Carbon Countdown
Prices and Politics in the EU-ETS

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About Carbon Tracker

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

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Prior to joining Carbon Tracker, Mark was Head of European Utilities Research at Barclays (2015-18), Chief Energy Economist at Kepler Cheuvreux (2014-15), and Managing Director and Global Head of Energy Research at Deutsche Bank, where he worked for 14 years until 2013. His research on power, gas, and emissions was ranked Number 1 by Energy Risk magazine in its 2011, 2010, 2009 and 2008 surveys, and his report on the Paris Climate-Change Agreement was runner-up in the 2015/16 City of London Farsight Award for long-term financial research.

In addition to his experience as a sell-side financial analyst, Mark spent one year as Deputy Head of investor relations at E.ON at the beginning of the *Energiewende*, and two years as a credit analyst covering the European utility sector at Standard & Poor's (1997-99). In total, Mark has over 20 years' experience as a financial analyst covering global energy markets, having worked prior to that as an academic at London University.

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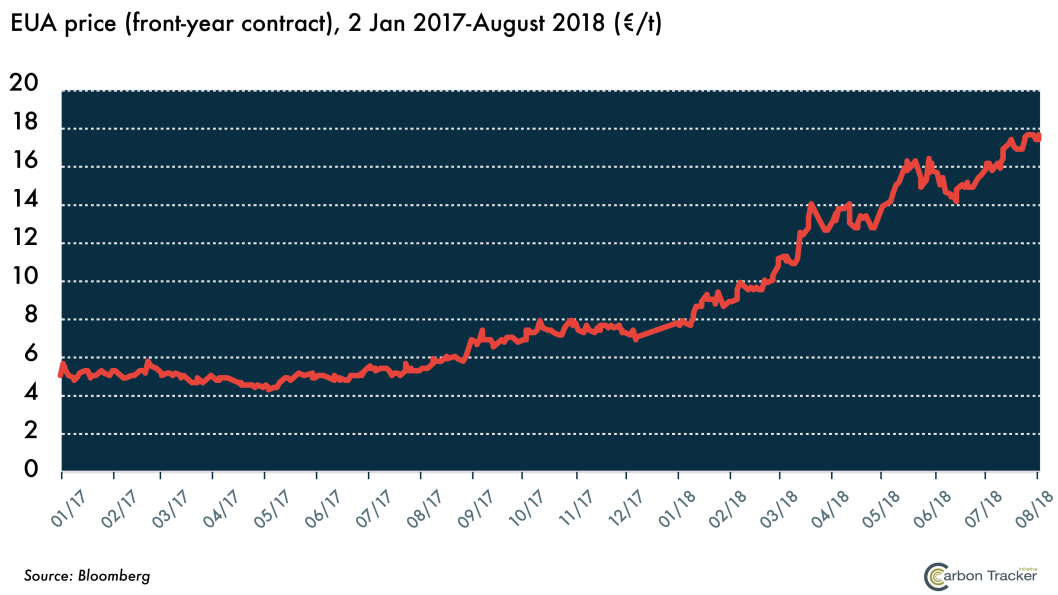
Carbon Countdown at a glance …

Market counts down to the MSR

The EU carbon market has been the hottest commodity market in the world over the last 16 months, with the price of European carbon allowances (EUAs) up 310% since May 2017, 120% since the start of the year, and 33% since we published our Carbon Clampdown report in April (Figure 1). This stunning performance has been driven by the market's anticipation of the start-up from January 2019 of the Market Stability Reserve (MSR), the centerpiece of the EU-ETS reform agreed last year. With only five months to go before the MSR starts reducing the over-supply of EUAs by 24% of the outstanding cumulative surplus each year over 2019-2023, the market is now counting down to the biggest supply squeeze the EU-ETS has ever seen.

Figure 1: EUA price (front-year contract), 2Jan 2017-August 2018 (€/t)



Fuel switching remains the key to our implied pricing trajectory for EUAs…

Against this backdrop, the logic of our argument in this report is that the supply squeeze caused by the MSR over 2019-23 will create a cumulative deficit for the power and aviation sectors over these five years of ~1.4bn tonnes, and that in order to clear the market over this period power generators will have to bid up EUA prices to fuel-switching levels. This is so that generators can both (i) reduce their own supply gap as much as they can themselves, and (ii) provide the necessary price incentive to enable the re-allocation of market length from those with surplus EUAs (industry and speculators) to those with deficits (generators and airlines).

