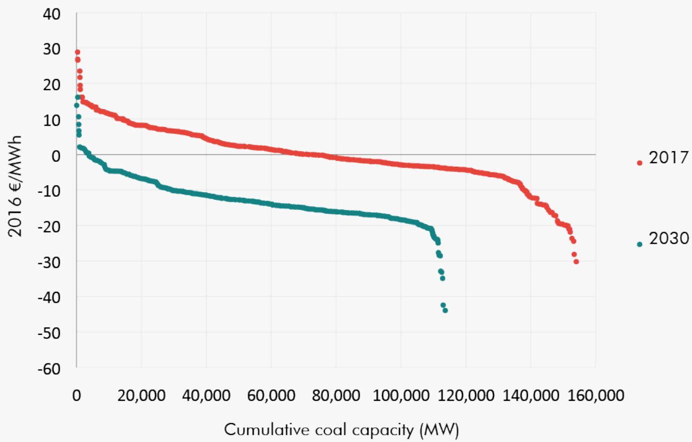
Carbon Tracker outlook: coal generation looks economically unviable, making units reliant on capacity market payments which the European Commission wants to ban.

We modelled the operating cost and gross profitability of every operating coal unit in the EU and found 54% are cashflow negative as of 2017 and by 2030 this could increase to 97%.[9] This is due to BREF and rising carbon prices, which increase operating costs. It is important to note, utilities often keep unprofitable units open for a number of reasons, including: (i) in the hope government authorises capacity or retirement payments in the future; (ii) the expectation a competitor will close capacity in the future, lifting power prices and potentially increasing the chance of capacity or retirement payments; (iii)

[9]*Gross profitability equals revenues (both in and out of market) minus operating costs, which include: fuel (including travel), carbon, fixed operating costs, variable operating costs and environmental controls where applicable. See Box 1 and Box 4 for more information.*

clean-up costs associated with retiring capacity; and (iv) governments directly (e.g., a royal decree) or indirectly (e.g., shareholder activism) refusing closures for economic and technical reasons.[10] Despite these reasons, the dire economics of coal-fired power in the EU will put utilities in a precarious position: retire units due to market forces or lobby for out of market revenues. In our opinion, the former is more likely than the latter, as the European Commission recently proposed to ban coal from capacity markets from 2025.[11] It should also be noted that the latest EU emissions trading system (EU ETS) reforms mean no money will go to coal power with the exception of district heating projects in Romania and Bulgaria.[12]

Figure 4. Gross profitability of operating coal fleet in 2017 and 2030



Source: Carbon Tracker analysis

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[10]*More recently, the Spanish Ministry of Energy announced a Royal Decree to protect coal-fired power plants in Spain, so they can impede their closure. If approved, this Decree can be applied retroactively and was announced three days after Iberdrola (Spanish utility) announced its intention to close its coal plants in Spain. See: El Confidencial, (2017). Nadal hace retroactiva la ley de clausura del carbón para poder vetar el cierre a Iberdrola. Available: https://www.elconfidencial.com/empresas/2017-11-13/energia-nadal-iberdrola-galan-carbon-lada-velilla_1476918/*

[11]*Capacity markets are designed to ensure sufficient reliable capacity is available by providing payments to generators to encourage investment in new capacity or for existing capacity to remain open. The European Commission has proposed to ban payments for coal. See: European Commission, (2016). Regulation of the European Parliament and of the Council on the internal market for electricity. Available: http://eur-lex.europa.eu/resource.html?uri=cellar:9b9d9035-fa9e-11e6-8a35-01aa75ed71a1.0012.02/DOC_1&format=PDF*

[12]*Financial Times, (2017). EU emissions reforms send a strong smoke signal. Available: https://www.ft.com/content/26826eec-c55c-11e7-a1d2-6786f39ef675*

Coal industry argument: renewables and other low carbon alternatives require subsidies

Carbon Tracker outlook: the operating cost of coal could be higher than the LCOE of onshore wind by 2024 and solar PV by 2027, while battery storage and demand response increasingly provide auxiliary services and peak shaving.

Carbon Tracker's theory of change for the power sector involves three inflection points which will make coal economically obsolete: (i) new renewables outcompete new coal; (ii) new renewables outcompete operating existing coal; and (iii) firm new renewables outcompete operating existing coal.[13] According to our 2017 LCOE analysis of EU power generation technologies, coal is already being challenged by low cost variable renewable energy (see Figure 5).[14] By design, LCOE analysis is an economic simplification. Many of the risk factors are project, company, technology and region specific. For instance, building a coal plant in the EU is often met with considerable resistance from the anti-coal lobby who are organised and well resourced.[15] This resistance can lead to project delays and higher costs.[16]

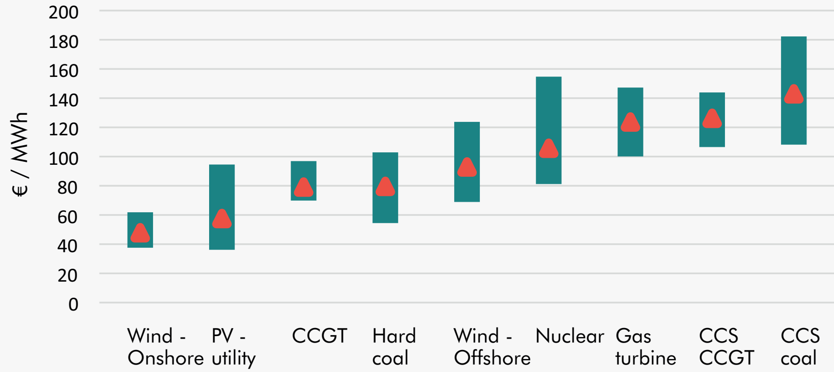
[13]A blog on our theory of change for the US coal power sector can be read here: Gray, (2017). Rick Perry's proposed rulemaking—more noise before the inevitable demise of US coal power. Available: https://medium.com/@matthewcgray/rick-perrys-proposed-rule-making-more-noise-before-the-inevitable-demise-of-us-coal-power-8171bb57134e

[14]Based on an average of UK, Germany, Italy and Spain. LCOE analysis provides one way of comparing the costs of power technologies, although it is widely recognized that other factors, such as system value, are also important. To give an empirical understanding of the competitiveness of power technologies, our LCOE analysis reflects market conditions. This involves using realised load factors, for example. See Appendix 1 for a breakdown of the figures.

