

15 July 2009

Carbon Emissions

Which Way Blows the Wind? German Nuclear Policy in Focus

Germany's Federal election on 27 September is key to future energy policy

Our ETS emissions forecasts over 2010-20 assume that Germany's nuclear phase-out will not proceed as planned. As a result, should the current policy remain in place after the election, we would expect to raise our ETS-emissions forecasts by 15Mt for 2013 and by up to 40Mt by 2020. With German generators set to start hedging 2013 power later this year, we think any election outcome that indicated a continuation of the current nuclear phase-out policy could provide support for EUA and power prices in Q4 of this year.

Germany's nuclear phase-out set to start in earnest over the next Parliament

In April 2002 Germany's amended Atomic Energy Act entered into force mandating the closure of all nuclear power plants by 2022. Two plants were shut down under the previous government, but during the current parliament there have been no further closures. However, over 2010-13 there are 7.1GW of nuclear capacity scheduled to close. This means that the government that emerges from September's election will have to decide whether to continue the phase-out or offer lifetime extensions to the seven nuclear plants due to come offline by 2013.

If the nuclear phase-out continues, the main replacement fuel will be coal

Of 21.4GW of planned new German generation capacity by 2013 (11.1GW already under construction, 9.5GW approved, and 800MW pending approval), 10.3GW is coal based (7.5GW of hard coal, and 2.8GW of lignite), 4.7GW CCGT, and 6GW offshore wind. However, we think the higher cost and greater challenge of building so much new offshore-wind capacity so quickly will lead to overruns against the expected start-up dates. As a result, we assume that only 2.1GW of offshore-wind capacity will in fact be onstream by 2013. And since only 10% of gross offshore-wind capacity can be considered firm, this means that we expect coal or lignite capacity to account for two thirds of a total 15.6GW of new firm capacity by 2013, with most of the remaining third being CCGT.

This would mean higher CO2 emissions by 2013 and 2020

In the base-case scenario we have modelled in this report, we conclude that Germany's power sector would likely emit 15Mt of CO2 more by 2013 than it does today if the 7.1GW of nuclear capacity were indeed to be removed from the grid along with 9.4GW of older fossil-fuel plant. On a worst-case scenario we find that emissions could rise by as much as 30Mt by 2013 relative to today's levels, while on a best-case scenario the increase might be only 6Mt. Assuming that the nuclear phase-out were then to continue over 2014-20, we calculate that emissions would likely increase by c.40Mt by 2020 compared with today's level. Our worst-case scenario suggests emissions could be up to 62Mt higher by 2020 than they are today, while best case they would be only 14Mt higher.

EUAs set to rise gradually and EUA/CER spread to widen in next 12 months

With German generators set to start 2013 power sales from mid-2010, there could be significant demand for Phase-3 EUAs next year that would have to be met from Phase-2 allocations. As a result, if September's election result indicated a continuation of the current nuclear policy, this could exacerbate the German generators' already severe EUA shortage from 2013 and thereby provide further support for EUA and power prices in Q4 of this year given (i) the increase in expected emissions such an electoral outcome would lead to, and (ii) the higher carbon price that would be needed under such a scenario to make new CCGT plant competitive with new coal plant in Germany. Meanwhile, we expect EUA prices to remain sensitive to macro newsflow and oil prices over the summer.

Valuation and risks: Please see pages 6 and 36 for our methodology and risks.

Deutsche Bank AG/London

All prices are those current at the end of the previous trading session unless otherwise indicated. Prices are sourced from local exchanges via Reuters, Bloomberg and other vendors. Data is sourced from Deutsche Bank and subject companies. DISCLOSURES AND ANALYST CERTIFICATIONS ARE LOCATED IN APPENDIX 1. MICA(P) 106/05/2009



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Executive Summary

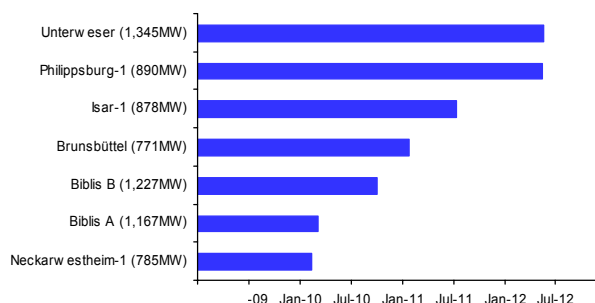
Germany's nuclear phase-out is due to get serious over 2010-13

In April 2002 Germany's amended Atomic Energy Act entered into force with the objective of phasing out all nuclear power by 2022. In accordance with this law, two nuclear power stations were permanently shut down under the previous SPD/Green coalition government (Stade in 2003, and Obrigheim in 2005), but over the lifetime of the current parliament – governed by a so-called 'Grand Coalition' CDU/CSU-SPD Government following the last general election in September 2005 – there have been no further closures.

However, over 2010-13 – i.e. over the period covered by the next German parliament – there are seven plants totalling 7.1GW of nuclear capacity scheduled to come off the system under the terms of the existing legislation (Figure 1). In total, these plants account for 35% of Germany's remaining nuclear capacity of 20.3GW, and 8% of Germany's total firm capacity of 89.2GW as at year-end 2007.

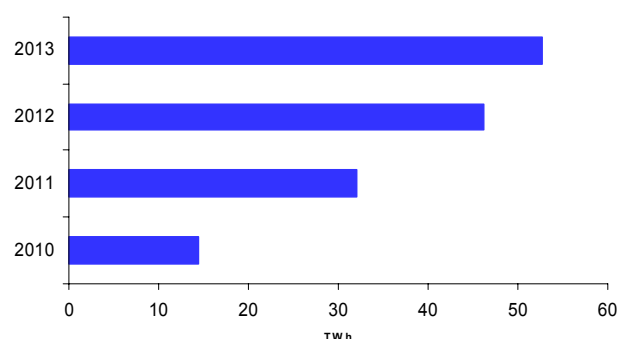
At the same time, assuming an 85% load factor, these plants currently produce 53TWh of CO₂-free electricity per year. Given the profile of the scheduled shutdowns, this means that compared with current production levels Germany could lose 14TWh of nuclear output in 2010, 32TWh in 2011, 46TWh in 2012, and 53TWh in 2013 (Figure 2).

Figure 1: German nuclear plants to be closed under existing legislation, 2010-2013



Source: Deutsche Bank

Figure 2: Lost German nuclear output over 2010-13 if existing legislation remains in place



Source: Deutsche Bank

At the same time, assuming older fossil-fuel fired plants were to close after 40 years' operating life, then Germany could lose a further 9.4GW of capacity by 2013.

In short, if the nuclear phase-out were to go ahead in line with the existing legislation, then other things being equal Germany would have to replace 53TWh of CO₂-free output by 2013 while also ensuring that a total of up to 16.5GW of new capacity were built by that date to preserve capacity-reserve margins at today's levels.

Fossil-fuel capacity dominates new build out to 2013

The data we use in this report (taken from the Platts publication *Power in Europe*, Issue 548, April 2009) identifies a total potential of 21.4GW of new power-generation capacity in Germany by 2013. Of this, we believe that 11.1GW are already under construction, with 9.5GW approved by the authorities but not yet being built and a further 800MW pending approval.

Of the 11.1 GW under construction, the overwhelming majority (10.9GW) is fossil-fuel fired capacity. This breaks down as 5.9GW of hard-coal capacity, 2.8GW of lignite, and 2.3GW of CCGT. The rest comprises two pioneer offshore-wind projects totaling a little over 100MW.

As far as the new capacity that has been approved but is not yet under construction is concerned, there would appear to be a maximum theoretical capacity that could come onstream by 2013 of 9.5GW, most of which (6GW) would be offshore wind (there are also 800MW of planned new CCGT capacity pending approval that we assume will receive the necessary authorization in time to be built by 2013).

However, most of this 6GW of planned new offshore capacity is on a bigger scale than the two pioneer farms already under construction, and much of it is also further out to sea and in deeper water. As a result, we think there is a big risk that the higher cost, greater engineering challenge, and logistical bottlenecks of trying to build so much offshore capacity so quickly at such an early stage of the industry's development will lead to overruns against the expected start-up date. For this reason, we assume that only 2GW of the 6GW of offshore capacity currently approved will actually be online by 2013, albeit with an average load factor of 35% (materially higher than the 19% posted in 2008 by Germany's onshore wind portfolio).

However, even with this higher assumed load factor, 2GW of *gross* new offshore-wind capacity would equate to only 200MW of *firm* new capacity as in the least favourable weather conditions only 10% of this capacity would actually be available to generate.

Accordingly, we assume total new *gross* capacity of 17.5GW by 2013, but total new *firm* capacity of 15.6GW after adjusting for the contribution from offshore wind. Nearly all of this would be fossil-fuel based (15.4GW), and most of it either coal or lignite (10.3GW).

In short, we conclude that there is enough new build in the pipeline to cover the capacity that would be lost by the continuation of the nuclear phase-out and the closure of older fossil fuel plants by 2013, but that the average carbon intensity of the new plant would be significantly greater than the average carbon intensity of the lost nuclear and the older fossil-fuel plants combined.

Upside risk to emissions forecasts if nuclear phase-out continues

The change in the profile of Germany's generating capacity that would occur by 2013 based on the assumptions we have made in Sections 1 and 2 of this report would result in an increase in emissions from Germany's power sector against today's levels.

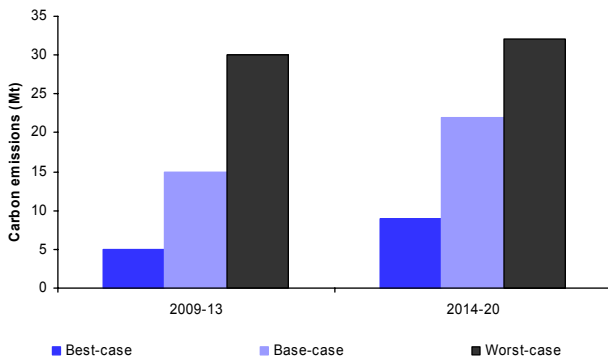
In the base-case scenario we have modelled, we conclude that Germany's power sector would likely emit 15Mt of CO₂ more by 2013 than it does today if the 16.5GW of capacity that could close by that date were indeed to be removed from the grid and replaced by the profile of new build we here assume (Figure 3).

Running two sensitivities against this base case, we find that on a worst-case scenario emissions could rise by as much as 30Mt by 2013 relative to today's levels, while on a best-case scenario the increase might be only 6Mt (again, Figure 3).

Looking beyond 2013, and again assuming that the nuclear phase-out continued as planned, our assumptions on other plant closures and new build over 2014-20 lead us to conclude that emissions from German generators would likely increase by nearly 40Mt by 2020 compared with today's level (Figure 4).

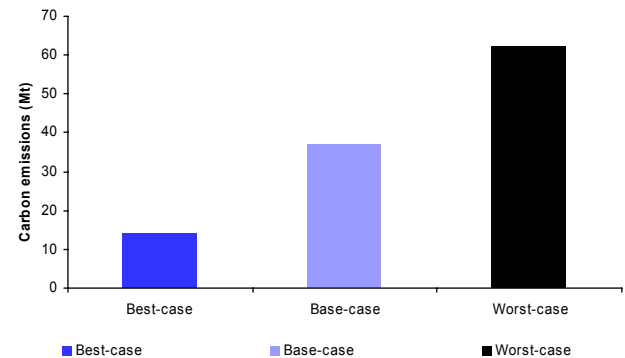
Our worst-case scenario suggests that by 2020 emissions could be up to 62Mt higher than they are today, while in our best case they would be only 14Mt higher (again, Figure 4).

Figure 3: DB estimate of increase in ETS emissions from changing German capacity mix under nuclear phase-out, 2009-13 and 2014-20



Source: Deutsche Bank

Figure 4: DB estimate of increase in ETS emissions from changing German capacity mix under nuclear phase-out, 2009-20



Source: Deutsche Bank

However, in order for the mix of new capacity to be built that we have assumed in all our scenarios, both power and carbon prices would have to be higher than current levels.

The need for new build would help both power and EUA prices

As far as the capacity situation is concerned, we conclude that the situation would be manageable out to 2013, but in order to ensure that the planned 4.7GW of new CCGT plant we assume would come onstream by 2013 were indeed built EUA prices would need to be higher than they are today.

Otherwise there would be less new CCGT capacity than we have assumed by 2013, more new coal capacity instead, and a correspondingly greater increase in emissions than we have calculated (indeed, the recent decision of E.ON and Gazprom to postpone their planned 1,200MW CCGT plant at Lubmin strongly supports this view – see Caveat 3 below).

This means that there would be a positive impact on EUA prices from the continuation of the nuclear phase-out in two ways: (i) emissions would be higher by 2013 than they are today owing to the loss of CO₂-free output from nuclear capacity (by 15Mt in our base-case); (ii) the EUA price would need to be above current levels to ensure that the CCGT plant we are assuming were actually built.

However, if the nuclear phase-out were to continue over 2014-20 then we think that the capacity situation would become increasingly difficult to sustain as our base-case scenario results in a decline in firm capacity of 15GW by 2020 against current levels, to only 5GW. If we assume the same level of peak demand in 2020 as today (70GW), then this would leave a very tight reserve margin of only 7% by 2020, well below the 10% normally considered the minimum prudent level.

As a result, in the event of the nuclear phase-out's continuing over 2014-20, we think both power and carbon prices would have to rise significantly over this period in order to ensure (i) that the amount of new capacity we have here assumed by 2020 would indeed be built, and (ii) that the new CCGT plant in particular that we have assumed would be built.

EUAs could benefit if election results indicate unchanged policy

We expect German generators to start selling 2013 electricity from mid-2010, and with power companies having to purchase 100% of their EUAs from 2013, and the EU very unlikely to auction 2013 EUAs already by mid-2010, this could create significant demand for Phase-3 EUAs next year that would have to be met from Phase-2 allocations.

As explained in our report of 5 May 2009, *The Long and the Short of It*, for Germany alone we estimate that demand for Phase-3 EUAs could reach 139Mt by year-end 2010, 480Mt by y/e 2011, and 1,100Mt by y/e 2012. For the EU overall we think demand for Phase-3 EUAs could reach at least 210Mt by y/e 2010, 720Mt by y/e 2011, and 1,615Mt by y/e 2012.