… but we are now assuming a broader range of fuel switching will be necessary

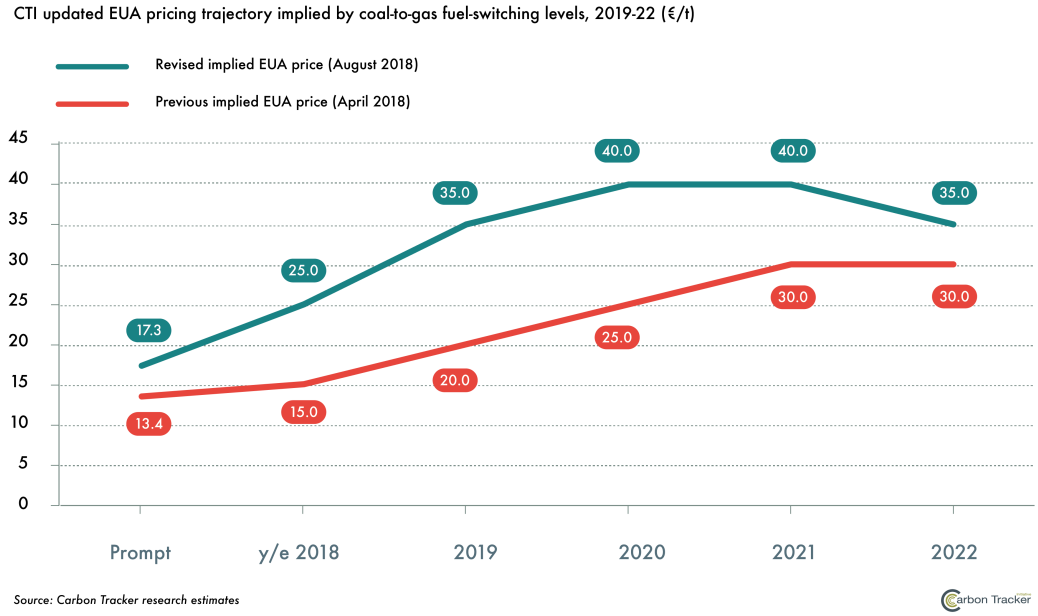
In our updated analysis, we conclude that in order to achieve the level of fuel-switching required to clear the market over 2019-23 it will be necessary for combined-cycle gas-turbine plants (CCGTs) with a thermal efficiency rate of 45% and above to displace coal plants with thermal efficiencies of 38% and below.[1] With the fuel-switching price very sensitive to efficiency rates, this implies higher EUA prices than we imputed from our previously assumptions.

[1] In *Carbon Countdown* we were assuming that CCGTs with a thermal efficiency of 50% and above displacing coal plant with thermal efficiency of 36% and below would be enough to clear the market, but we no longer think that the emissions reductions that could be achieved by this more limited efficiency range will be sufficient. As explained in our Executive Summary below, in our post-abatement modelling of the EU-ETS we now explicitly assume 60Mt of emissions reductions in the power sector in 2019, 90Mt per year over 2020-22, 70Mt in 2023 and 30Mt in 2024 compared with the numbers in our pre-abatement modelling. These emissions reductions are achieved mainly via fuel switching but also via energy-efficiency savings prompted by higher prices.

We think EUAs could hit €25/t by y/e 2018, and average €35-40/t over 2019-22

Based on the current forward curves for coal and gas,[2] the level of fuel switching likely required over 2019-23 as indicated by our modelling implies to us that EUA prices could reach €25/t by the end of this year as both compliance entities and speculators continue to anticipate the coming MSR supply squeeze. Thereafter, our modelling implies average prices of €35/t in 2019, €40/t in 2020 and 2021, and back to €35/t in 2022 as the impact of the MSR on auction volumes softens somewhat (Figure 2).