[15]The Beyond Coal Campaign, for example, recently expanded to Europe. Guardian, (2017). Michael Bloomberg's 'war on coal' goes global with $50m fund. Available: https://www.theguardian.com/environment/2017/nov/09/michael-bloombergs-war-on-coal-goes-global-with-50m-fund

[16]Vattenfall's Moorburg hard coal plant in Germany, for example, took eight years to complete in part due to significant resistance from the local community. See: Carbon Tracker, (2015). Coal: Caught in the EU Utility Death Spiral. Available: https://www.carbontracker.org/reports/eu_utilities/

Figure 5. 2017 LCOE of new generation capacity for the EU28



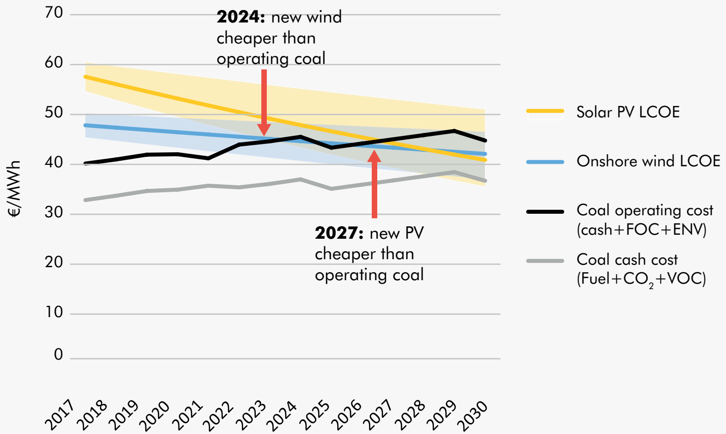
Source: Carbon Tracker analysis

Moreover, as detailed in Figure 6, the operating cost of existing coal could be higher than onshore wind by 2024 and utility scale solar PV by 2027.[17] An important distinction needs to be made between operating and cash costs of coal units. Cash costs include fuel, carbon and variable operating costs, while operating costs include cash costs, as well as fixed operating costs and control technologies to meet BREF. Unit owners who are expecting to close within 3 to 5 years can take a "sellotape" strategy to operations by only making minimal investments to keep the unit running. However, over the long-term, unit owners need to make investments in operations and maintenance to sustain unit performance and availability, as well as investments in control technologies to meet BREF. Crucially, by the early 2030s new investments in solar PV and onshore wind could be lower than the cash cost of coal, meaning there may be so much variable renewable energy that negative pricing becomes common and coal units become unusable without out of market revenues. Battery storage and demand can also help reduce the amount of coal required, by providing auxiliary services and shaving the peaks from increased levels of variable renewable energy. This still leaves a significant opportunity for gas or another technology to meet demand during longer periods of low renewable output.[18]

[17]Based on averages from Figure 5 with learning rates of 20% for solar PV and 5% for onshore wind. The capacity additions are based on the IEA's B2DS and the learning rates are from the IEA's 2016 power generation assumptions. See: IEA, (2016). WEO 2016 Power Generation Assumptions. Available: http://www.worldenergyoutlook.org/weomodel/investmentcosts/

[18]According to BNEF, 196 GW will still be needed in 2040 to meet peak demand and supply energy in low renewable output hours. BNEF forecasts 56 GW of battery storage by 2040 and argues that to shift fully away from fossil fuels, a technology is required that can provide peak capacity and meet demand during potentially long periods of low renewable output. See BNEF (2016), EU Power Weekly: Can Renewables Oust All Coal and Gas? Unavailable without subscription.

Figure 6. LCOE of onshore wind and solar PV versus the capacity-weighted average operating cost of existing coal plants



Source: Carbon Tracker analysis based on data from IEA (2017) and BNEF (2017) as well as Carbon Tracker assumptions

Coal industry argument: coal is needed because renewable energy is intermittent

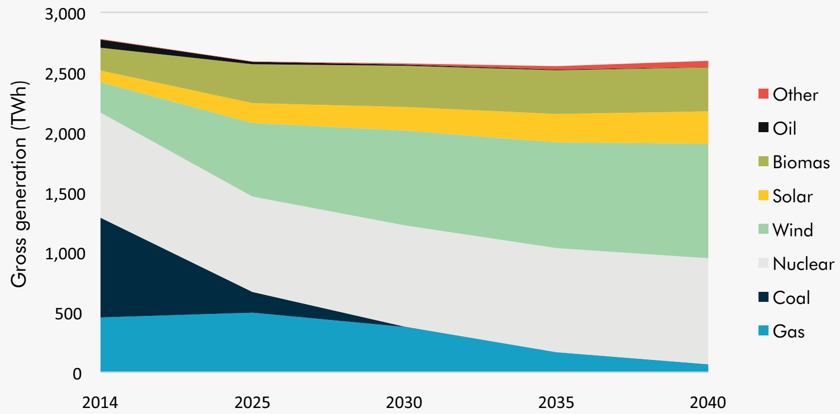
Carbon Tracker outlook: the IEA's Paris-compliant modelling shows a coal-free Europe by 2030 without security of supply issues.

Another lobbying challenge to renewables is in the form of grid security concerns. Coal's role providing baseload power has been a major selling point for the industry. As grids throughout the EU accommodate increased amounts of low-cost wind and solar, mid-merit or flexible power will be needed to match supply and demand. While this risks investment lock-in from gas power (which is regarded as the cheapest form of dispatchable generation in several markets) there is no role for coal in this future unless carbon capture and storage (CCS) becomes cost-competitive.

[19]Reuters (2015). Peabody reaches deal with New York AG on climate disclosures. Available: http://www.reuters.com/article/us-peabody-energy-climatechange/peabody-reaches-deal-with-new-york-ag-on-climate-disclosures-idUSKCN0SY1U420151110

[20]According to Eurostat, gross generation from solar and wind grew at a CAAGR of 15% and 36% respectively from 2010 to 2015.

Figure 7. The IEA's B2DS gross power generation in the EU28



Source: IEA (2017)

The IEA's B2DS phases-out all coal power in the EU by 2030, without compromising security of supply. The IEA was established in 1974 with a broad mandate on energy security and consequently takes a conservative approach to modelling future power systems. The IEA's scenarios have previously been used by the coal industry to support misguided assumptions about future coal demand.[19] Due to prohibitively high costs and a lack of government support, the B2DS has no CCS-equipped coal capacity in the EU. Moreover, the B2DS shows wind and solar collectively increasing at a compounded annual average growth rate (CAAGR) of 5% from 2014 to 2030, which is substantially less than the CAAGR of these fuels over the last five years.[20]

Methodology and assumptions

How the model works

The scenario outputs of this report have been generated through a net present value (NPV) model which seeks to replicate the real-world economic and investment decisions associated with a phase-out of coal-fired power in the EU. Our modelling approach involves three steps.