We expect this in itself to be enough to bid up EUAs relative to CERs and to move EUAs into a €16-18/t range over the next 12 months, but the phase-out of 7.1GW of nuclear power over 2010-13 would exacerbate the German generators' already severe EUA shortage from 2013.

As a result, if Germany's general-election outcome in September indicated a continuation of the current nuclear phase-out policy, this could provide further support for EUA and power prices in Q4 of this year and beyond given (i) the increase in expected emissions such an electoral outcome would lead to, and (ii) the higher carbon price that would be needed under such a scenario to make new CCGT plant competitive with new coal plant in Germany.

Meanwhile, we expect EUA prices to remain sensitive to macro newsflow and oil prices over the summer.

Caveats to our analysis in this report

There are three main caveats to our findings in this report:

Caveat 1: The timing of individual plant closures if the nuclear phase-out continued

The dates by which Germany's remaining nuclear power plants are due to close shown in Figure 5 below assume they generate their allowed residual output at an 85% load factor. If they were to run at higher or lower load factors than this, or were subject to unscheduled outages, the dates by which they would close would in practice be different. Moreover, in the case of Biblis-B, the closing date will in practice be 2013 rather than 2010 owing to the transfer of some of the output to this station from Mühlheim-Kärlich.

Nonetheless, if the phase-out law remained in place after September's election we would still expect Biblis-B to close towards the end of the next parliament (in 2013), and the six other stations affected to close more or less around the dates shown in Figure 5. As a result, we think our analysis concerning the impact of their potential closures on 2013 CO₂ emissions holds good.

Caveat 2: The impact on the merit order of new fossil-fuel fired plant

In analyzing the extent to which new fossil-fuel plant would displace older fossil-fuel plant and thereby offset to some extent the increase in emissions that would result from the continuation of the nuclear phase-out, we assume that the new CCGT plant – like the new lignite and hard coal plant – will for the most part run baseload (not least because we expect carbon prices to rise over the medium to long term).

However, if most new CCGT plant were to run at a lower load factor than the 82% we have assumed, then the increase in CO₂ emissions in the event of the nuclear phase-out's proceeding over 2010-20 would be greater than our analysis indicates.

More generally, we would emphasize that it is impossible to know for sure what the precise impact of the ripple effect on the merit order of our assumed capacity changes over 2009-13 and 2014-20 would be, and hence impossible also to know what the precise impact of these changes on emissions would be.

For example, new baseload lignite plant will directly displace older baseload-lignite plant, and this will reduce emissions. However, some of the older baseload-lignite capacity thus displaced might then, in turn, displace older baseload-coal capacity, thereby actually increasing emissions. Similarly, new baseload coal might displace older lignite or coal plant and hence reduce emissions, but the older coal and/or lignite plant thereby displaced might in turn displace older gas plant in mid-merit running hours, thereby increasing emissions.

As a result, our stylized analysis in this report should be taken as a best estimate of the likely increase in CO₂ emissions that would result from the nuclear phase-out and the other capacity changes over 2009-13 and 2014-20 we have here modelled.

Caveat 3: Would all the new capacity we are here assuming by 2013 in fact be built?

In Section 2 below our analysis of the capacity that would be built in the event that the nuclear phase-out were to go ahead includes at least one plant – the 1,200 MW CCGT at Lubmin – that has recently been put on hold by its developers. However, the decision to put this plant on hold has been taken before we know what the outcome of the election will be and hence what the policy on the nuclear phase-out over 2010-13 will be.

In our view, if the nuclear phase-out were to go ahead as planned – which is the scenario we are analyzing in this report – then this plant would indeed be built precisely because there would then be a clear need for new firm capacity of this kind, and hence a price signal to incentivize it. As already explained above, however, power prices and carbon prices would have to rise materially above current levels to ensure (i) that the capacity we have here assumed were indeed built, and (ii) that the CCGT plant in particular were built.

Otherwise, if EUA prices were not high enough to incentivize enough new CCGT plan, more new coal plants would be built and the increase in emissions by 2013 in the event of the nuclear phase-out would be greater than we have here assumed.

Caveat 4: Our analysis in this report is of ETS emissions only

Our conclusion that Germany's CO₂ emissions would rise by 2013 and 2020 in the event of the nuclear phase-out's continuation beyond the forthcoming election relates only to ETS emissions from the power generators. It is worth noting, however, that 1,600MW of the new coal plant we assume will be built by 2013 would be combined heat-and-power (CHP) plant, and this should help reduce emissions in the non-ETS part of the economy.

The structure of this report

This report is divided into three main sections, with a glossary at the end to explain the acronyms used throughout. Section 1 sets out the planned phase-out of Germany's nuclear plant over 2010-20, as well as the older fossil-fuel plant that could be taken off the grid over the same period. Section 2 then examines the planned new capacity to be built in Germany over 2009-13, breaking it down by fuel-type and by its current stage of development.

Section 3 then analyzes in detail the impact that the potential plant closures shown in Section 1 and the likely new build shown in Section 2 would have on Germany's generation-capacity levels and CO₂ emissions by 2013. It also examines potential new build over 2014-20 and the impact this new build – together with the potential nuclear and fossil-fuel plant closures over this period – could have on capacity levels and CO₂ emissions by 2020.

Valuation and risks

In theory, we think that the Phase-3 ETS cap agreed at the EU Heads of Government Summit last December is tight enough to imply an EUA price of €25-€30/t already in 2009. This is because expectations about a much tighter cap in Phase 3 will make Phase-2 allowances more valuable given that they can be carried over into Phase 3.

In effect, the bankability of Phase-2 EUAs means that the shortage of EUAs foreseen by the market in Phase 3 should already be anticipated in Phase 2 (assuming the market is efficient). In other words, bankability means that we have to consider the expected residual abatement requirement in Phases 2 and 3 together rather than separately. On our assumptions, the proposed Phase-3 cap results in an average residual abatement requirement within the ETS of 42Mt per year over the entire 2008-20.

In practice, we think that market inefficiencies engendered principally by the *ex-ante* free allocation of EUAs could keep prices well below our theoretical fair value throughout 2009 and the first half of 2010. In particular, with our forecasts showing Phase 2 viewed in isolation to be long of EUAs by an average of 23Mt per year, we think the EUA price will remain volatile and potentially vulnerable to any further deterioration in the EU economy beyond that already indicated in our forecasts.

1. The impact of the nuclear phase-out over 2010-13

In 2000, the German Government passed a law to phase out all nuclear power stations after the equivalent of 32 years' operating life, granting a set number of hours per station according to a standardized load factor over 32 years. This is well below the standard operating life of 40 years that was assumed when these PWR (pressurized-water reactor) and BWR (boiling-water reactor) stations were built, and barely more than half the 60 years' life of which they are technically capable after additional capex, and which has been granted to over 30 PWR and BWR stations in the US in recent years.

So far, 980MW of nuclear capacity has been shut down in accordance with this law, but the two plants that have been closed to date were both taken offline in the previous parliament under the SPD-Green coalition government.

However, with elections for a new parliament to take place this coming 27 September, the next government will have to decide whether to leave the nuclear-phase out law in place, or whether to extend the lifetimes of those plants due to close over the next four years. The stakes are high, as between October 2009 and September 2013 – the period covered by the next Parliament – there are 7.1GW of nuclear capacity due to close.

At the same time, assuming older fossil-fuel fired plants were to close after 40 years' operating life, then Germany could lose a further 9.4GW of capacity by 2013. In short, if the nuclear phase-out were to go ahead, then other things being equal Germany would have to replace 53TWh of CO₂-free output by 2013 while also ensuring that a total of up to 16.5GW of new capacity were built by that date to preserve capacity-reserve margins at today's level.

There are 7GW of nuclear capacity scheduled for closure by 2013

In April 2002 Germany's amended Atomic Energy Act entered into force with the objective of phasing out all nuclear power by 2022 (although outages since have meant this is now likely to be 2023).

In accordance with this law, two nuclear power stations were permanently shut down under the previous SPD/Green coalition government (Stade in 2003, and Obrigheim in 2005), but over the lifetime of the current parliament – governed by a so-called 'Grand Coalition' CDU/CSU-SPD Government following the last general election in September 2005 – there have been no further closures.

However, over 2010-13 – i.e. over the period covered by the next German parliament – there are 7.1GW of nuclear capacity scheduled to come off the system under the terms of the existing legislation. The plants in question are Biblis-A (1,167MW), Neckarwestheim-1 (785MW), Biblis-B (1,227MW), Brunsbüttel (771MW), Isar-1 (878MW), Unterweser (1,345MW) and Philippsburg-1 (890MW). These seven plants are highlighted in blue in Figure 5.

(As explained in Caveat 1 above, in reality Biblis B will likely run until early 2013 with the output transferred to it from Mühlheim-Kärlich, but this does not materially alter our analysis as we would still expect it to come offline over the course of the next Parliament, and what we are interested in here is the impact of changes in Germany's capacity mix by 2013).

Figure 5: Nuclear power plants in Germany: remaining capacities after shut-down

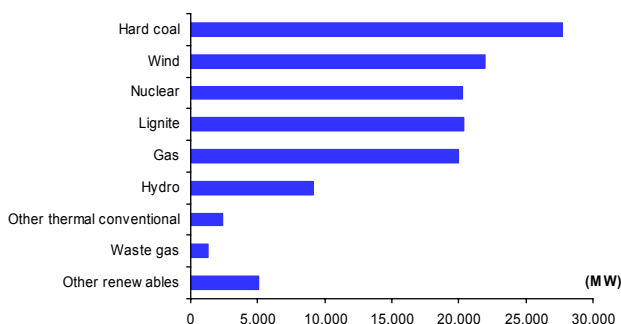
Power Plant	Owner	Chronological order of phase-out	Capacity per power plant (MW)	Date of shut-down (load factor 85%)	Remaining German capacity after shut-down**
Stade	EON:66.7% / Vattenfall:33.3%	1	640	11/14/2003	20,757
Obrigheim	EnBW:99.8% / Deutsche Bahn:0.2%	2	340	05/11/2005	20,457
Neckarwestheim-1	EnBW:99.8% / Deutsche Bahn:0.2%	3	785	02/13/2010	19,667
Biblis A	RWE	4	1,167	03/10/2010*	18,500
Biblis B	RWE	5	1,227	10/04/2010*	17,273
Brunsbüttel	Vattenfall:66.7% / EON:33.3%	6	771	01/29/2011	16,502
Isar-1	EON	7	878	07/15/2011	15,624
Philippsburg-1	EnBW:99.8% / Deutsche Bahn:0.2%	8	890	05/19/2012	14,734
Unterweser	EON	9	1,345	05/23/2012	13,389
Grafenheinfeld	EON	10	1,275	04/09/2015	12,114
Gundremmingen B	RWE:75% / EON: 25%	11	1,284	04/17/2016	10,830
Gundremmingen C	RWE:75% / EON: 25%	12	1,288	03/22/2017	9,542
Krümmel	Vattenfall:50% / EON:50%	13	1,346	12/29/2017	8,196
Philippsburg-2	EnBW:99.8% / Deutsche Bahn:0.2%	14	1,392	11/15/2018	6,804
Grohnde	EON:83.3% / SW Bielefeld:16.7%	15	1,360	03/02/2019	5,444
Brokdorf	EON:80% / Vattenfall:20%	16	1,410	02/07/2020	4,034
Isar-2	EON:75% / SW München:25%	17	1,400	03/18/2021	2,634
Emsland	RWE:87.5% / EON:12.5%	18	1,329	03/12/2022	1,305
Neckarwestheim-2	EnBW:99.8% / Deutsche Bahn:0.2%	19	1,305	07/11/2023	0

Source: RWE; * Separate estimation for Biblis A and B, including extended inspection outages in 2009; ** Inconsistencies are caused by increased power outputs of the remaining plants due to retrofit, 21397 MW after Stade closing

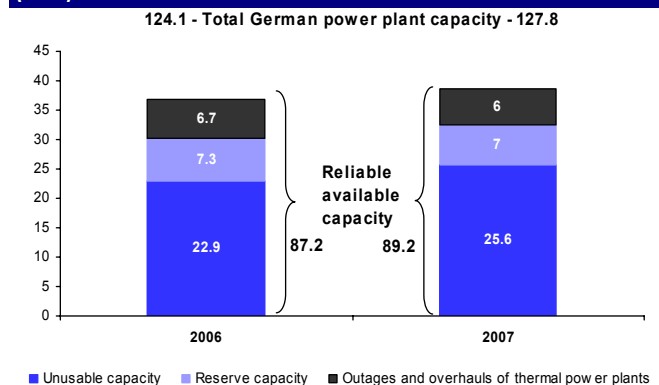
To put these planned closures into context, it is useful to look at Germany's nuclear power as a proportion of both total capacity and output

Nuclear plants account for 20%-25% of Germany's available firm capacity

Figure 6 shows the breakdown of Germany's generation capacity at year-end 2007 by fuel type, the total amounting to 128GW at the end of 2007 (Figure 7). At 27GW, hard-coal plants accounted for 21% of Germany's total capacity, while at 20.5GW nuclear stations accounted for 16% (about the same as lignite).

Figure 6: Total generation capacity in Germany, 2007

Source: UCTE, EURACOAL, European Union, German Energy Agency

Figure 7: Reliable available capacity in Germany, 2007 (GW)

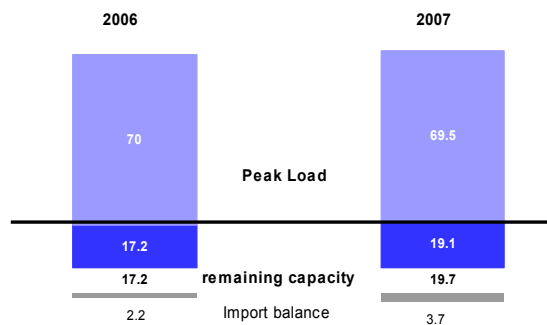
Source: RWE from UCTE

In reality, however, this understates the true proportion of capacity accounted for by nuclear power in Germany because much of the capacity theoretically available is not reliable at all times.

For example, Germany has 24GW of installed onshore-wind capacity, but only 5% of this gross number (i.e. 1.2GW) can be considered 'firm' as in the least favourable weather conditions only 5% of this capacity would actually be available to generate (for offshore-wind farms, we assume firm capacity to be 10% of the gross capacity to reflect its correspondingly higher level of minimum availability).