Figure 2: CTI updated implied EUA pricing trajectory imputed from coal-to-gas fuel-switching levels, 2019-22 (€/t)



Pricing caveat

There are many dynamic variables in play when we consider how EUA prices might evolve over 2019-23, and we would therefore emphasize that our revised indicative pricing range for EUAs comes with a number of caveats. In particular, depending on (i) exactly how much abatement might be required over 2019-23, (ii) the amount and availability of CCGTs with the required efficiency levels, and (iii) the evolution of commodity prices between now and 2021, the EUA price required to plug generators' and airlines' forward-hedging gap could be higher[3] or lower than the levels imputed from our modelling. Nonetheless, with significant fuel switching likely required to push prices to levels that will incentivize the re-allocation of market length from industry and speculators to power and aviation, €30-50/t seems to us a reasonable estimate of the range EUA prices could trade in over 2019-22, while we think average prices could trade in a narrower range of €35-40/t over this period, again based on fuel-switching levels.

Political caveat

It is important to remember that the EU-ETS is ultimately a political construct, and if EUAs were too rise too far too quickly we think political pressure would emerge to limit the extent and duration of excessive prices. Of course, this begs the question as to what would constitute an 'excessive' price, but in our view if prices were to exceed €50/t for more than a couple of months at any point within the next two to three years this would likely lead to pressure for countervailing measures.[4]

[2] Throughout this report we have used the forward curves for coal (the ARA contract) and gas (the TTF contract) as of 1 August 2018 to calculate fuel-switching price levels. See Figure 26 in Section 2 below for the full breakdown of these forward curves.

[3] As explained below, however, we also think there are political limits on how high prices can go, and that this level is not much higher than our updated base-case scenario for EUA prices.

[4] While we think prices might conceivably trade up to as high as €50/t for limited periods in the winter of 2020-21, and 2021-22 (i.e. when gas prices are at their seasonal highs and in those years where we see the supply squeeze on generators to be at its peak), we see EUAs trading within an *average* price range of €35-40/t over 2019-23. That said, even prices in the range of €35-40/t would in our view greatly increase the scrutiny of the EU-ETS, but would nonetheless in our view be politically tolerable.

This is not only because of the impact of CO2 prices themselves on EU industry – after all, industry is largely protected from high prices at the moment owing to its accumulated surplus of EUAs and to the fact that it is still receiving the vast amount of its EUAs for free – but also because higher CO2 prices will raise power prices for both industry and households. Accordingly, we also provide a reminder in this report of the measures that could be taken under existing legislation – i.e. before the scheduled review of the MSR in 2021 – to smooth the impact of lower auction volumes when the MSR is at its peak over 2019-21.

What about prices beyond 2023?

On our updated numbers, the supply squeeze for generators and airlines is greatest when auction volumes are at their lowest and the forward-hedging requirement is at its greatest, i.e. over 2019-23. This is why we think EUA prices will have to go to the fuel-switching level over this period, thereby enabling the market length to be re-allocated from industry and speculators to generators and airlines.

Over the second half of Phase 4, the annual deficits for fixed installations that our model is projecting are much smaller, with the aviation sector's growing deficits becoming the main driver of marginal EUA demand and hence of the abatement requirement in the system overall. However, and although as our numbers stand today we think that some fuel switching would still be required over 2025-30, we think there is much less visbility regarding the implied outlook for pricing over 2024-30 than over 2019-23.

This is because we expect the cost of both renewables and energy-storage technology to continue falling over the next decade, while the impact of coal phase-out policies across a number of EU member states by the middle of Phase 4 could be greater than we are currently assuming (especially if Germany decides to phase out a significant amount of old coal and lignite capacity by the middle of the next decade). We also think policy-makers will concentrate further effort on energy-efficiency measures.

Accordingly, we think it is an open question as to whether or not fuel switching will actually be required over the second half of Phase 4 at all given that these trends will lead to a structural decline in the power sector's emissions in any case.

This raises difficult questions about the visibility of EUA prices beyond 2024, which in turn explains why some EU governments – and especially the French government – continue to push the idea of a carbon-price floor that would rise over time.