Firstly, identify the amount of capacity required to fill the generation requirement in the IEA's B2DS. As detailed above, under the B2DS, coal-fired power is phased-out by 2030. To keep coal generation consistent with a below 2°C pathway, units are retired when generation exceeds the B2DS generation. For example, the model keeps retiring units on a yearly basis until generation reaches or goes below B2DS generation.

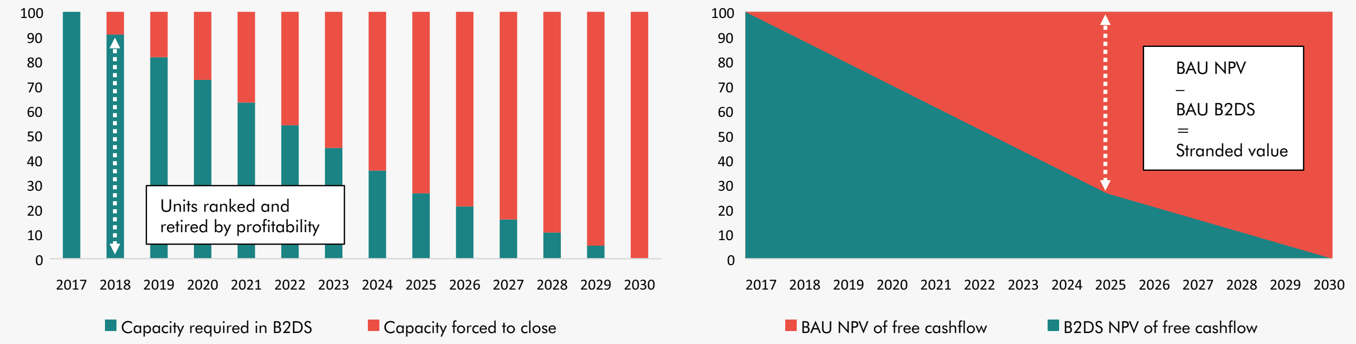
Secondly, rank the units. We rank units based on gross profitability per member state instead of operating cost and carbon intensity, due to the liberalised nature of European power markets and our expectation that economics will become the primary driver to phase-out coal.[21] This scenario aims to replicate a phase-out from the perspective of a utility interested in maximising free cashflow.[22] Gross profitability is based on in market and out of market revenues minus operating costs.

Thirdly, value every operating unit in both the B2DS and BAU outcomes to understand stranded value. Stranded value under the B2DS is defined as the difference between the NPV of cashflow in the B2DS (which phases-out all coal power by 2030) and the NPV of cashflow in the BAU scenario (which is based on retirements announced in company reports). Both the B2DS and BAU acknowledge existing phase-out policies by member states. A schematic illustration of the modelling methodology is provided in Figure 8 below.

[21]We also have operating cost and carbon intensity scenarios, which are available upon request. Please contact the authors for more information.

[22]We acknowledge some units are needed for local or regional grid support rather than national wide issues. That might mean in exceptional circumstances units are needed for longer or have extra revenue from grid operators.

Figure 8. Schematic illustration of the modelling methodology



Source: Carbon Tracker illustration

Key assumptions

As detailed in Box 1 above, the modelling in this report is based on a series of reasonable assumptions about commodity prices (fuel, power and carbon), asset operating costs (variable and fixed) and policy outcomes (out of market revenues and control technologies costs). Appendix 1 has further information on our operating cost and revenue assumptions.

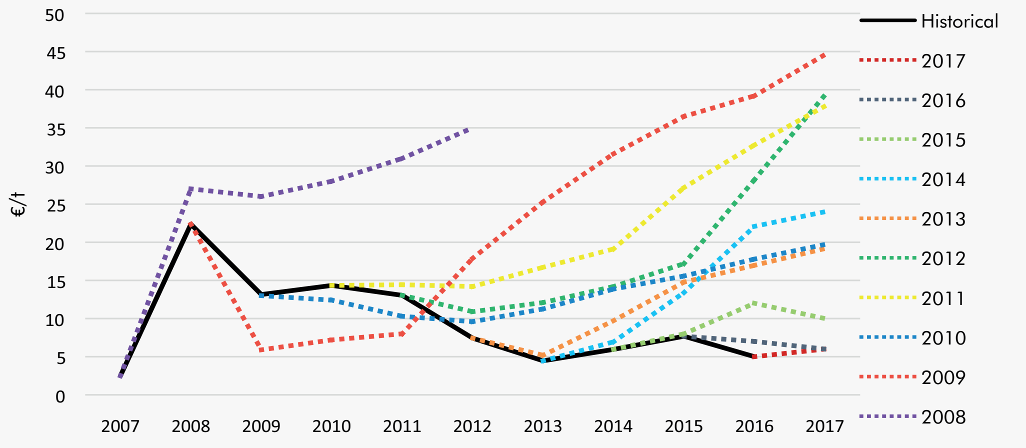
The other key assumptions are detailed below:

- Year-ahead power contracts (2017 average unchanged to 2030)
- €70/t for hard coal and €15/t for lignite (unchanged to 2030)
- Linear carbon price scenario increasing from €7.5/t in 2017 to €20/t by 2030
- Compliance with the European Commission's BREF document
- Capacity market payments in accordance with the European Commission's proposal 2016/0379
- Member state phase-outs: Denmark (2025), Finland (2030), France (2022), Italy (2025), Netherlands (2030), Portugal (2030) and UK (2025).