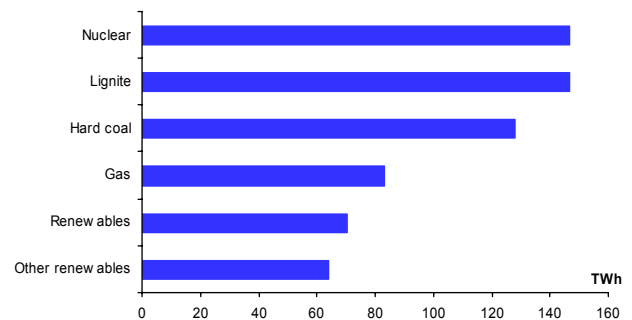
As a result, once adjustments are made for unusable capacity, reserve capacity, and outages, the real figure for reliable available capacity is much lower. As shown in Figure 7, RWE's estimates a more realistic number for total German capacity in 2007 would be 89.2GW, against peak demand of 70GW (Figure 8).

Figure 8: Germany's capacity margin, 2007 (GW)



Source: RWE

Figure 9: German power output by source, 2007



Source: RWE from UCTE

Accordingly, we would estimate that nuclear accounts for about 23% of total firm capacity at the moment, which, as Figure 9 shows, is in line with its share of output (149TWh out of 639TWh in 2007, or 23%).

In short, the seven plants due to close over the course of the next Parliament account for 35% of Germany's remaining nuclear capacity of 20.5GW, and 8% of Germany's total reliable available capacity of 89.2GW as at year-end 2007.

Nuclear power: carbon free and 23% of Germany's electricity output in 2008

As shown in Figure 9, nuclear power was the joint-first source of electricity along with lignite, accounting for 149TWh or 23% of the total 639TWh generated last year.

The reason nuclear accounts for a higher proportion of total output than hard coal even though, as shown in Figure 6, Germany has more hard-coal capacity than nuclear is that nuclear power plants run baseload for technical and economic reasons.

Technically, nuclear plants are not as flexible as coal plants, so once online they generally run 24 hours a day for seven days a week, with maintenance outages scheduled at appropriate intervals, such that on average in Germany they typically run at an annual load factor of 85%.

Economically, nuclear power plants have very high upfront capital costs, and the construction-lead times are much longer than those for fossil-fuel plants. Once built, however, nuclear plants have much lower running costs than fossil-fuel plants, and for this reason they are the cheapest source of power after hydro and wind. As a result, they are dispatched ahead of fossil-fuel plants in the merit order.

All of which means that assuming an 85% load factor, the seven plants scheduled to close by 2012 currently produce 53TWh of CO₂-free electricity per year, or 8% of Germany's total output. Given the profile of the scheduled shutdowns, this means that compared with 2008 production levels Germany would lose 14TWh of nuclear output in 2010, 32TWh in 2011, 46TWh in 2012, and 53TWh in 2013.

This is shown in blue in Figure 10, along with the cumulative loss in nuclear output at the end of each year, which we estimate would reach 145TWh by 2013.

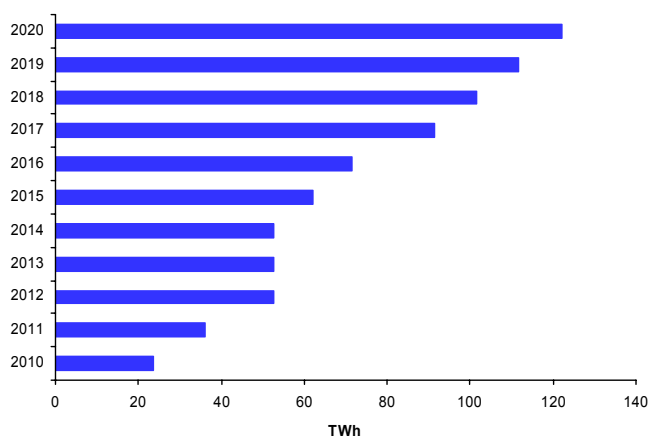
Figure 10: Yearly output loss due to nuclear plant closure over 2010-2020 (MWh)

	Capacity loss in the year	Output loss in a year due to closures of the year	Output loss in a year due to all closures since 2010	Cumulative output loss since 2008
2010	3,184	14,422,759	14,422,759	14,422,759
2011	1,649	8,311,735	32,019,799	46,442,558
2012	2,235	10,194,492	46,181,010	92,623,568
2013	0	0	52,628,328	145,251,896
2014	0	0	52,628,328	197,880,224
2015	1,275	6,918,660	59,546,988	257,427,212
2016	1,284	6,757,949	68,879,927	326,307,139
2017	2,634	7,517,074	79,199,716	405,506,855
2018	1,392	1,306,253	92,601,659	498,108,514
2019	1,360	8,434,176	110,094,414	608,202,928
2020	1,410	9,405,828	121,192,626	729,395,554
2021	1,400	8,225,280	130,510,938	859,906,492
2022	1,329	7,970,810	140,680,868	1,000,587,360
2023	1,305	4,605,606	147,211,398	1,147,798,758

Source: Deutsche Bank

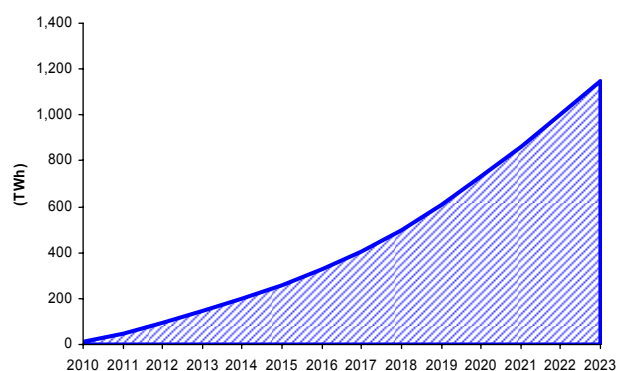
Figures 11 and 12 then show the annual and cumulative nuclear output lost over 2010-20 and 2010-23 respectively

Figure 11: Annual nuclear output loss, 2010-2020



Source: Eurelectric

Figure 12: Cumulative nuclear-output loss, 2008-20



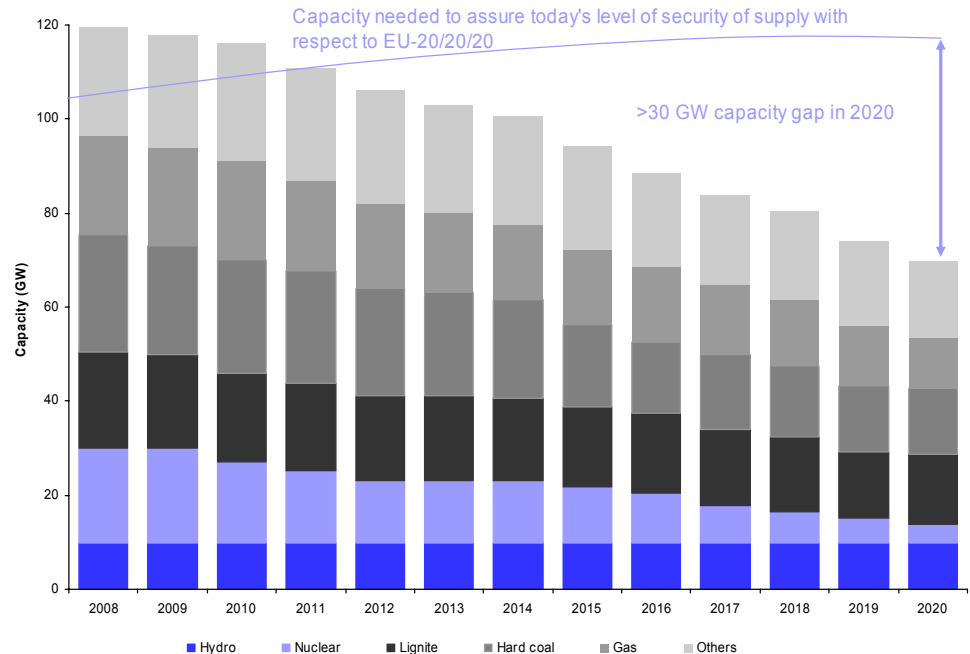
Source: VDN, RWE from UCTE

The phase-out of 7GW of nuclear power over the course of the next German parliament would mean that at least this much firm capacity would have to be built by 2013 to maintain current reserve margins, but at the same time there is another 9.4GW of capacity that could come off the system over 2009-13.

And up to 9.4GW of older fossil-fuel plant might close by 2013

Figure 13 shows the potential closure of power plants in Germany over 2008-20 assuming the nuclear phase-out goes ahead and that all fossil-fuel power plants close after an operating life of 40 years. The graph is taken from RWE's *Facts and Figures 2009* publication (available at <http://www.rwe.com/web/cms/en/114404/rwe/investor-relations/events-presentations>).

Figure 13: Potential capacity withdrawals in Germany, 2008E-2020E



Source: RWE

RWE estimates that after taking into account the nuclear phase-out and the closure of all fossil-fuel plants after 40 years' operating life, then even after allowing for all the new plant currently under construction (which, as explained in Section 2 below, we estimate at 11.1GW) there would need to be a further 30GW of new capacity constructed by 2020 in order to retain the reserve margin at today's levels. Figure 14 shows our estimate of the breakdown of plant closures by 2020 based on RWE's numbers, which totals nearly 50GW.

Figure 14: Capacity loss from expected closures in fossil fuel & nuclear power plants over 2008-20 (MW)

	Nuclear power plants	Lignite fired plants	Coal fired plants	Gas fired plants	Other (assumed oil)	TOTAL
2009	0	385	2,000	0	0	2,385
2010	3,184	1,000	0	0	0	4,184
2011	1,649	500	0	2,000	0	4,149
2012	2,235	500	0	1,000	0	3,735
2013	0	0	1,000	1,000	0	2,000
2014	0	500	1,000	1,000	0	2,500
2015	1,275	500	3,500	0	1000	6,275
2016	1,284	0	2,500	0	2000	5,784
2017	2,634	1,000	0	1,000	1000	5,634
2018	1,392	0	0	1,000	0	2,392
2019	1,360	2,000	1,000	1,000	1000	6,360
2020	1,410	-1,000	0	2,000	2000	4,410
TOTAL	16,463	5,385	11,000	10,000	7,000	49,808

Source: RWE, Deutsche Bank

Looking more closely at the four-year period covered by the next German parliament, we estimate that in addition to the 7.1GW of nuclear capacity currently scheduled for closure there would be 9.4GW of older fossil-fuel plant that would come off the grid by 2013 (Figure 15). Of this, 2.4GW would be lignite capacity, 3GW hard coal, and 4GW gas.

Figure 15: Capacity loss from expected closures in fossil-fuel & nuclear power plants over 2009-13 (MW)

	Nuclear power plants	Lignite-fired plants	Coal-fired plants	Gas-fired plants	Other (assumed oil)	TOTAL
2009		3,85	2,000	0	0	2,385
2010	3,184	1,000	0	0	0	4,184
2011	1,649	500	0	2,000	0	4,149
2012	2,235	500	0	1,000	0	3,735
2013		0	1,000	1,000	0	2,000
TOTAL	7,068	2,385	3,000	4,000	0	16,453

Source: RWE, Deutsche Bank

In short, in addition to the 7.1GW of nuclear plant to come off the grid by 2013, there would also be up to 9.4GW of older fossil-fuel fired plant potentially taken permanently offline by the end of the next Parliament.

Conclusion: next Parliament could see closure of 16.5GW

If the nuclear phase-out were to go ahead as planned over the course of the next German parliament, then we estimate that a total of nearly 16.5GW of capacity could be shut down by 2013.

The closure of any old capacity raises the need for replacement plants, but the point about the seven nuclear plants due to close by 2012 is not just the loss of output and reliable capacity that their closure over 2009-13 would imply, but the fact that nuclear power generates CO₂-free electricity.

Finding reliable, emissions-free replacement plants for this 7GW of nuclear capacity is therefore complicated. New fossil-fuel plants would be reliable and hence 'firm' capacity, but even the best-available technology CCGT plants emit 0.35t of CO₂ per MWh generated. On the other hand, wind capacity, like nuclear, generates CO₂-free power, but only a fraction of its gross capacity can be considered firm (we assume 5% for onshore and 10% for offshore).

All of which means that in replacing the 16.5GW of capacity that could be lost over the course of the next parliament it is not just a question of how much new capacity is in the pipeline and likely to be on the grid by 2013, but also what kind of capacity is being planned and constructed.

It is to a detailed examination of these questions that we now turn.

2. Fossil fuels dominate new build to 2013

As shown in Section 1, if the nuclear phase-out goes ahead as planned then there will be a need for the equivalent of 7.1GW of replacement capacity by 2013, while at the same time potential closures of older fossil-fuel plants could increase this new-build requirement by a further 9.4GW. Overall, this means that over the course of the next four-year Parliament, up to 16.5GW of new capacity could be required. So, based on current plans for new build, could this potential need actually be met, and, if so, what would be the implications for emissions and capacity margins in Germany?

In this respect, it is important from the outset to draw a distinction between the capacity already under construction and that which has been approved but where the ground (or seafloor) has not yet been broken. The data we are using (taken from the Platts publication *Power in Europe*, Issue 548, April 2009) identifies a total potential of 20.6GW of new power-generation capacity in Germany by 2013. Of this, we believe that 11.1GW are already under construction, with the remaining 9.5GW approved by the authorities but not yet being built.

Of the 11.1 GW under construction, the overwhelming majority (10.9GW) is fossil-fuel fired capacity. This breaks down as 5.9GW of hard-coal capacity, 2.8GW of lignite, and 2.3GW of CCGT. The rest comprises two pioneer offshore-wind projects totaling a little over 100MW.

As far as the new capacity approved but not yet under construction is concerned, there would appear to be a maximum theoretical capacity that could come onstream by 2013 of 9.5GW, most of which (6GW) would be offshore wind. However, most of this 6GW of planned new offshore capacity is on a bigger scale than the two pioneer farms already under construction, and much of it is also further out to sea and in deeper water.

As a result, we think there is a big risk that the higher cost, greater engineering challenge, and logistical bottlenecks of trying to build so much offshore capacity so quickly at such an early stage of the industry's development will lead to overruns against the expected start-up date. For this reason, we assume that only 2GW of the 6GW of offshore capacity currently approved will actually be online by 2013, albeit with an average load factor of 35% (which is materially higher than the 19% posted in 2008 by Germany's onshore wind portfolio).