Box 3. EU carbon prices: risk favoured the downside until now

To date analysts have overestimated European carbon prices (termed European Unit Allowances – EUAs). EUA forecasting is a difficult endeavour as the market is a political construct and therefore its relevance is determined by politicians. The EU ETS is the only market in the world where demand is determined in near-real time and supply is allocated years in advance. This makes EUAs sensitive to endogenous interactions (i.e. other energy and climate policies) and exogenous factors (i.e. fuel costs, technology costs and macroeconomic instability).[23] A combination of policy overlap, lower growth and political interference have negatively influenced prices to date, making long-term EUA forecasting what Philip Tetlock and Dan Gardner call an impenetrable "cloud-like" question (where advanced statistical models are less accurate than a dart-throwing chimp).[24]

*Figure 9. BNEF EUA forecast history**



Source: BNEF (2007-2017) ** Prices are nominal.*

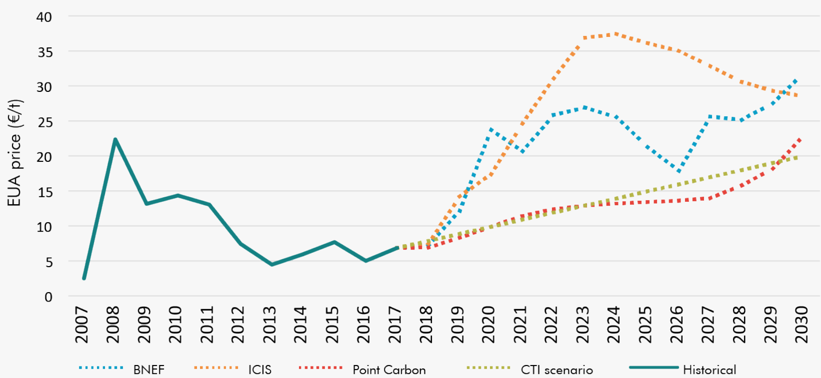
Box 3 continues overleaf

[23]Gray and Worthington, (2015). ETS in Context. Available: https://sandbag.org.uk/wp-content/uploads/2016/10/ETS_Position_Report_240615_1_1.pdf

[24]Tetlock and Gardner, (2015). Super-forecasting: the art and science of prediction.

To allow the EU ETS to respond to endogenous interactions and exogenous factors, the European Commission proposed the market stability reserve (MSR) in 2014. The MSR moderates the cumulative surplus by injecting allowances into the MSR or releasing allowances into the market. At the time of writing, the European Parliament and the Council agreed to inject 24% of cumulative oversupply into the MSR from 2019 to 2022. The MSR will allow the EU ETS to operate like a quasi-carbon tax, providing more price stability. Nonetheless, significant uncertainty remains. The biggest downside risk is a member state coal phase-out without the cancellation of allowances. If member states phase-out coal and fail to cancel allowances from those installations being closed, the MSR could quickly become overwhelmed and prices will remain suppressed. That said, the EU ETS should not be considered the only carbon price risk in the EU. The Netherlands – who recently announced a coal phase-out – is cancelling allowances and introducing a supplementary carbon price. The UK and Portugal all have additional carbon prices, and other member states are likely to follow suit. For this report, we use a simple linear price scenario which assumes €20/t by 2030, which is conservative compared to other analysts.

*Figure 10. Carbon Tracker scenario compared to other forecasters**



Source: BNEF (2017), Point Carbon (2017), ICIS (2017) and Carbon Tracker analysis

** The prices from BNEF, Point Carbon and ICIS are nominal while the prices in our scenario are real. Our linear price scenario is 26% less than what we forecasted in Coal: Caught in the EU Utility Death Spiral.*

Results

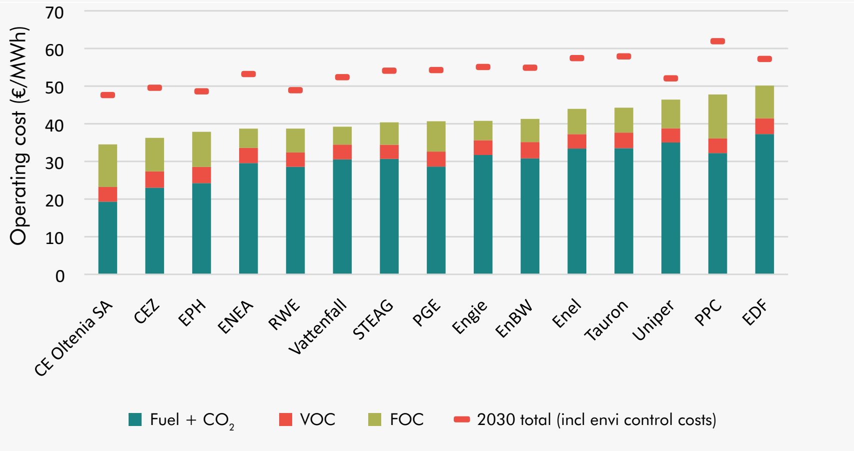
Utilities

The results shown here are for the 15 largest utilities by coal capacity, who represent over 70% of total operating coal capacity in the EU.[25]

Operating costs

CE Oltenia, a Romanian utility, has the lowest operating costs out of the utilities surveyed. CE Oltenia only owns old subcritical lignite units, which typically have lower running costs. RWE's hard coal units have some of the lowest operating costs out of the utilities surveyed. This is due to unit age, which results in higher efficiency (7 GW of RWE's coal capacity has an efficiency of 40% or more). Those utilities with greater exposure to lignite typically have lower fuel costs but higher fixed costs, owning to the significant annual costs associated with running a lignite mine. EDF, Tauron and Uniper have a high proportion of hard coal units which were commissioned decades ago and thus have a higher cost profile. All utilities see their operating costs rise significantly by 2030, as BREF and higher carbon prices increase the cost profile of their coal units. Older inefficient units, in particular, are more likely to be non-compliant with BREF and therefore have higher costs in the future, due to the installation of control technologies (see Box 4).

Figure 11. Capacity-weighted operating cost for utilities in 2017 and 2030



Source: Carbon Tracker analysis

[25] *We also have model outputs for over 92 companies with exposure to coal power in the EU.*

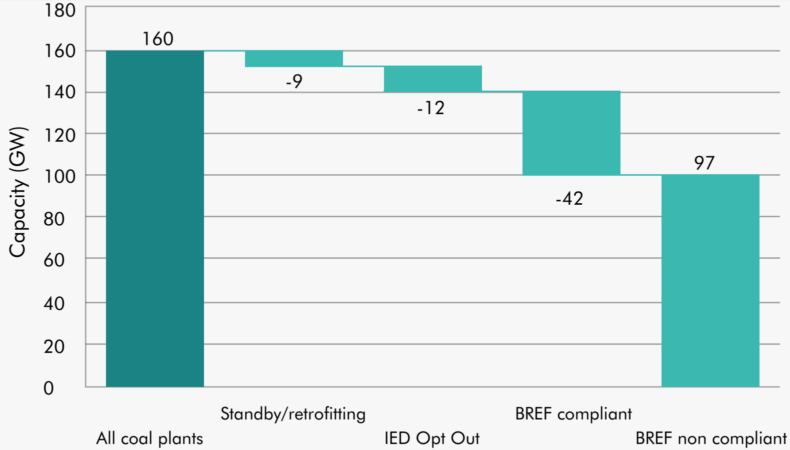
Box 4. EU air pollution policy: the death knell for coal power

The EU regulates air pollutions from large industrial facilities. The Large Combustion Plant Directive (LCPD) regulates sulphur oxides, nitrogen oxides and particulate matter emissions. EU-regulated plants are given a choice to opt in or out. Plants opting out are allocated 20,000 hours to run over the years 2008-2015. Plants opting in must comply with emissions limit values for the above pollutants. In 2010, the LCPD was combined with six other existing directives to form the IED. LCPD plants which opted in to the IED must agree to stricter emissions limits. Plants which opted in to the LCPD but choose not to opt in to the IED had their hours capped before being forced to close.

BREF, the most recent air pollutant controls in the EU, restrict the production of pollutants like sulphur dioxides (SOx) and nitrogen oxides (NOX), as well as mercury and dust. This legislation comes under the EU's IED and supersedes its previous limits which came into force in 2016. National regulators are required to uphold the limits set out in BREF by 2021, and in our model, we assume that non-compliant plants (based on their 2015 emissions) act to meet SOx and NOx limits by installing best in class technology. The control technologies we consider are wet flue gas desulphurisation (capex of €44/kW and opex of €0.72/kW) and selective catalytic reduction (capex of €78/kW and opex of €1.15/kW). We do not consider the IED limits for dust and mercury, or the fact that the BREF limits are a range and some plants will have more stringent targets, so our cost estimates due to BREF are conservative. As we are using generation data and capacity factors from 2016, plants that have opted out of the IED will have already derogated their running hours. As detailed in Figure 12, 70% of operating coal capacity is non-compliant and therefore will be forced to either shut down or have expensive control technologies installed.

Box 4 continues overleaf

Figure 12. The impact of BREF on operating coal plants in the EU

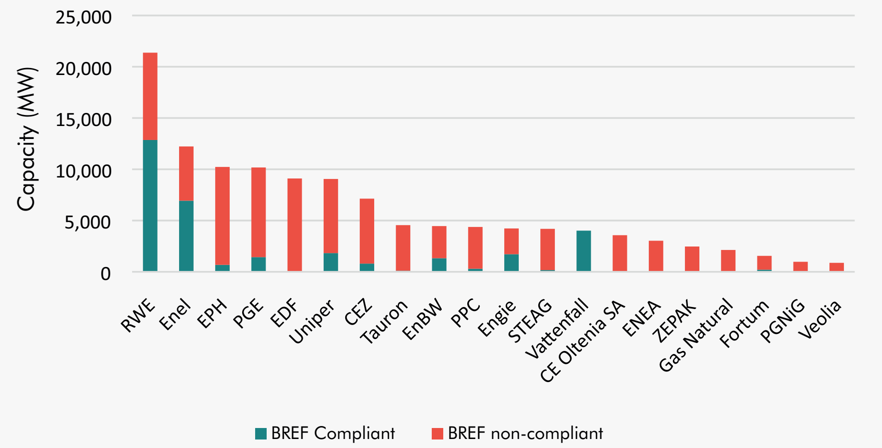


Source: Carbon Tracker analysis

Box 4 continues overleaf

Vattenfall is the only utility that appears to be in full compliance with BREF. RWE, Enel and Engie are also comparatively well placed with 60%, 57% and 41% of compliant coal capacity, respectively. Those utilities with exposure to Eastern Bloc markets are typically less prepared for BREF.

Figure 13. BREF compliance by utility

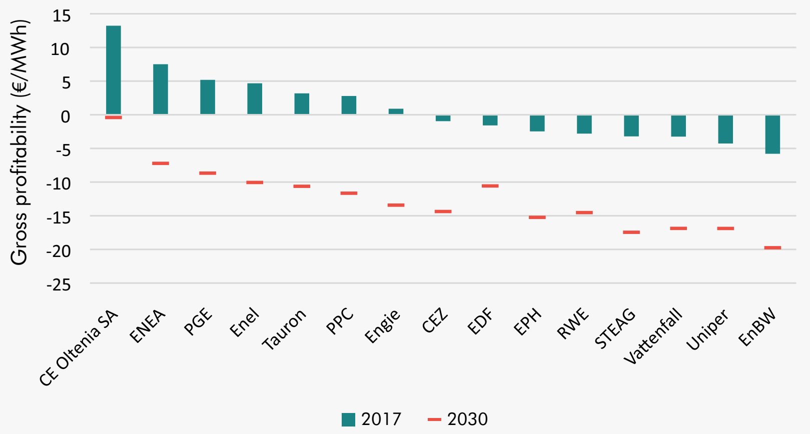


Source: Carbon Tracker analysis

Gross profitability

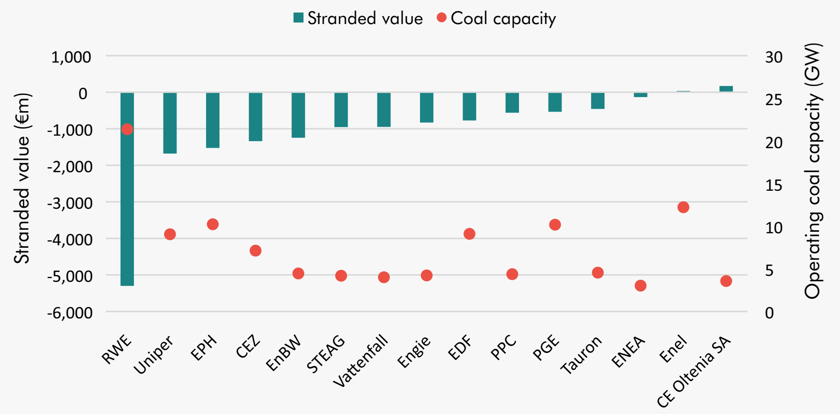
Figure 14 below includes gross profitability of utilities under the BAU scenario, whereby coal units are only retired if stated in company reports or situated in a member state which has a phase-out policy. It assumes units install the control technologies required to meet BREF in 2021. As of 2017, those utilities with exposure to Italian, Spanish and Eastern Bloc markets have slightly higher profitability, due to power prices in those markets. RWE, which has some of the most competitive hard coal units, is undermined by its exposure to markets with lower power prices (i.e. Germany) and higher carbon prices (i.e. the UK). EnBW and Uniper are the least profitable in 2017, due to a combination of higher operating costs and the location of their assets. By 2030, the gross profitability of all surveyed utilities becomes negative, due to a combination of higher operating costs from increased carbon prices and control technologies to meet BREF.