However, even with this higher assumed load factor, 2GW of *gross* new offshore-wind capacity would equate to only 200MW of *firm* new capacity as in the least favourable weather conditions only 10% of this capacity would actually be available to generate. Accordingly, we assume total new *gross* capacity of 17.5GW by 2013, but new *firm* capacity of 15.6GW after adjusting for the contribution from offshore wind. Nearly all of this would be fossil-fuel based (15.4GW), and most of it either coal or lignite (10.3GW).

In short, we conclude that there would be just about enough new build in the pipeline to cover the capacity that would be lost by the continuation of the nuclear phase-out and the closure of older fossil fuel plants by 2013, but that the average carbon intensity of the new plant would be greater than the average carbon intensity of the lost nuclear and older fossil-fuel plants combined.

We examine the implications of this conclusion for carbon emissions and capacity margins in Section 3 below.

Planned new capacity in Germany: coal is still king

Figure 16 shows the planned new capacity in Germany either already under construction or approved for construction. Our source for this data is the *Platts* publication *Power in Europe* (Issue 548, April 2009), which to our knowledge provides the most comprehensive survey and updates on planned new capacity across the EU. The capacity of the plants already under construction in Germany comes to 11.1GW, and that approved but awaiting construction 9.5GW. We have highlighted the planned offshore wind capacity in blue.

Figure 16: German power plants under construction or approved

Location	Estimated capacity (MW)	Type	Potential start date as given by Platts	DB estimated start date*
UNDER CONSTRUCTION				
Lingen, Emsland	875	CCGT	Spring 2009	2009
Neurath, Rheinland-Pfalz	2,100	Lignite	Mid/late 2011	2011
Walsum – Unit 10, Duisburg	750	Coal	1.1.2010	2010
Boxberg, Saxony	675	Lignite	2011	2011
Irsching 5, Ingolstadt	845	CCGT	End 2008	2009
Irsching 4, Ingolstadt	530	CCGT	End 2008	2011
Westfalen, Hamm-Uentrop	1,600	Coal	2013	2013
Lunen, West Rhine Westphalia	750	Coal	2012	2012
Baltic 1, Baltic Sea	52.5	Offshore wind	2010-11	2011
Datteln 4	1,100	Coal	2011	2011
Rheinhafen (RDK8), Karlsruhe	912	Coal	2011/12	2012
Alpha Ventus (Borkum West)	60	Offshore wind	2009	2009
Wilhelmshaven	800	Coal	2012	2013
TOTAL under construction	11,050			
APPROVED				
Nordergrunde, North Sea	90	Offshore wind	2010	2010
Burg	150	Waste – CHP	2009	2009
Borkum Riffgrund	231	Offshore wind	2009	2011
Borkum Riffgrund	450	Offshore wind	(4 years later)	2015 or later
Dillingen steel works, Saarland	230	Waste gas	2009	2010
Butendiek, North Sea	270	Offshore wind	End-2012	2013
Amrumbank West	350	Offshore wind	2010-11?	2014 or later
Nordsee Ost	360	Offshore wind	Sep-12	2015 or later
Sandbank 24, 90km west of Sylt	400	Offshore wind		2013
Bay of Lubeck	150	Offshore wind	2008?	2011
Offshore North Sea Wind Station, Juist	280	Offshore wind		2015 or later
Gode Wind, Norderney, North Sea	400	Offshore wind	2010?	2012
Lubmin, Mecklenburg-Vorpommern	1,200	CCGT	2011	2011
Bard Offshore 1, western North Sea	400	Offshore wind	2009	2014 or later
Kriegers Flak 1	332	Offshore wind		2013
Hochsee Windpark Nordsee, N Sea	400	Offshore wind	2012	2014 or later
Global Tech 1	360	Offshore wind	2012	2014 or later
Moorburg, Hamburg	1,640	Coal CHP	Apr-12	2012
Bocholt Power, NRW	420	CCGT	2012	2012
Nordlicher Grund, North Sea	400	Offshore wind	2008?	2014 or later
Borkum West 2	200	Offshore wind	2011-12	2012
Dan Tysk, North Sea	400	Offshore wind	2013	2014 or later
Meerwind, North Sea	400	Offshore wind	2012-13	2014 or later
TOTAL approved	9,513			

Source: Deutsche Bank from Platts; *the dates in this column are those by which we think it is realistic to assume the plant in question will be online

Coal is the dominant fuel source in plants under construction

Grouping the 11.1GW of capacity under construction by fuel type (Figure 17), we can see that coal accounts for over half (5.9GW, or 54%), followed by lignite (2.8GW or 25%), and CCGT (2.3GW or 20%). The amount of offshore wind, by contrast, is negligible.

Figure 17: Breakdown of new generation capacity in Germany under construction

Fuel source	Capacity (MW)	% of total
Hard coal	5,912	53.5
Lignite	2,775	25.1
CCGT	2,250	20.4
Offshore wind	113	1.0
TOTAL	11,050	100

Source: Platts, Deutsche Bank

Offshore wind accounts for the majority of the approved capacity

Looking next at the breakdown of the 9.5GW of approved capacity awaiting construction by fuel type (Figure 18), we can see that offshore wind accounts for the majority (6GW or 62%), followed by coal-fired CHP and CCGT.

Figure 18: Breakdown of approved new capacity in Germany awaiting construction

Fuel source	Capacity (MW)	% of total
Coal-fired CHP	1,640	17.2
Lignite	0	0
CCGT	1,620	17.0
Offshore wind	5,873	61.8
Other	380	4.0
TOTAL	9,513	100

Source: Platts, Deutsche Bank

While coal is again the dominant fuel source for plants proposed but not yet approved

Figure 20 shows all the other potential new capacity in Germany, which is to say capacity either at the application stage, the proposal or pre-proposal stage, or plants where the project has either been suspended or postponed. In this case, as shown in Figure 19, fossil-fuel fired capacity dominates, with 24GW of the 26GW in total either coal, lignite, or CCGT, although 5.1GW of this is planned to be either CHP or CCS.

Figure 19: Breakdown of other planned generation capacity in Germany

Fuel source	Capacity (MW)	% of total
Hard coal	11,825	45.5
Lignite	660	2.5
Conventional coal	12,485	48.0
CCGT	6,546	25.2
Conventional fossil fuel	19,031	73.2
Lignite CCS	450	1.7
Coal CHP/cogen	4,525	17.4
Gas CHP	120	0.5
CHP and CCS fossil fuel	5,095	19.6
All Fossil fuel	24,126	92.8
Other	1,869	7.2
TOTAL	25,995	100

Source: Platts, Deutsche Bank

Figure 20: Planned new generation capacity in Germany at early stages of development

Location	Estimated capacity (MW)	Type	Starting date	DB estimated start date*
APPLIED				
Eisenhüttenstadt, Brandenburg	800	CCGT	2010?	2012
PROPOSED/PROPOSAL				
Rheinhafen (RDK8), Karlsruhe	460	CCGT	2010	Not before 2013
Duisburg	300	Waste gas	Post-2008	Not before 2013
Lippstadt	260	CCGT	2008/9	Not before 2013
Stade or Brunsbüttel	800	Coal	2012	Not before 2013
Brunsbüttel	1800	Coal	2012	Not before 2013
Brunsbüttel	800	Coal – CHP?	2013	Not before 2013
Salzgitter	220	Waste gas, LFO	2011	Not before 2013
Dettelnbach	800	CCGT		Not before 2013
Gerhausen, Ulm	45	Pumped storage	2011	Not before 2013
Dillfeld, Wetzlar	40	Waste to energy	2011	Not before 2013
Ludwigsau, Hessen	1,100	CCGT	2012?	Not before 2013
Innogy Nordsee 1	960	Offshore wind	2015	Not before 2013
Braunschweig	76	CCGT	Dec-10	Not before 2013
Lünen	750	Coal	2012	Not before 2013
Mittelsbüren, Bremen	420	CCGT	2013	Not before 2013
Ingelheimer Aue, Mainz	775	Coal CHP	2013	Not before 2013
Griesheim, Frankfurt am Main	450	CCGT	2011	Not before 2013
Krefeld-Uerdingen, NRW	750	Coal cogen	2012	Not before 2013
Dorpen, Lower Saxony	900	Coal (CHP?)	2015?	Not before 2013
Riffgat, Lower Saxony	264	Offshore wind	2012	Not before 2013
Griesswald (Lubmin), Mecklenburg-Vorpommern	1,600	Coal	2012	Not before 2013
Stade, Lower Saxony	850	Coal, gas	End-2014	Not before 2013
Hurth, Cologne, North Rhine Westphalia	450	Lignite IGCC + CCS	2014	Not before 2013
Staudinger (Grosskrotzenburg) Hesse	1,100	Coal	2013	Not before 2013
Mannheim	900	Coal CHP	2013	Not before 2013
Profen, Saxony Anhalt	660	Lignite	2014/15	Not before 2013
Frankfurt	1,100	Coal	2014/15	Not before 2013
Wilhelmshaven	500	Coal	2014	Not before 2013
Premnitz, Berlin	400	CCGT	2013-14	Not before 2013
Klingenberg, Lichtenfelde, Berlin	40	Biomass	2014	Not before 2013
Klingenberg, Lichtenfelde, Berlin	580	CCGT	2015	Not before 2013
PRE-PROPOSAL				
Dortmund	750	Coal		Not before 2013
Bestenheid industrial estate, Wertheim?	350	Gas or coal	2009 or 2013/14	Not before 2013
Lausward, Düsseldorf harbour	400	Coal CHP	2012	Not before 2013
Duisburg-Wanheim	120	Gas CHP	End 2012	Not before 2013
Gelsenkirchen-Scholven?	1,100	Coal	2014/15	Not before 2013
Arneburg, Stendal, Saxony Anhalt	?	Coal	2014-18	Not before 2013
SUSPENDED/POSTPONED				
Niehl, Cologne	775	Coal	2012	Not before 2013
Herne 5	750	Coal	2011	Not before 2013
Kiel	800	Coal		Not before 2013
GRAND TOTAL	25,995			

Source: Deutsche Bank from Platts; *Given the obstacles to large new infrastructure projects outlined in the main text below, we do not think that it is realistic to assume that any of these plants will be online before 2014 apart from the 800MW CCGT plant at Eisenhüttenstadt

Coal is still the new entrant of choice in Germany

As is clear from our analysis of the planned new capacity in Germany above, when we take all of this capacity into account – that which is already under construction, approved, or at earlier stages of planning – it is clear that coal is the pre-eminent fuel source for plant developers.

The question is, how much of this plant will actually make it onto the grid by 2013 and thus be able to replace the 7GW of potentially lost nuclear plant and the 9GW of potentially lost older fossil-fuel plant?

We expect 17.5GW of total new capacity by 2013

Figure 21 shows how much of the planned new capacity shown above we think it reasonable to assume will be on the system by 2013. In our view, all of the plant currently under construction will be on the system by 2013 or before. As far as the plant that has been approved is concerned, we expect only 5.6GW out of the total 9.5GW to be online by 2013, while of the capacity at earlier stages of planning we think only the plant that has already applied for a licence – an 800MW CCGT in Eisenhüttenstadt – will be generating by 2013. In total, then, we are expecting 17.5GW of new capacity to be available by 2013.

Figure 21: DB estimate of planned new capacity available by 2013

Fuel source	Planned new capacity (MW)	DB estimate by 2013
Already under construction	11,050	11,050
Approved and awaiting construction	9,513	5,663
Earlier stages of planning	25,995	800
TOTAL	46,558	17,513

Source: Platt's, Deutsche Bank

Offshore-wind capacity will take time to build up

As far as the 9.5GW of planned new capacity that has already been approved is concerned, we are expecting all of the fossil-fuel plant approved to be online by 2013 (3.6GW as shown in Figure 17 above), but only 2GW of the planned 5.9GW of offshore wind. This is not because we think that much of this planned offshore capacity will ultimately not come onstream at all, but simply that the build-out of such a large amount of new capacity of a new technology in such a short space of time represents an enormous challenge. Specifically, we would highlight the following obstacles to building the full 5.9GW of approved offshore capacity by 2013:

- (i) Offshore wind is a new technology, and the pioneer plants reflect this fact. Baltic 1 and Alpha Ventus – the only two offshore-wind farms already under construction in Germany – are small scale at 53MW and 60MW respectively;
- (ii) Much of the planned capacity already approved is of a much bigger scale than these two pioneer projects (i.e. >200MW) and is further out to sea in deeper water, thereby increasing the engineering and logistical challenges;
- (iii) The planned development of so much new capacity in such a relatively short space of time could create supply bottlenecks for turbines and for the ships needed to install them;
- (iv) Grid connections, particularly further out to sea, are a further potential bottleneck.

As a result, we think it is unrealistic to assume that all of the 5.9GW of approved offshore capacity will be on the grid by 2013. Figure 22 shows which of the planned offshore projects we expect to be on the grid by 2013. In total, we think the full 113MW already under construction will be generating well before 2013, but that only 2,023MW of the planned 5,873 of approved capacity will be on the grid by then.

In general, we assume that the smaller the project, the earlier the planned start date, and the closer to the shore, then the more likely it is that the plant will be generating by 2013.

(As a caveat, we would point out that without precise updates on all matters relating to all projects there is inevitably a risk that our generalized approach here could be viewed as somewhat arbitrary at the level of individual projects. With this in mind we would emphasize that our assessment of which projects will be up and running by 2013 and which will not in no way reflects any judgement on our part concerning the intrinsic merits of the particular projects in question, simply our assessment based on the challenges we listed above, the criteria we have outlined, and the knowledge of each project that we have from the Platts Power in Europe publication.)