Figure 14. Capacity-weighted gross profitability for utilities in 2017 and 2030



Source: Carbon Tracker analysis

Figure 15. B2DS stranded value for utilities

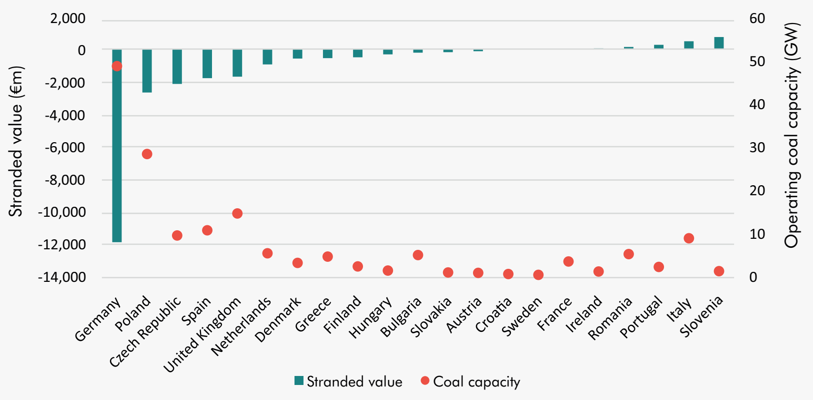


Source: Carbon Tracker analysis

Stranded value

Our NPV model values units under both B2DS and BAU to understand stranded value. The B2DS shuts coal units quicker than the BAU scenario and thus saves money, as the majority of units are loss-making from 2017 to 2030 due to rising carbon prices and BREF regulations. For this reason, the amount of stranded value in the B2DS is negative, meaning relative to the BAU scenario they avoid losing money by phasing out coal in a manner consistent with the Paris Agreement. The utilities who have the most to gain from phasing-out coal are RWE and Uniper, who could avoid losing €5.3bn and €1.7bn, respectively. CE Oltenia SA and Enel are the only utilities surveyed in this report which stand to lose from retiring its coal units in a manner consistent with the Paris Agreement. Based on our modelling, CE Oltenia SA and Enel could lose €170m and €34m respectively, as most of their coal units operate regions with relatively high power prices.

Figure 16. B2DS stranded value for member states

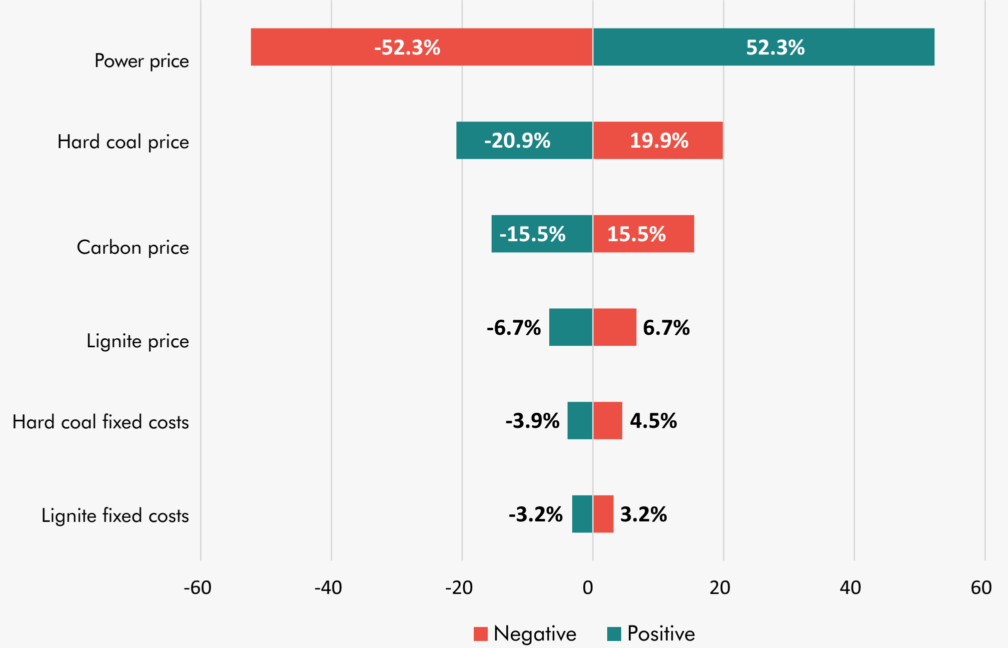


Source: Carbon Tracker analysis

Member states

In the aggregate, the member states could avoid losing €22bn by phasing-out coal in a manner consistent with the Paris Agreement. Those units based in Germany could avoid losing €12bn by phasing-out coal, while units in Poland could avoid losing €2.7bn. The UK has a proportionally lower stranded value saving, due to the fact it already has a phase-out policy. Coincidentally, by phasing-out coal the UK is not only acting in the best interests of their citizens through improved air quality, but also the financial interests of utility shareholders through avoided value destruction. Italy and Slovenia have positive stranded value of €480m and €740m, respectively. To a much lesser degree, Portugal, Romania, Ireland and France also have positive stranded value and could lose a trivial amount if the EU complies with Paris.

Figure 17. Sensitivity analysis of stranded value against a 10% change of model inputs



Source: Carbon Tracker analysis

Sensitivity analysis

To understand how the model output varies with changes to the inputs, we performed a sensitivity analysis. By varying one input value while holding all others constant, the models' sensitivity to that value can be determined. Stranded value is the most sensitive to power price tariffs, with a 10% increase across all regional tariffs resulting in a 52% increase in stranded value. A 10% increase in hard coal prices and the price of carbon in 2020 could result in a 20% and 16% decrease in stranded value, respectively. A company-focused look at outcomes under various changes in our assumptions can be found in Appendix 2.

Recommendations for investors and utilities

Coal-heavy utilities are at a strategic crossroads: continue to invest in coal power and hope governments will allow rent-seeking in the form of capacity and retirement payments, or divest and prepare for a low carbon future. This crossroads is already materialising through the contrasting strategies of Vattenfall and EPH. In 2016, Vattenfall made a strategic decision to divest from German lignite. In Coal: Caught in the EU Utility Death Spiral we showed how Vattenfall's newly operational Moorburg hard coal plant was likely to be cashflow negative for its project lifetime, as competition from renewables reduced its utilisation and revenues. In late 2016, the CEO of Vattenfall announced it would likely sell Moorburg within 5 years to avoid losing more money and to prepare the company for the EU's energy transition.[26]

In contrast, EPH has embarked on a strategy of purchasing coal-fired assets at distressed prices, including the purchase of Vattenfall's German lignite units. The Vattenfall acquisition almost doubled EPH's generation portfolio to over 5 GW of coal. EPH is not the only utility that is betting on coal. While RWE, EON, Enel and Iberdrola have divested billions over the last five years, confidence in fossil fuel capacity is returning. RWE, for example, is considering acquisitions and is rumoured to be considering Uniper's coal and gas generation assets.[27,28]

Furthermore, Eurelectric, a European utility association, is lobbying for capacity payments for coal, even though a recent report commissioned by them showed the payments would be used to invest in extending the oldest and dirtiest coal plants from 40 years to 60 years.[29]

A pro-coal strategy is largely dependent on lobbying strategies to avoid regulations and secure support payments.[30] We believe this is a risky strategy that could lead to additional value destruction over the long-term. BREF reforms to the EU ETS and the European Commission's proposal to ban coal from capacity markets highlight the risk of a pro-coal strategy and could prove to be the final straw which phases-

[26]*Reuters, (2016). Vattenfall CEO sees sale of Moorburg coal plant in next 5 years. Available: http://www.reuters.com/article/vattenfall-coal/update-1-vattenfall-ceo-sees-sale-of-moorburg-coal-plant-in-next-5-years-idUSL8N1BV32C*

[27]*Handelsblatt, (2017). RWE Revival: On the Cusp. Available: https://global.handelsblatt.com/companies-markets/on-the-cusp-847088*

[28]*Reuters, (2017). RWE likely to target Uniper assets after Fortum takeover: sources. Available: https://uk.reuters.com/article/us-uniper-m-a-fortum-oyj-rwe/rwe-likely-to-target-uniper-assets-after-fortum-takeover-sources-idUKKBN1CI18U*

[29]*Euroelectric, (2017). Impact assessment of a 550 Emission Performance Standard - A study for EURELECTRIC. Available: http://www.politico.eu/wp-content/uploads/2017/09/EURELECTRIC-report-on-capacity-mechanisms.pdf*

[30]*As argued by Sandbag, cost of capital and cutting operating costs are also important. Sandbag, (2016). Who are EPH? Available: https://sandbag.org.uk/wp-content/uploads/2016/10/EPH-Vattenfall.pdf*

out coal power in the EU. Moreover, low cost renewable energy, battery storage and demand response are energy sector mega trends which will change power systems in the EU and throughout the world. Those utilities who expect to operate their coal units beyond 2030 are putting their assets on a collision course with these mega trends.

Investors should adjust the valuation ascribed to coal generation assets held by utilities. This will involve using an asset-level model which provides a 2030 retirement schedule by dynamically determining which units close when. Utilities should acknowledge and prepare for coal to be phased-out by 2030 due to a combination of policy commitments, technological progress and business model changes.

Moreover, utilities should prepare for the reality that compensation may not get paid for early closure. The Netherland's phase-out is a case in point: by incorporating a carbon price, the government has avoided paying compensation to asset owners.[31]

[31] *The Guardian, (2017). Dutch parliament votes to close down country's coal industry. Available: https://www.theguardian.com/environment/2016/sep/23/dutch-parliament-votes-to-close-down-countrys-coal-industry*

Conclusion

Power markets in the EU have undergone significant change over the last decade as energy policy, technology costs and new business models disrupted incumbents who were banking on the status quo. The days of utility businesses securing high margins from large planned assets are over and may never return. Several utilities have recognised the need for change and have restructured their businesses and started to develop the partnerships to grasp the available opportunities, as the EU makes the transition to a low carbon economy.

However, few utilities are expecting the EU to phase-out coal-fired generation by 2030, and yet this appears to be the direction of travel for both economic and political reasons. Utilities should learn from previous mistakes and prepare for a EU-wide coal phase-out by 2030. Investors can aid this transition by encouraging utilities to realign their strategies and base their valuations on a 2030 coal phase-out.

The impending implementation of BREF in 2021 is an obvious hurdle which, combined with the growing national phase-out commitments, should be putting coal closures on the agenda for operators now. Whilst the political context is constantly changing at a national level, with Germany a key market in this regard, the trends and relative economics are not favourable. Our conservative assumptions indicate how unprofitable the existing coal fleet is now. Varying the key factors in terms of prices and costs only alters the speed and timing of adding to this unprofitable capacity.

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Appendix 1 – modelling assumptions

		Overnight investment costs (€/kW)	Fixed OM costs (€/kW)	Technical lifetime (years)	Capacity factor (%)	Capture rate (%)	Efficiency (%)	Discount rate (%)
Coal	Max	1,980	59	40	40	0	40	5
	Average	1,800	54	40	50	0	40	5
	Min	1,530	41	40	70	0	40	5
Coal – CCS	Max	4,950	198	40	40	80	36	5
	Average	4,950	171	40	50	85	36	5
	Min	4,950	171	40	70	90	36	5
CCGT	Max	1,248	23	30	40	0	59	5
	Average	840	23	30	50	0	59	5
	Min	840	23	30	70	0	59	5
OT	Max	450	18	30	10	0	40	5
	Average	450	18	30	15	0	40	5
	Min	450	18	30	30	0	40	5
CCGT – CCS	Max	2,790	90	30	40	80	52	5
	Average	2,790	90	30	50	85	52	5
	Min	2,790	90	30	70	90	52	5

Table continues overleaf

Nuclear	Max	5,940	153	60	40	0	33	5
	Average	5,940	153	60	60	0	33	5
	Min	5,940	153	60	80	0	33	5
Onshore wind	Max	1,664	24	25	25	0	100	5
	Average	1,576	20	25	30	0	100	5
	Min	1,498	20	25	35	0	100	5
Offshore wind	Max	4,419	104	25	40	0	100	5
	Average	3,746	87	25	45	0	100	5
	Min	3,117	70	25	50	0	100	5
PV - utility	Max	1,035	13	25	10	0	100	5
	Average	959	11	25	15	0	100	5
	Min	809	9	25	20	0	100	5