Figure 22: German offshore-wind capacity DB expects online by 2013

Location	Estimated capacity (MW)	DB estimated start date*	DB estimated capacity by 2013*	Comment
UNDER CONSTRUCTION				
Baltic 1, Baltic Sea	52.5	2011	52.5	Pioneer small-scale plant, 15 km out to sea
Alpha Ventus (Borkum West)	60	2009	60	Pioneer small-scale plant, 45km out to sea
TOTAL under construction	113		113	
APPROVED				
Nordergrunde, North Sea	90	2010	90	Small scale, 20km out to sea
Borkum Riffgrund	231	2011	231	Mid-size project, 38km out to sea
Borkum Riffgrund	450	2015	0	Second phase of this project, and bigger scale
Butendiek, North Sea	270	2013	270	Mid-size project, 35km out to sea
Amrumbank West	350	2014	350	Bigger size but planned project start date indicated at 2010-11, and at 30km from shore not too far out
Nordsee Ost	360	2014	0	Planned online date 2012, 30km out to sea
Sandbank 24, 90km west of Sylt	400	2013	0	Big size and 90km out to sea
Bay of Lubeck	150	2011	150	Relatively small scale and only 20km out to sea
Offshore North Sea Wind Station, Juist	280	2014	0	Decent size, 40km out to sea, we think 2014 realistic
Gode Wind, Norderney, North Sea	400	2012	400	Big size, but Platts indicates a possible start date of 2010, 33km out to sea, we think 2012 more realistic
Bard Offshore 1, western North Sea	400	2014	0	Big size and 100km out to sea so unrealistic before 2013 in our view
Kriegers Flak 1	332	2013	332	Scheduled completion end-2012 according to Platts, 30km out, 2013 more realistic in our view
Hochsee Windpark Nordsee, N Sea	400	2014	0	Big size and 90km out to sea
Global Tech 1	360	2014	0	Big size and 93km out to sea
Nordlicher Grund, North Sea	400	2014	0	Big size and at 84km out to sea
Borkum West 2	200	2012	200	Mid-size, 45 km out to sea
Dan Tysk, North Sea	400	2014	0	Big size, 50km out to sea, Platts says "completion scheduled for 2013" but we see 2014 more realistic
Meerwind, North Sea	400	2014	0	Big size and at 80km out to sea
TOTAL approved	5,873		2,023	

Source: Deutsche Bank from Platts

But offshore-wind capacity will have a much higher load factor than onshore wind

Figure 23 shows the implied expected load factors of three of the planned German offshore-wind farms, based on the expected annual output of each project as given in our source document, Platts' *Power in Europe*.

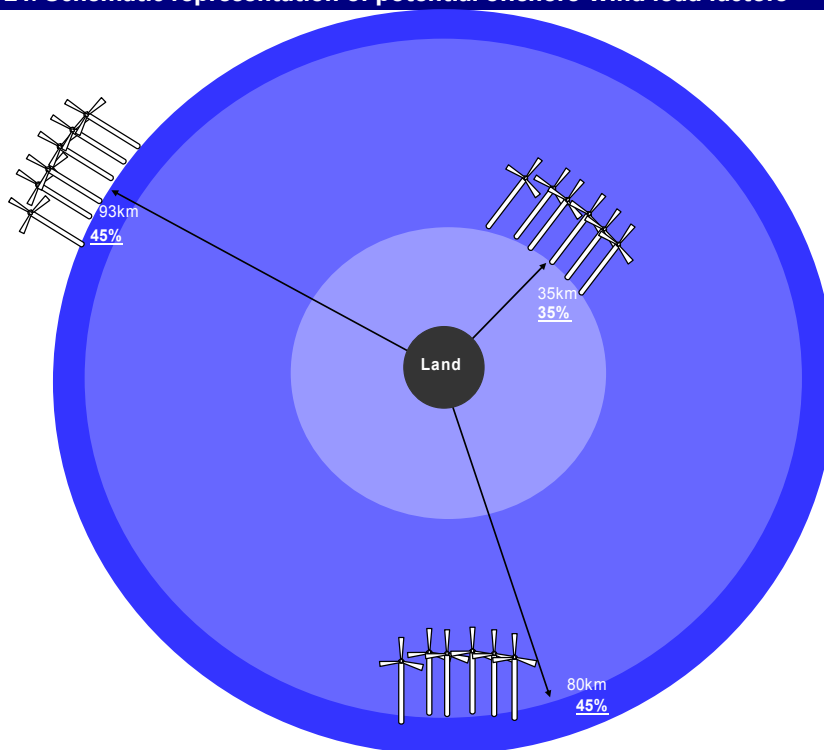
Figure 23: Implied load factor of selected planned German offshore wind farms

Location	Estimated capacity (MW)	Expected annual output	Implied load factor	Distance out to sea
Butendiek, North Sea	270	0.8TWh	35%	35km
Global Tech 1	360	1.4TWh	45%	93km
Meerwind, North Sea	400	1.6TWh	45%	80km

Source: Deutsche Bank from Platts

The implied load factors range from 35% to 45%, with the highest implied yields expected from farms to be located 80-90km out to sea. At ranges of 35-40km out to sea, the implied load factor is 35%. Figure 24 shows this schematically.

Figure 24: Schematic representation of potential offshore-wind load factors



Source: Deutsche Bank

These numbers are significantly better than the 19% load factor recorded by Germany's onshore-wind portfolio in 2008 (40TWh from an installed capacity of 23.9GW), and we henceforth assume an average load factor of 35% for offshore wind.

Large fossil-fuel plants at earlier planning stages face significant challenges

There are three main reasons why we expect so little of the capacity that has not yet been approved to be onstream by 2013:

- (i) the development of large new fossil-fuel plants has become more complicated in the last 18-24 months owing to higher construction costs (largely a function of higher commodity prices);

- (ii) supply bottlenecks on the part of component suppliers (a function of the high global demand over the last couple of years for large infrastructure projects, particularly in Asia); and
- (iii) increasingly difficult location issues (public protests in Germany against new coal power plants have increased markedly in the last couple of years).

As a result, we include the 800MW CCGT plant at Eisenhüttenstadt in our numbers (which has applied for a licence), but do not expect any of the other planned power plants listed in Figure 20 to be onstream by 2013.

... or 15.6 GW after adjusting for the load factor of offshore wind

Given that the load factor of offshore wind is significantly lower than that of a new fossil-fuel plant (up to 85% for a baseload plant), we need to adjust the 17.5GW of total new capacity we expect to be online by 2013.

Figure 25: DB estimate of adjusted planned new capacity available by 2013

Fuel source	Planned new capacity (MW)	DB estimated capacity by 2013 (MW)	DB firm capacity estimate by 2013 (MW)
Already under construction	11,050	11,050	10,948
<i>o/w offshore wind with an assumed firm capacity of 10% of gross amount</i>	<i>113</i>	<i>113</i>	<i>11</i>
Approved and awaiting construction	9,513	5,663	3,842
<i>o/w offshore wind with an assumed firm capacity of 10% of gross amount</i>	<i>5,873</i>	<i>2,136</i>	<i>202</i>
Earlier stages of planning	25,995	800	800
TOTAL	45,652	17,513	15,591

Source: Platts, Deutsche Bank

Figure 25 shows that the firm capacity we are expecting by 2013 is 15.6GW. This is because we adjust the gross wind capacity of 2,136MW to 214MW, reflecting our view that only 10% of the gross amount can be considered firm capacity.

Conclusion: new capacity by 2013 should just cover closures

Figure 26 shows the profile of new capacity start-ups derived from our analysis above. In total, we see 17.5GW coming online by 2013, 15.6GW of which would be firm. Nearly all of this would be fossil-fuel based (15.4GW), and most of it either coal or lignite (10.3GW).

Figure 26: DB assumed ramp-up of new capacity, 2009-2013 (MW)

	2009	2010	2011	2012	2013	TOTAL
Lignite			2,775			2,775
Coal		750	1,100	1,662	2,400	5,912
Coal CHP				1,640		1,640
CCGT	1,720		1,730	1,220		4,670
Offshore wind	60	90	684	550	752	2,136
Waste gas	150	230				380
TOTAL	1,930	1,070	6,289	5,072	3,152	17,513
<i>o/w firm capacity</i>	<i>1,876</i>	<i>989</i>	<i>5,673</i>	<i>4,577</i>	<i>2,475</i>	<i>15,591</i>
<i>o/w fossil fuel capacity</i>	<i>1,870</i>	<i>980</i>	<i>5,605</i>	<i>4,522</i>	<i>2,400</i>	<i>15,377</i>

Source: Deutsche Bank from Platts

Although at 15.6GW the new firm capacity we have assumed is almost 1GW less than the 16.5GW of capacity that would be lost by the continuation of the nuclear phase-out and the closure of older fossil fuel plants by 2013 shown in Figure 15 above, we conclude that there is just about enough new build in the pipeline to cover the potential closures.

(The new fossil-fuel plant would be much more reliable on a MW for MW basis than the old fossil-fuel plant that would leave the grid over 2009-13, and for reasons we explain in Section 3 below it is probably unrealistic to assume that the full 9.4GW of older fossil-fuel plant will close by 2013 in any case).

However, the average carbon intensity of the new plant that would be built would be significantly greater than the average carbon intensity of the lost nuclear and older fossil-fuel plants combined.

3. The upside risk to our ETS emissions forecasts

The change in the profile of Germany's generating capacity that would occur by 2013 based on the assumptions we have made in Sections 1 and 2 above would result in an increase in emissions from Germany's power sector against today's levels.

Overall, in the base-case scenario we have modelled we conclude that Germany's power sector would likely emit 15Mt of CO₂ more by 2013 than it does today if the 16.5GW of capacity that could close by that date were indeed to be removed from the grid and replaced by the profile of new build we outlined in Section 2. Running two sensitivities against this base case, we find that on a worst-case scenario emissions could rise by as much as 30Mt by 2013 relative to today's levels, while on a best-case scenario the increase might only be 6Mt.

Looking beyond 2013, and again assuming that the nuclear phase-out continued as planned, our base-case assumptions on other plant closures and new build over 2013-20 lead us to conclude that emissions from German generators would likely increase by c.40Mt by 2020 compared with today's level (the 15Mt by 2013 plus an incremental 22Mt owing to the changes in the capacity profile that we assume over 2013-20). Our worst-case scenario suggests that by 2020 emissions could be up to c.62Mt higher than they are today, while in our best-case scenario they would be only c.14Mt higher.

As far as the capacity situation is concerned, we conclude that the situation would be manageable out to 2013, as in our base-case scenario there would actually be a net increase in firm capacity of 2.3GW by 2013. However, if the nuclear phase-out were to continue over 2014-20 then we think that the capacity situation would become increasingly difficult to sustain as our base-case scenario results in a decline in firm capacity of 15GW by 2020 against current levels.

Emissions likely 15Mt higher by 2013 under nuclear phase-out ...

Figure 27 shows the net changes in the profile of Germany's generation capacity that would occur based on the assumptions we have made in Sections 1 and 2 above.

Figure 27: Change (>50MW) in capacity up to 2013 by type of power plants (MW)

	Nuclear		Lignite		Hard coal		Gas		Waste gas		Offshore wind		Annual total		Net cumulative change
	-	+	-	+	-	+	-	+	-	+	-	+	-	+	
2009			-385	0	-2,000	0	0	1,720	0	150	0	60	-2,385	1,930	-455
2010	-3,184	0	-1,000	0	0	750	0	0	0	230	0	90	-4,184	1,070	-3,569
2011	-1,649	0	-500	2,775	0	1,100	-2,000	1,730	0	0	0	683.5	-4,149	6,289	-1,430
2012	-2,235	0	-500	0	0	3302	-1,000	1,220	0	0	0	550	-3,735	5,072	-93
2013	0	0	0	0	-1,000	2,400	-1,000	0	0	0	0	752	-2,000	3,152	1,060
TOTAL		-7,068		390		4,552		670		380		2,136		1,060	

Source: Deutsche Bank

Given these changes in the amount and the profile of the capacity that we have assumed out to 2013 in the event of the nuclear phase-out going ahead as planned, what would be the impact on reserve margins and emissions of these changes?

The capacity change by 2013 is neutral in terms of its impact on the reserve margin

As shown in Figure 27, on our assumptions the net change in capacity by the end of 2013 compared with the amount of capacity available today is a small addition of 1,060MW if we take our assumed addition in offshore-wind capacity at full face value (i.e. the gross 2,136MW of capacity that we assume will be built by 2013).

However, and as we emphasized in Section 2 above, although offshore-wind capacity will have a significantly higher yield than onshore wind, at our assumed average load factor of 35% is still far below the 85% that would be achieved by a new fossil-fuel plant running at baseload. Adjusting for this by assuming an increase in net offshore-wind capacity of only 214MW rather than the gross 2,136MW (i.e. taking only 10% of the gross capacity as firm) would mean that there would in fact be a small reduction in overall capacity by 2013 of – about 900MW (Figure 28).

Figure 28: Change (>50MW) in capacity up to 2013 by type of power plants, adjusting for offshore-wind (MW)

	Nuclear		Lignite		Hard coal		Gas		Waste gas		Offshore wind		Annual total		Net cumulative change
	-	+	-	+	-	+	-	+	-	+	-	+	-	+	
2009			-385	0	-2,000	0	0	1,720	0	150	0	6	-2,385	1,876	-509
2010	-3,184	0	-1,000	0	0	750	0	0	0	230	0	9	-4,184	989	-3,704
2011	-1,649	0	-500	2,775	0	1,100	-2,000	1,730	0	0	0	68	-4,149	5,673	-2,180
2012	-2,235	0	-500	0	0	3,302	-1,000	1,220	0	0	0	55	-3,735	4,577	-1,338
2013	0	0	0	0	-1,000	2,400	-1,000	0	0	0	0	75	-2,000	2,475	-862
TOTAL		-7,068		390		4,552		670		380		214		-862	

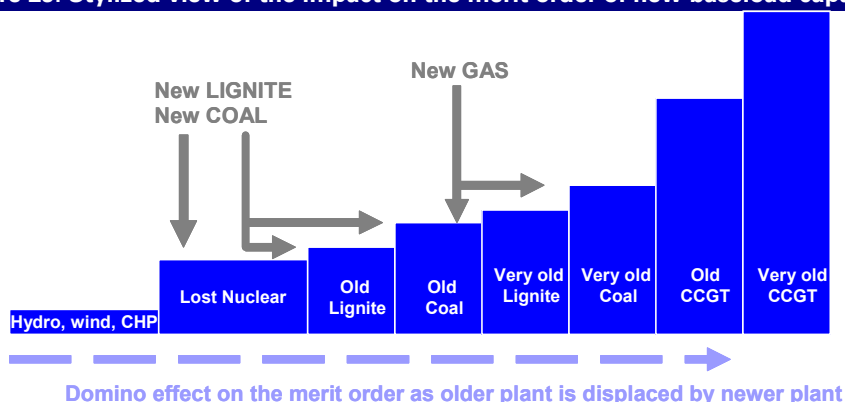
Source: Deutsche Bank

This means that the overwhelming majority of the new capacity that we have assumed will be built by 2013 will be new fossil-fuel plant (15GW), nearly all of which would run baseload. By contrast, the 9GW of fossil-fuel plant that we have assumed will close by 2013 is older plant, much of which would run mid-merit at best, or only at peak hours.

As a result, the new fossil-fuel plant will not replace the old plant directly. Rather, as the new plant runs baseload it (i) replaces the lost nuclear capacity, and (ii) pushes some fossil-fuel plant that was previously running baseload into the mid-merit part of the dispatch curve.

There is thus a domino effect across the merit order, finally resulting in our assumed closure of 9GW of older fossil-fuel plant, most of which was only running mid-merit or at the peak previously. This is shown in stylized form in Figure 30.

Figure 29: Stylized view of the impact on the merit order of new baseload capacity



Source: RWE, Deutsche Bank

In terms of its impact on the reserve margin we think the reduction in overall available capacity of 900MW that would occur in this scenario by 2013 would be offset by the fact that the new fossil-fuel plant would be more efficient, reliable and flexible than the older fossil-fuel plant removed from the grid.

As a result, we conclude that the impact on reserve margins by 2013 of the changes in Germany's capacity profile that we are assuming if the nuclear phase-out went ahead would be neutral.

Our assumed new capacity would generate 119TWh by 2013 with 74Mt of emissions

Figure 30 shows the breakdown of the new capacity that we assume will be built by 2013 by fuel type, together with the average load factor at which we would expect it to operate.

For the hard coal and lignite, we assume all plant runs baseload at an average load factor of 85%. We assume a slightly lower load factor for the new CCGT plant as although we expect most of the new capacity to run baseload, there is one plant that is being built specifically to run mid-merit (the 875MW plant at Lingen). As already explained above, we assume a load factor for offshore wind of 35%, while for the new waste-gas capacity we assume 50%.

Figure 30: DB base-case assumed new German capacity and load factors by 2013

Fuel source	Capacity (MW)	Expected average load factor
Hard coal	7,552	85%
Lignite	2,775	85%
CCGT	4,670	82%
Offshore wind	2,136	35%
Other	380	50%
TOTAL	17,513	n/a

Source: Platts, Deutsche Bank

Figure 31 then shows the average carbon-intensity factors of the new fossil-fuel fired plant being built against those of the older types (for gas plant the new build is CCGT and the old plant OCGT).

Figure 31: Carbon-intensity rates of new and older fossil-fuel plants (tCO₂/MWh)

Fuel source	New	Old
Lignite	0.93	1.14
Hard coal	0.75	0.92
CCGT	0.35	0.5*

Source: RWE, Deutsche Bank; *The older gas plant in Germany is of the open-cycle gas-turbine variety (OCGT), whereas the new plant is combined-cycle technology and is therefore much more efficient

Based on the new capacity and the respective load factors for each plant type we have assumed, Figure 32 then shows the annual output by 2013 by fuel source of our assumed new build.

Figure 32: DB base-case assumed annual output from new plants, 2009-2013 (GWh)

	Nuclear	Lignite	Hard coal	Gas	Waste	Offshore wind	Annual output
Load-factor	85%	85%	85%	82%	50%	35%	
2009	0	0	0	12,355	657	184	14,203
2010	0	0	5,585	12,355	657	460	20,064
2011	0	20,663	13,775	24,782	657	2,557	63,441
2012	0	20,663	38,362	33,546	657	4,243	98,478
2013	0	20,663	56,232	33,546	657	6,549	118,654

Source: Deutsche Bank

On our assumptions, then, the new capacity that would be in place by 2013 would generate 119TWh per year. The new coal capacity built over 2009-13 would generate 56TWh per year by 2013, the new CCGT capacity 34TWh, and the new lignite 21TWh, with 6.5TWh coming from offshore wind. Using the carbon-intensity factors shown in Figure 31, this would give rise to 74Mt of CO₂ emissions by 2013 (Figure 33).

Figure 33: DB base-case output and CO₂ emissions by 2013 from new capacity

Fuel source	Output (TWh)	CO ₂ emissions (Mt)
Hard coal	56.2	42.2
Lignite	20.7	19.2
CCGT	33.5	11.7
Offshore wind	6.5	0
Other	1.7	1.8
TOTAL	118.6	73.8

Source: Deutsche Bank

The question is, how would this compare with the output that it would be replacing in the event that the nuclear phase-out went ahead as planned, and what would be the net impact on CO₂ emissions?

Base-case scenario: nuclear phase-out would increase emissions by 15Mt p.a. by 2013

Figure 34 shows the annual output loss from the nuclear and old fossil-fuel plant closures we are here assuming take place over 2009-13. For the nuclear plants we assume an average load factor of 85% for the plants that close over 2009-13, whereas for all the fossil-fuel plants we assume a load factor half that of the average for all plants of the fuel type in question.

Figure 34: DB assumed annual loss in output from closing plants, 2009-2013 (GWh)

	Nuclear	Lignite	Hard coal	Gas	Lost annual output
Load-factor	85%	40%	27%	20%	
2009	0.0	-1,353	-4,810	0	-6,163
2010	-14,422.8	-4,868	-4,810	0	-24,101
2011	-32,019.8	-6,626	-4,810	-3,450	-46,906
2012	-46,181.0	-8,383	-4,810	-5,175	-64,549
2013	-52,628	-8,383	-7,215	-6,900	-75,127

Source: Deutsche Bank

This is because we are assuming that the plants that close are the oldest plants in their respective fuel categories, with lower efficiency rates but also, as a consequence, lower running hours. So, we assume a 40% load factor for the lignite plants that close over 2009-13, 27% for coal, and 20% for gas, in each case this being half the average load factor at which plants of these types ran in 2007 (Figure 35).

Figure 35: Average running hours for nuclear and fossil-fuel plant in Germany, 2007

	Average running hours in 2007	Implied load factor
Nuclear	7,790	88.9%
Lignite	7,030	80.3%
Hard coal	4,810	54.9%
Gas (OCGT)	3,450	39.4%

Source: BMU from BDEW

As shown in Figure 34, this means that the plant closures we are here assuming lead to a loss of 53TWh of nuclear output and 22TWh of fossil-fuel output by 2013 (8TWh of lignite, and 7TWh each of coal and gas). In total, therefore, we derive lost annual output by 2013 of 75TWh.

This is well below the 119TWh of output from new build that we are assuming by 2013, but as we explained above when looking at the impact of the capacity changes over 2009-13 on reserve margins, the new fossil-fuel plant would not replace the old fossil-fuel plant directly in any case.

Rather, the new fossil-fuel output would replace first the 53TWh of lost nuclear output resulting from the phase-out, and then other baseload output from fossil-fuel plants (although some of the CCGT output would displace mid-merit output from older gas plants).

In turn, the fossil-fuel plants moved lower in the merit order by the new plants would displace older fossil-fuel plants in the ripple effect we described above (Figure 29), culminating in the removal of the 9GW of old fossil-fuel capacity.

All of which means that the 119TWh of output by 2013 from the new capacity we are here assuming has to displace 53TWh of nuclear and 66TWh of fossil-fuel fired output. We assume that the new lignite plant replaces old lignite baseload plant on a MW for MW basis, and that most of the rest of the baseload capacity displaced by new fossil-fuel fired plant is coal, with only 12TWh of old gas-fired output replaced (Figure 36).

Figure 36: DB base-case assumed output directly replaced by new capacity by 2013

Fuel source	Output (TWh)	CO2 emissions (Mt)
Nuclear	52.6	0.0
Lignite	20.7	22.7
Hard coal	33.5	30.2
Gas (OCGT)	11.8	5.9
TOTAL	118.7	58.8

Source: Deutsche Bank

We derive the emissions profile of this replaced output by using a carbon-intensity factor of 1.1t/MWh for lignite and 0.9t/MWh for coal (this is slightly lower than the average intensity factors for old lignite and coal shown in Figure 31 above, but reflects the fact that the fossil-fuel plant displaced directly by the new plant will by definition be the most efficient of its kind). For the old OCGT plant we take the CO₂-intensity factor of 0.5t/MWh shown in Figure 31 above.

On this basis we calculate the total emissions of the output directly replaced by the 17.5GW of new capacity at 59Mt (Figure 36 again).

Comparing Figure 36 against Figure 33 above, this would mean that emissions were 15Mt higher by 2013 than they are today (74Mt versus 59Mt).

(As emphasized in Caveat 2 in our Executive Summary above, it is impossible to know for sure what the precise impact of the ripple effect on the merit order of our assumed capacity changes over 2009-13 would be, and hence impossible also to know what the precise impact of these changes on emissions would be. For example, new baseload lignite plant will directly displace older baseload-lignite plant, and this will reduce emissions. However, some of the older baseload-lignite capacity thus displaced might then, in turn, displace older baseload-coal capacity, thereby actually increasing emissions. Similarly, new baseload coal might displace older lignite or coal plant and hence reduce emissions, but the older coal and/or lignite plant thereby displaced might in turn displace older gas plant in mid-merit running hours, thereby increasing emissions. As a result, our stylized analysis should here be taken as a best estimate of the likely increase in CO₂ emissions that would result from the nuclear phase-out and the other capacity changes over 2009-13 we have here modelled).

Looking at this another way, effectively what happens here is that 53TWh of nuclear output is being replaced by a combination of offshore wind, lignite, and coal, and this pushes up emissions by 38Mt because the nuclear output was entirely CO₂-free (Figure 37).

Figure 37: DB base-case increase in CO₂ emissions by 2013 from lost nuclear output

Fuel source	Output (TWh)	CO ₂ emissions (Mt)
Lost nuclear output replaced replaced by:		
Offshore wind	6.5	0.0
Lignite	20.7	19.2
Hard coal	25.4	19.0
TOTAL	52.6	38.2

Source: Deutsche Bank

However, the residual 66TWh of new fossil-fuel fired output is materially less carbon intensive than the output from the older plant it replaces, and this reduces CO₂ emissions and thus partly offsets the increase in emissions from the replaced nuclear output. Assuming that the residual new hard-coal output of 31TWh displaces older coal and lignite plant at an average saving of 0.3t/MWh, then this would reduce emissions by 9Mt. Similarly, with 34TWh of CCGT output displacing older coal and OCGT plant at an average saving of 0.4t/MWh, then this would reduce emissions by 14Mt. In total this would reduce emissions by 23Mt (Figure 38).

Figure 38: DB base-case reduction in CO₂ emissions by 2013 from new fossil-fuel plant

Fuel source	Output (TWh)	CO ₂ emissions saved (Mt)
Older fossil-fuel output replaced replaced by:		
New hard coal	30.9	-9.3
New CCGT	33.5	-13.6
Other	1.7	-0.4
TOTAL	66.1	-23.2

Source: Deutsche Bank

Figure 39 then shows the net impact of these two effects: an increase of 15Mt, as already explained above.

Figure 39: DB base-case net increase in emissions by 2013 under nuclear phase-out

Fuel source	Output (Mt)
Increase in emissions from replacing nuclear with fossil-fuel plant	38.2
Reduction in emissions from new FF plant displacing older FF plant	-23.2
NET INCREASE IN EMISSIONS	15.0

Source: Deutsche Bank

In short, we conclude that if the phase-out of 7GW of nuclear capacity over the course of the next parliament were to go ahead in accordance with existing legislation and the rest of the capacity mix to change as we have assumed in this report, Germany's CO₂ emissions from power generation would be some 15Mt per year higher by 2013 than they are today.

At the same time, emissions could be higher or lower than this base-case assumption depending on how much of the new build that we have assumed will be online by 2013 actually does get built.

Worst-case scenario: emissions could increase by 30Mt by 2013

What would happen if the amount of new capacity built by 2013 were lower than we assumed in our base-case scenario?

For example, if we assumed that only the fossil-fuel capacity already under construction were built by 2013 (i.e. the 11GW shown in Figure 17 above), together with 1,068MW of offshore wind (i.e. half the amount we have assumed in our base case above), what would be the impact on emissions relative to today's levels?

Figure 40 shows that in this instance the total new capacity online by 2013 would be only 12GW (rather than the 17.5GW in our base case), and total output from this capacity at our assumed load factors for each fuel type only 84TWh (rather than the 119TWh in our base case). CO₂ emissions from this new capacity would be 58Mt per year.

Figure 40: DB worst-case new-build scenario under nuclear phase-out by 2013

Fuel source	Capacity (MW)	Output (TWh)	CO ₂ emissions (Mt)
Hard coal	5,912	44.0	33.0
Lignite	2,775	20.7	19.2
CCGT	2,250	15.8	5.5
Offshore wind	1,068	3.3	0.0
TOTAL	12,005	83.7	57.8

Source: Deutsche Bank

This output would be more than enough to replace the 53TWh of lost nuclear output by 2013, but the mix would be slightly different than under our base-case scenario as there would be less offshore-wind output (Figure 41). As a result, at 41Mt the increase in emissions from replacing the lost 53TWh of nuclear output would be slightly higher than the 38Mt shown in Figure 37 above.

Figure 41: DB worst-case increase in CO₂ emissions by 2013 from lost nuclear output

Fuel source	Output (TWh)	CO ₂ emissions (Mt)
Lost nuclear output replaced replaced by:		
Offshore wind	3.3	0.0
Lignite	20.7	19.2
Hard coal	28.6	21.5
TOTAL	52.6	40.7

Source: Deutsche Bank

Moreover, there would then be only 31TWh of new fossil-fuel output to displace older fossil-fuel output. As a result, the extent to which the displacement of older plant by newer plant would compensate for the loss of nuclear output in terms of CO₂ emissions would be lower than in our base-case scenario. Assuming again that the new coal plant displaced a mixture of older lignite and coal such that the average reduction in CO₂ emissions were 0.3t/MWh and the CCGT output displaced a mixture of older coal and gas such that the average CO₂ reduction were 0.4t/MWh, then the net saving in CO₂ emissions would be 11Mt (Figure 42).

Figure 42: DB worst-case emissions reduction by 2013 from displacing older FF plant

Fuel source	Output (TWh)	CO ₂ saving (Mt)
Hard coal	15.3	-4.6
CCGT	15.8	-6.4
TOTAL	31.1	-11.0

Source: Deutsche Bank

Deducting this saving from the increase in emissions from replacing the lost nuclear output results in a net increase in emissions of 30Mt per year by 2013 (Figure 43).