Source: Carbon Tracker analysis based on data from IEA (2017) and BNEF (2017) as well as Carbon Tracker assumptions

Fuel cost excluding transport (€/t)		
	Hard coal	Lignite
2017	€70	€15
2018	€70	€15
2019	€70	€15
2020	€70	€15
2021	€70	€15
2022	€70	€15
2023	€70	€15
2024	€70	€15
2025	€70	€15
2026	€70	€15
2027	€70	€15
2028	€70	€15
2029	€70	€15
2030	€70	€15

EUA price (€/t)	
2017	€7.5
2018	€8.5
2019	€9.4
2020	€10.4
2021	€11.3
2022	€12.3
2023	€13.3
2024	€14.2
2025	€15.2
2026	€16.2
2027	€17.1
2028	€18.1
2029	€19.0
2030	€20.0

Balancing revenues (€/kW)	
All units	€2,000

Ancillary services revenues (€/kW)	
All units	€2,000

Fixed operating cost (€/kW)		
	Hard Coal	Lignite
0-100 MW	33	58
100-300 MW	23	48
300 MW or more	20	45

Variable operating cost (€/MWh)	
0-100 MW	5.42
100-300 MW	4.34
300 MW or more	4.07

Appendix 2 – sensitivity analysis and scenarios

While the sensitivity analysis presented in the main report shows how sensitive the model outputs are to equal proportional changes to input values; in reality those variables may change at wildly different rates under different assumptions. For example, the carbon price has historically been very volatile and while we feel our forward-looking assumptions on the carbon price are reasonable, there are various scenarios where it could be quite different. If the main EU ETS forecasters are correct it could drive it up to €30/t by 2030. Contrastingly, a poorly co-ordinated phase-out of coal power could see oversupply holding the price at current levels of €7.5/t at the time of writing.

As the most sensitive variables, we explore scenarios of varying power prices, hard coal prices and carbon prices. Applying a 1.4% growth rate to power prices results in 20% higher prices in 2030, with 77% of plants unprofitable and a stranded value of €7bn compared to 97% and €22bn in our base case. A -1.7% rate of change in power prices results in 20% lower prices in 2030, with 99% of plant capacity unprofitable and €38bn of stranded value. As shown in Figure 19 below, while absolute stranded values change significantly, the approximate rankings of the largest 15 companies by coal capacity do not vary dramatically.

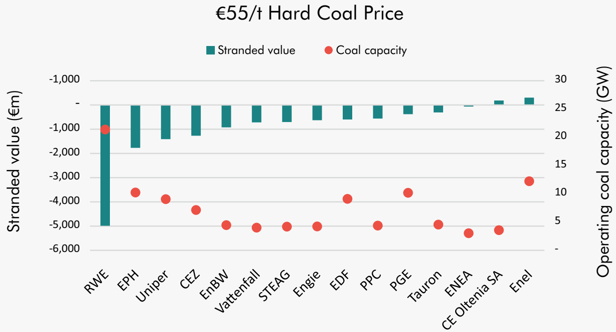
Figure 19. Power price sensitivity for utilities

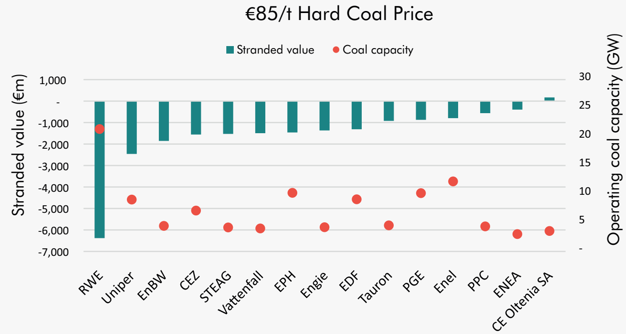
Source: Carbon Tracker analysis

Our assumption for hard coal price is €70/t. A price of €85/t gives a stranded value of €32bn, while a price of €55/t gives a stranded value of €19bn. The results for utilities are shown below, with variation in company rankings dependent on the amount of hard coal versus lignite in their portfolio.

Figure 20. Coal price sensitivity for utilities

Figure 19. Power price sensitivity for utilities

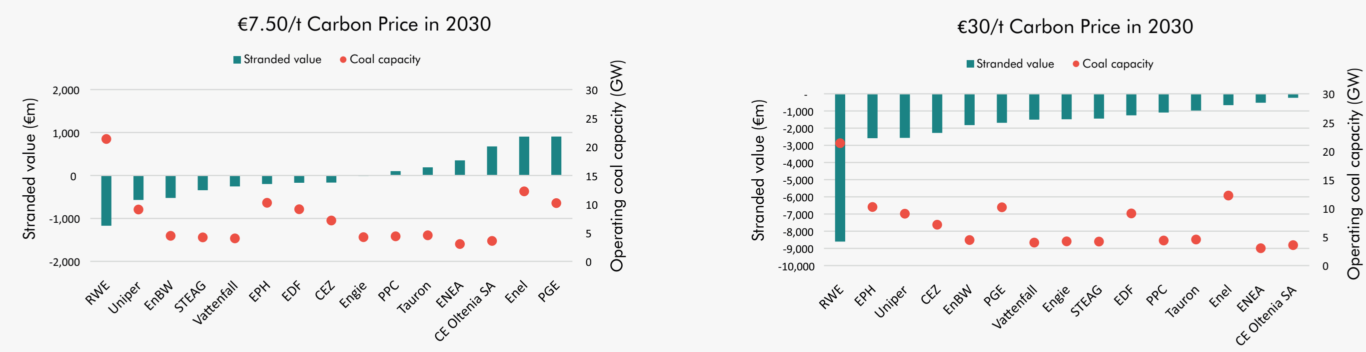




Source: Carbon Tracker analysis

With a carbon price of €30/t in 2030 we see a stranded value of €39bn and 99% of plants unprofitable, and with a flat price of €7.5/t by 2030 we see only €1bn of stranded value and 57% of plants unprofitable.

Figure 21. Carbon price sensitivity for utilities



Source: Carbon Tracker analysis

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