Figure 43: DB worst-case net increase in emissions by 2013 under nuclear phase-out

Fuel source	Output (TWh)
Increase in emissions from replacing nuclear with fossil-fuel plant	40.7
Reduction in emissions from new FF plant displacing older FF plant	-11.0
TOTAL INCREASE IN EMISSIONS	29.7

Source: Deutsche Bank

In short, on a worst-case scenario basis, we calculate that CO₂ emissions from the German power sector would increase by 30Mt per year by 2013 against current levels if the nuclear phase-out continued over the next parliament.

Best-case scenario: emissions could increase by only 5Mt by 2013

What would happen if the amount of new capacity built by 2013 were greater than we assumed in our base-case scenario? For example, if we assumed that not only the 17.5GW of plant already under construction and approved were built but also a small proportion of the plants in earlier stages of planning? In this instance the total new capacity online by 2013 would be 21.1GW (rather than the 17.5GW in our base case), and total output from this capacity at our assumed load factors for each fuel type 143 TWh (rather than the 119TWh in our base case). CO₂ emissions from this new capacity would be 86Mt per year (Figure 44).

Figure 44: DB best-case new-build scenario by 2013 under nuclear phase-out

Fuel source	Capacity (MW)	Output (TWh)	CO ₂ emissions (Mt)
Hard coal	9,000	67.0	50.3
Lignite	2,775	20.7	19.2
CCGT	6,000	44.2	15.5
Offshore wind	3,000	9.2	0.0
Other	380	1.7	0.7
TOTAL	21,115	142.7	85.6

Source: Deutsche Bank

In this case, the mix to replace the lost nuclear output would be slightly different than under our base-case scenario as there would be more offshore-wind output (Figure 45). As a result, at 36Mt the increase in emissions from replacing the lost 53TWh of nuclear output would be slightly lower than the 38Mt shown in Figure 37 above.

Figure 45: DB best-case increase in CO₂ emissions by 2013 from lost nuclear output

Fuel source	Output (TWh)	CO ₂ emissions (Mt)
Lost nuclear output replaced replaced by:		
Offshore wind	9.2	0.0
Lignite	20.7	19.2
Hard coal	22.7	17.0
TOTAL	52.6	36.3

Source: Deutsche Bank

Moreover, there would then be a further 90TWh of new fossil-fuel output available to displace older fossil-fuel output. As a result, the extent to which the displacement of older fossil-fuel plant by newer plant would compensate for the loss of nuclear output in terms of CO₂ emissions would be greater than in our base-case scenario.

Assuming again that the new coal plant displaced a mixture of older lignite and coal such that the average reduction in CO₂ emissions were 0.3t/MWh and that the CCGT output displaced a mixture of older coal and gas such that the average CO₂ reduction were 0.4t/MWh, then the net saving in CO₂ emissions would be 32Mt (Figure 46).

Figure 46: DB best-case emissions reduction by 2013 from displacing older FF capacity

Fuel source	Output (TWh)	CO2 saving (Mt)
Hard coal	44.3	-13.3
CCGT	44.2	-17.8
Other	1.7	-0.4
TOTAL	31.1	-31.5

Source: Deutsche Bank

Deducting this saving from the increase in emissions from replacing the lost nuclear output results in a net increase in emissions of only 5Mt per year by 2013 against current levels (Figure 47).

Figure 47: DB best-case net increase in emissions by 2013 under nuclear phase-out

Fuel source	Output (TWh)
Increase in emissions from replacing nuclear with fossil-fuel plant	36.3
Reduction in emissions from new FF plant displacing older plant	-31.5
TOTAL INCREASE IN EMISSIONS	4.7

Source: Deutsche Bank

In short, on a best-case scenario basis, we calculate that CO2 emissions from the German power sector would increase by only 5Mt per year by 2013 against current levels if the nuclear phase-out continued over the next parliament.

Conclusion: if nuclear phase-out continues, new fossil-fuel capacity will be key

It is clear from our analysis above that in addition to the positive impact of offshore wind, replacing older fossil-fuel fired capacity with newer fossil-fuel plant can reduce CO2 emissions very materially. As a result, we conclude that if the nuclear phase-out were to continue over 2009-13, the net impact on emissions would depend crucially on the amount of new offshore and fossil-fuel fired capacity that were built by 2013.

In our base-case scenario emissions from the German power sector would be 15Mt higher by 2013 than they are today, but the range is 5Mt-30Mt: in our best-case scenario emissions would increase by only 5Mt, in our worst case by 30Mt.

Emissions likely 40Mt higher by 2020 under nuclear phase-out

Looking at the impact of the nuclear phase-out beyond the period covered by the next parliament, we can conduct a similar analysis to the one we have just done above (although with the extra caveat that modeling changing capacity scenarios out to 2020 is considerably more speculative than it is out to 2013 simply because there is much less clarity on the new capacity that will be built over 2014-20 than there is over 2009-13).

Reminding ourselves of the scheduled closures of Germany's nuclear plants out to 2020 (Figure 5, Section 1 above), we can see that the incremental capacity to be closed over 2014-20 is 9,355MW. The plants in question are Grafenheinfeld (1,275MW), Grundremmingen-B (1,284MW), Grundremmingen-C (1,288MW), Krümmel (1,346MW), Philippsburg-2 (1,392MW), Grohnde (1,360MW), and Brokdorf (1,410MW).

Assuming an 85% load factor, this would amount to an annualized loss of output by the end of 2020 of 69.7TWh above and beyond the 52.6TWh lost by 2013. In total, therefore, the annualized loss in nuclear output by year-end 2020 would be 122TWh.

The question is, how would this incremental 70TWh of lost annualized output by 2020 be compensated?

Base-case scenario: nuclear phase-out would increase emissions by 37Mt p.a. by 2020

Figure 48 shows our base-case scenario of the new capacity that would be built over 2014-20 if the nuclear phase-out were to continue over this period.

As shown in Figure 16, Section 2 above, there is a significant amount of offshore-wind capacity already approved but that we do not think will be built by 2013 (3,850MW in total). By contrast, we think it is reasonable to assume that the majority of this capacity will be built by 2020, as well as some of the offshore capacity shown in Figure 20, Section 2 above. As a result, we assume that there will be 4GW of incremental offshore-wind capacity built over 2014-20.

We also assume that the 450MW CCS plant planned at Hurth (Figure 20, Section 2 above) will be on the grid before 2020. Given that most of the rest of the capacity shown in Figure 20 above – i.e. plant at various stages of early planning – is hard coal or CCGT, we assume 4.6GW and 5GW capacity of these fuel types respectively will be built over 2020.

As shown in Figure 48, this means that we assume a total of new capacity to be built over 2014-20 of 14GW. We continue to assume a load factor of 85% for ne hard-coal and for lignite CCS, but increase our yield for offshore-wind to 40% from 35% as much of the capacity built over 2014-20 will be further out to sea. We also assume that all new CCGT plant built over 2014-20 will run baseload at 85%. Overall, this gives annualized output from the new capacity built over 2014-20 of 89TWh by 2020.

Figure 48: DB base-case assumed new German capacity and output by 2020

Fuel source	Capacity (MW)	Expected average load factor	Output (TWh)
Hard coal	4,550	85%	33.9
Lignite CCS	450	85%	3.4
CCGT	5,000	85%	37.2
Offshore wind	4,000	40%	14.0
TOTAL	14,000	n/a	88.5

Source: Platts, Deutsche Bank

The 70TWh of lost nuclear output would thus be replaced by a combination of offshore wind, lignite CCS, hard coal, and CCGT plant, which pushes up emissions by 29Mt by 2020 against 2013 levels (Figure 49).

Figure 49: DB base-case increase in emissions over 2014-20 from lost nuclear output

Fuel source	Output (TWh)	CO2 emissions (Mt)
Lost nuclear output replaced by:		
Offshore wind	14.0	0.0
Lignite CCS	3.4	0.5*
Hard coal	26.1	20.9
CCGT	26.1	9.7
TOTAL	69.7	28.8

Source: Deutsche Bank; *we assume a carbon-intensity factor of CCS of 0.15t/MWh

However, there would still be a residual 19TWh of new fossil-fuel fired output – hard coal and CCGT – available to displace older fossil-fuel fired output. Assuming that the residual new hard-coal output of 8TWh displaced older coal and lignite plant at an average saving of 0.3t/MWh, then this would reduce emissions by 2Mt. Similarly, with 11TWh of CCGT output displacing older coal and CCGT plant at an average saving of 0.4t/MWh, this would reduce emissions by 5Mt. Together, this would reduce emissions by 7Mt (Figure 50).

Figure 50: DB base-case reduction in emissions over 2014-20 from new fossil-fuel plant

Fuel source	Output (TWh)	CO2 emissions saved (Mt)
Older fossil-fuel output replaced replaced by:		
New hard coal	7.7	-2.3
New CCGT	11.1	-4.5
TOTAL	18.8	-6.8

Source: Deutsche Bank

Figure 51 then shows the net impact of these two effects: an increase in emissions of 22Mt by 2020 versus 2013 levels.

Figure 51: DB base-case net increase in emissions over 2014-20 with nuclear phase-out

Fuel source	Output (Mt)
Increase in emissions from replacing nuclear with fossil-fuel plant	28.8
Reduction in emissions from new FF plant displacing older FF plant	-6.8
NET INCREASE IN EMISSIONS	22.0

Source: Deutsche Bank

In short, we conclude that if the phase-out of 9GW of nuclear capacity over 2014-20 were to go ahead in accordance with existing legislation and the rest of the capacity mix to change as here assumed, Germany's CO2 emissions from power generation would be some 22Mt per year higher by 2020 than in 2013.

Adding this 22Mt increase in emissions by 2020 against 2013 levels to the 15Mt increase by 2013 against current levels shown in Figure 39 above means that overall our base-case scenario assumes that emissions from Germany's power sector would increase by 37Mt by 2020 against current levels (Figure 52).

Figure 52: DB base-case net increase in emissions over 2009-20 with nuclear phase-out

Fuel source	Output (Mt)
Net increase in emissions by 2013 versus 2009 under nuclear phase-out	15.0
Net increase in emissions by 2020 versus 2013 under nuclear phase-out	22.0
NET INCREASE IN EMISSIONS BY 2020 VERSUS 2008	37.0

Source: Deutsche Bank

At the same time, emissions could be higher or lower than this base-case assumption depending on how much of the new build that we have assumed will be built over 2014-20 actually does get built.

Worst-case scenario: emissions could increase by 62Mt by 2020

What would happen if the amount of new capacity built over 2014-20 were lower than we assumed in our base-case scenario? For example, if we assumed that only an incremental 3GW of offshore wind were built over this period, that the planned CCS plant did not materialize, and that only 4GW apiece of new hard-coal and CCGT capacity were built?

As shown in Figure 53, under this scenario the new capacity built over 2014-20 would be 11GW, enough to cover the lost nuclear output of 69.7TWh, but no more. As a result, emissions would increase by 33Mt as coal and CCGT plant replaced most of the lost nuclear output, and there would be no partial offset of this increase via new fossil-plant displacing older plant.

Figure 53: DB worst-case assumed new German capacity and output by 2020

Fuel source	Capacity (MW)	Expected average load factor	Output (TWh)	CO2 emissions (TWh)
Hard coal	3,975	85%	29.6	22.2
CCGT	3,975	85%	29.6	10.4
Offshore wind	34,000	40%	10.5	0.0
TOTAL	10,950	n/a	69.7	32.6

Source: Platts, Deutsche Bank

In short, we conclude that if the phase-out of 9GW of nuclear capacity over 2014-20 were to go ahead in accordance with existing legislation with only enough new capacity built to cover this lost output, Germany's CO2 emissions from power generation would be some 33Mt per year higher by 2020 than in 2013.

Figure 54: DB worst-case net increase in emissions 2009-20 with nuclear phase-out

Fuel source	Output (Mt)
Net increase in emissions by 2013 versus 2009 under nuclear phase-out	29.7
Net increase in emissions by 2020 versus 2013 under nuclear phase-out	32.6
NET INCREASE IN EMISSIONS BY 2020 VERSUS 2008	62.3

Source: Deutsche Bank

Adding this 33Mt increase in emissions by 2020 against 2013 levels to the 30Mt increase by 2013 against current levels shown in Figure 43 above means that overall our worst-case scenario assumes that emissions from Germany's power sector would increase by 62Mt by 2020 against current levels (Figure 54).

Best-case scenario: emissions could increase by only 14Mt by 2020

What would happen if the amount of new capacity built over 2014-20 were greater than we assumed in our base-case scenario? For example, if we assumed that 6GW each of offshore wind, new hard coal, and CCGT were built, as well as the 450MW lignite CCS plant?

As shown in Figure 55, under this scenario the new capacity built over 2014-20 would be 18.5GW, enough to cover the lost nuclear output of 69.7TW and still leave 44TWh of new fossil-fuel output to displace production from older plants.

Figure 55: DB best-case assumed new German capacity and output by 2020

Fuel source	Capacity (MW)	Expected average load factor	Output (TWh)
Hard coal	6,000	85%	44.7
Lignite CCS	450	85%	3.4
CCGT	6,000	85%	44.7
Offshore wind	6,000	40%	21.0
TOTAL	18,450	n/a	113.7

Source: Platts, Deutsche Bank

The 70TWh of lost nuclear output would thus be replaced by a combination of offshore wind, lignite CCS, hard coal, and CCGT plant, which would raise emissions by 25Mt (Figure 56 below).

However, there would still be a residual 44TWh of new fossil-fuel fired output – hard coal and CCGT – available to displace older fossil-fuel fired output. Assuming that the residual new hard-coal output of 22TWh displaced older coal and lignite plant at an average saving of 0.3t/MWh, then this would reduce emissions by 7Mt.

Figure 56: DB best-case increase in emissions over 2014-20 from lost nuclear output

Fuel source	Output (TWh)	CO2 emissions (Mt)
Lost nuclear output replaced replaced by:		
Offshore wind	21.0	0.0
Lignite CCS	3.4	0.5*
Hard coal	22.6	22.6
CCGT	22.6	22.6
TOTAL	69.7	24.9

Source: Deutsche Bank; *we assume a carbon-intensity factor of CCS of 0.15t/MWh

Similarly, with 22TWh of CCGT output displacing older coal and OCGT plant at an average saving of 0.4t/MWh, this would reduce emissions by 9Mt. Together, this would reduce emissions by 16Mt (Figure 57).

Figure 57: DB best-case reduction in emissions over 2014-20 from new fossil-fuel plant

Fuel source	Output (TWh)	CO2 emissions saved (Mt)
Older fossil-fuel output replaced replaced by:		
New hard coal	22.0	-6.6
New CCGT	22.0	-8.9
TOTAL	44.1	-15.5

Source: Deutsche Bank

Figure 58 then shows the net impact of these two effects: an increase in emissions of 14Mt by 2020 versus 2013 levels.

Figure 58: DB best-case net increase in emissions over 2014-20 with nuclear phase-out

Fuel source	Output (Mt)
Increase in emissions from replacing nuclear with fossil-fuel plant	24.9
Reduction in emissions from new FF plant displacing older FF plant	-15.5
NET INCREASE IN EMISSIONS	9.4

Source: Deutsche Bank

In short, we conclude that if the phase-out of 9GW of nuclear capacity over 2014-20 were to go ahead in accordance with existing legislation and the rest of the capacity mix to change as here assumed, Germany's CO2 emissions from power generation would be some 9Mt per year higher by 2020 than in 2013.

Figure 59: DB best-case net increase in emissions over 2009-20 with nuclear phase-out

Fuel source	Output (Mt)
Net increase in emissions by 2013 versus 2009 under nuclear phase-out	4.7
Net increase in emissions by 2020 versus 2013 under nuclear phase-out	9.4
NET INCREASE IN EMISSIONS BY 2020 VERSUS 2008	14.1

Source: Deutsche Bank

Adding this 9Mt increase in emissions by 2020 against 2013 levels to the 5Mt increase by 2013 against current levels shown in Figure 47 above means that overall our base-case scenario assumes that emissions from Germany's power sector would increase by 14Mt by 2020 against current levels (Figure 59).

Conclusion: under nuclear phase-out 2020 will see higher emissions

We conclude that if the nuclear phase-out were to continue over 2014-20, the net impact on emissions would depend crucially on the amount of new offshore and fossil-fuel fired capacity that were built by 2013.

Nonetheless, under the phase-out of nuclear power we think that on any realistic scenario emissions from German generators would be higher by 2020 than they are today. In our base-case scenario emissions would be 37Mt higher than today, but the range is from 14Mt (best case) to 62Mt (worst case).

Capacity margins could be a real issue by 2020

We think that the capacity situation in Germany would become more serious by 2020 than by 2013 under the phase-out of nuclear power. As we indicated above, there looks to be enough capacity likely to be on the grid by 2013 to replace both the 7GW of nuclear capacity that would close by that date under the nuclear phase-out and the 9GW of older fossil-fuel plant that might close by this date as well.

By contrast, the situation over 2014-20 is more uncertain. As shown in Section 1 above, RWE estimates that up to 30GW of firm new capacity above the 11GW already under construction would be needed by 2020 to replace lost nuclear capacity and the fossil-fuel plant that could close by this date.

The complication here is that the German government would like to see much more offshore-wind capacity built but that offshore wind offers only 1MW of firm capacity for every 10MW built. As explained in Section 2 above, it is also very expensive and challenging to build.

As a result, in all of the scenarios for new capacity that we have modelled over 2014-20 (even our best-case scenario), the amount of new firm capacity built by 2020 would not be enough to replace lost nuclear capacity and the lost fossil-fuel capacity that could occur by this date.

Figure 60 shows what the impact of the nuclear phase-out and the closure of all the older fossil-fuel plants would be on the net-capacity situation by 2013 and 2020 under our base-case scenarios for new build over 2009-13 and 2014-20.

As can be seen, whilst the net change in capacity by 2013 would be negligible, under our base-case scenario for new build over 2014-20 there would be a very significant reduction in firm capacity over 2014-20 of 22.7GW. This means that overall the changes in capacity that we have modelled under our base-case scenario assuming the nuclear phase-out goes ahead and all of the older fossil-fuel plant with an operating life of >40 years closed by 2020 would result in a net loss of firm capacity by 2020 of 23.6GW.

Figure 60: Net change in firm generation capacity over 2009-20 under DB base-case new-build scenario (MW)

	Lost nuclear capacity by 2020	Lost fossil-fuel capacity by 2020	New fossil-fuel plant	New offshore-wind capacity*	NET CHANGE IN FIRM CAPACITY
By 2013	-7,068	-9,385	+15,377	+214	-862
Over 2014-20	-9,355	-24,000	+10,000	+400	-22,741
TOTAL by 2020	-15,415	-33,385	+25,377	+614	-23,603

Source: Platts, Deutsche Bank; *we take the firm offshore-wind capacity at 10% of the assumed gross installed capacity

That said, in our view this is a hypothetical scenario, because there are two important caveats to enter regarding the required replacement of older fossil-fuel-fired plants:

- (i) In reality, we think much of this plant is likely to be economically and technically viable beyond the 40-year lifespan assumed in Figure 13, Section 1 above;
- (ii) Replacing the plant that is not economically or technically viable beyond 40 years with new plants would lead to an increase in availability on a MW for MW basis, and hence to a natural improvement in capacity margins. As a result, a smaller amount of capacity could replace a larger amount of capacity without any negative impact on the capacity margin.

For these two reasons, we think that it is more reasonable to assume that only two thirds of the fossil-fuel capacity that would be withdrawn on the assumption of a uniform operating life of 40 years would actually need to be replaced over this period.

As shown in Figure 61, this means our base-case scenario for new build actually results in an increase in firm capacity over 2009-13 of 2.3GW, but a much larger reduction over 2014-20 of 17GW.

Figure 61: DB base-case net change in firm generation capacity over 2009-20 under nuclear phase-out (MW)

	Lost nuclear capacity by 2020	Lost fossil-fuel capacity by 2020	New fossil –fuel plant	New offshore-wind capacity*	NET CHANGE IN FIRM CAPACITY
By 2013	-7,068	-6,256	+15,377	+214	+2,267
Over 2014-20	-9,355	-18,000	+10,000	+400	-16,955
TOTAL by 2020	-15,415	-24,256	+25,377	+614	-14,688

Source: Platts, Deutsche Bank; *we take the firm offshore-wind capacity at 10% of the assumed gross installed capacity

As a result, we conclude that under the nuclear phase-out and the closure of two thirds of the fossil-fuel capacity with >40 years' operating life by 2020, there would be a significant reduction in Germany's firm capacity by 2020 of up to 15GW.

If we assume the same level of peak demand in 2020 as today (70GW), then this would leave a very tight reserve margin of only 7% by 2020, well below the 10% normally considered the minimum prudent level.

In reality, therefore, in the event of a continuation of the nuclear phase-out, German power prices and EUA prices would have to rise significantly over 2014-20 to ensure sufficient capacity margins and as limited an increase as possible in CO2 emissions.

Conclusion: nuclear policy central to next German parliament

Based on the assumptions we have made in our analysis above, we conclude that if the nuclear phase-out were to continue emissions from Germany's power sector would increase by 15Mt against current levels by 2013 and by 37Mt by 2020.

As a result, if the nuclear phase-out continues under the next German parliament, we would expect to raise our ETS emissions forecasts by 15Mt for 2013, and by c.40Mt by 2020.

As far as the capacity situation is concerned, we conclude that the situation would be manageable out to 2013, but in order to ensure that the planned 4.7GW of new CCGT plant we assume would come onstream by 2013 were indeed built EUA prices would need to be higher than they are now (otherwise there would be less new CCGT capacity than we have assumed by 2013, more new coal capacity, and hence a bigger increase in emissions).

This means that there would be a positive impact on EUA prices from the continuation of the nuclear phase-out in two ways: (i) emissions would be higher by 2013 than they are today owing to the loss of CO2-free output from nuclear capacity (by 15Mt in our base-case); (ii) the EUA price would need to be above current levels to ensure that the CCGT plant we are assuming were built.

However, if the nuclear phase-out were to continue over 2014-20 then we think that the capacity situation would become increasingly difficult to sustain as our base-case scenario results in a decline in firm capacity of 15GW by 2020 against current levels, to only 5GW.

If we assume the same level of peak demand in 2020 as today (70GW), then this would leave a very tight reserve margin of only 7% by 2020, well below the 10% normally considered the minimum prudent level.

As a result, in the event of the nuclear phase-out's continuing over 2014-20, we think both power and carbon prices would have to rise significantly over this period in order to ensure sufficient capacity margins and as limited an increase as possible in CO₂ emissions.

As a result, whether the nuclear phase-out should be continued or revoked under the next parliament following the forthcoming general election on 27 September will be a crucial policy decision for the next government.

Finally, we would note that if the phase-out were revoked and the operating lives of Germany's remaining nuclear stations extended, there would be no impact on our ETS-emissions model as we are already assuming that the operating lives will be extended in our current ETS forecasts over 2009-20.

Carbon valuation

The theory behind our valuation

In theory, we think that the Phase-3 ETS cap agreed at the EU Heads of Government Summit last December is tight enough to imply a EUA price of €25-€30/t already in 2009. This is because expectations about a much tighter cap in Phase 3 will make Phase-2 allowances more valuable given that they can be carried over into Phase 3. In effect, the bankability of Phase-2 EUAs means that the shortage of EUAs foreseen by the market in Phase 3 should already be anticipated in Phase 2 (assuming the market is efficient).

In other words, bankability means that we have to consider the expected residual abatement requirement in Phases 2 and 3 together rather than separately. On our revised assumptions, the proposed Phase-3 cap results in an average residual abatement requirement within the ETS of 44Mt per year over the entire 2008-20.

If there is insufficient fuel-switching capacity in the EU to meet the required level of abatement in the ETS then today's EUA price should reflect the long-run marginal cost (LRMC) of carbon, this being the carbon price required to ensure that CCGT gas-fired plant gets built ahead of coal-fired plant. On our estimates, however, the full ETS shortfall of 44Mt per year could in theory be met via existing plant across the EU, and if this were to happen the price of EUAs would be set by the short-run marginal cost (SRMC) of fuel switching rather than the LRMC, unless the SRMC of abating 44Mt per year were greater than the LRMC of building new capacity.

Given the volatility of commodity prices over the last 12 months – estimating both the LRMC and the SRMC of fuel switching is very difficult at the moment. At this point in time, however, we see no reason to change our long-run commodity-price forecasts as set out in our report of 15 October, *Emissions in Remission*. Our LRMC analysis would therefore still indicate a fundamental value for EUAs of €30/t already in 2009, rising thereafter at the cost of carry (we use 4% to derive a 2020 EUA fair value of €48/t), should the building of new capacity be necessary to meet the cap.

The SRMC changes constantly in response to the prompt prices of oil, gas, and coal, but we estimate that to abate 44Mt of CO₂ fuel switching would be required in both Spain and the UK. Given that the UK's CCGT fleet is on average older and less efficient than Spain's, then even with oil and gas prices having fallen so dramatically in recent months we calculate that a price in the range of €25/t-€30/t would be necessary to achieve this in the short run (assuming coal prices of \$80/t-\$90/t, and an oil price of \$50/bbl or higher).

Risks to our valuation

In practice, we think that market inefficiencies engendered principally by the *ex-ante* free allocation of allowances in the ETS could keep EUA prices significantly below our theoretical fair-value estimate throughout 2009 and the first half of 2010.

In particular, with our revised forecasts now showing Phase 2 viewed in isolation to be long of EUAs by an average of 23Mt per year, we think the EUA price will remain volatile and potentially vulnerable to any further deterioration in the EU economy beyond that already indicated in our forecasts.

Appendix A: Glossary

Figure 62 defines the technical terms used throughout this report.

Figure 62: Glossary of terms	
Abatement	In the carbon context, GHG-emissions reduction
Bankability/banking/to bank	In the EU ETS context, the carrying over of carbon credits from one phase to the next
Baseload	The continuous minimum level of electricity demand
Baseload plant	A power plant that generates electricity to meet continuous minimum demand
BAU	Business as usual
BDEW	Der Bundesverband der Energie-und Wasserwirtschaft (The German Energy and Water Association)
BMU	Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit, The Federal Environment Ministry
boe	Barrel-of-oil equivalent
CCGT	Combined Cycle Gas Turbine
CCS	Carbon-capture and storage
CER	Certified Emissions Reduction
CHP plant	Combined heat-and-power plant
CO₂	Carbon-dioxide
DB	Deutsche Bank
E	Estimated
EU	European Union
EUA	European Union Allowance being a type of carbon credit solely for use within the EU-ETS
EURACOAL	European Association for Coal and Lignite
ETS	European Union Emissions Trading Scheme
FF plant	Fossil-fuel plant (i.e. a power plant fired either by lignite, coal, gas, or oil)
GHG(s)	Greenhouse gas(es)
GW	Gigawatt, a measure of the capacity of a power station (one billion watts)
GWh	Gigawatt-hour, a measure of the output of a power station (one billion watts of power generated for an hour)
LRMC	Long-Run Marginal Cost
M or m	Million
Merit order	The order in which power plants are despatched to generate electricity for distribution to the grid
Mt	Million tonnes or Mega-tonnes
MW	Megawatt, a measure of the capacity of a power station (one million watts)
MWh	Megawatt-hour, a measure of the output of a power station (one million watts of power generated for an hour)
OCGT	Open Cycle Gas Turbine, an older form of gas-fired generation technology
p.a.	Per annum
p/y	Per year
Phase 1, Phase 2, Phase 3	Trading periods of the EU ETS running from 2005 to 2007, 2008 to 2012, and 2013 to 2020 respectively
Phase 4	EU-ETS trading period, which will run over 2021-28
Q1, Q2, Q3, Q4	First quarter, second quarter, third quarter, fourth quarter
SRMC	Short-Run Marginal Cost
t	Tonne
TWh	Terawatt-hour, a measure of the output of a power station (one million megawatts of power generated for an hour)
UCTE	Union for the Co-ordination of Transmission of Electricity
y/e	Year end

Source: Deutsche Bank, UNEP

Appendix 1

Analyst Certification

The views expressed in this report accurately reflect the personal views of the undersigned lead analyst(s). In addition, the undersigned lead analyst(s) has not and will not receive any compensation for providing a specific recommendation or view in this report. Mark-C Lewis

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