This is a topic we will explore in depth in our next report, not least as we think it will become increasingly central to the debate around the EU's strategy for aligning its long-term emissions target with the objective of the Paris Agreement.[5]

LATE UPDATE ON GERMAN AUCTIONS: As we go to print it is reported that Germany will postpone the sale of ~22m 2018-vintage EUAs ordinarily scheduled to be auctioned in November and December of this year until Q1 2019 while it finalizes the renewal of its contract with the EEX exchange as its auctioning platform.[6] On a fundamental basis this does not alter anything in our analysis as it simply means these allowances will come to market slightly later than scheduled, but at the margin it reduces supply in the run-up to the start of the MSR in January and could therefore be supportive from a sentiment point of view.

[5] The European Commission is expected to publish a first working paper on the strategy for aligning the EU's long-term emissions with Paris in the autumn, ahead of COP-24 in Poland in December. With this in mind, our next report will also revisit the analysis of what a Paris-compliant EU-ETS would look like that we first set out in *Carbon Clampdown*.

[6] See the story on *Carbon Pulse*, 14 August 2018, Protracted renewal of German EUA auction platform to leave gap in sales

Executive Summary

The logic of our argument in this report is that the supply squeeze caused by the MSR over 2019-23 will create a very significant forward-hedging gap for the power and aviation sectors, and that in order to clear the market over this period power generators will have to bid up EUA prices to fuel-switching levels so as (i) to reduce their supply gap as much as they can themselves, and (ii) In order to provide the necessary price incentive to enable the re-allocation of market length from those with surplus EUAs (industry and speculators) to those with deficits (generators and airlines).

Accordingly, we begin this Executive Summary with an explanation of the updated methodology we are using to model EU-ETS dynamics and implied EUA prices, setting out in detail the amount and timing of the emissions reductions we are now explicitly factoring into our projections from fuel switching and energy-efficiency savings. We then give a brief overview of each of the three main sections of this report. Section 1 focuses on our modelling of the supply gap created by the MSR over 2019-23 (our pre-abatement EU-ETS schedule), Section 2 on implied pricing as generators respond to this supply gap, and Section 3 on how higher prices change market dynamics (our post-abatement EU-ETS schedule).

Methodological changes to our modelling

We have made two changes to our overall modelling approach in this report compared with the analysis in our previous report, *Carbon Clampdown*.

1. Pre-and post-abatement analysis: higher prices needed for fuel switching and energy efficiency

In our report *Carbon Clampdown* we modelled the impact of the MSR on the EU-ETS over 2019-23 on a pre-abatement basis only, i.e. by looking primarily at the impact it would have on the supply side without explicitly trying to model the demand-side response to this. Our approach in that report was designed to indicate both (i) the magnitude of the supply squeeze the MSR will create over 2019-23, and (ii) the forward-hedging gap this will give rise to for the power and aviation sectors over this period, all with a view to then analysing how this supply gap might be filled.

We concluded that fuel-switching in the power sector would have to play a significant role in closing the supply gap, and hence that prices would have to rise to fuel-switching levels over 2019-23. However, we did not explicitly quantify how much fuel-switching would be required, imputing instead that switching between coal-fired power stations with efficiency rates of 36% and below on the one hand, and gas-fired power stations with efficiency rates of 50% and above on the other, would be enough to clear the market over 2019-23.

In this report, we begin our analysis with this same pre-abatement approach, setting out in detail the impact of the MSR on the supply of EUAs over 2019-23 and hence the size of the forward-hedging gap that we think generators and airlines will have to cover over this period (Section 1 of this report). And again, we conclude that fuel-switching will have to play a significant role in filling this gap, and hence that fuel switching will be instrumental in the pricing of EUAs over 2019-23 (Section 2).

This time, however, we also go one step further by attempting explicitly to model the amount of emissions reductions that can occur from fuel switching and energy-efficiency savings over 2019-23 in response to the higher prices that will be necessary to flip the merit order across the EU and dispatch gas ahead of coal. We then factor these emissions reductions into our modelling over 2019-23, thus deriving a post-abatement schedule for the EU-ETS as well (Section 3). This post-abatement schedule is effectively our new base-case scenario for the EU-ETS out to 2030, as it shows our best estimate of how both supply *and* demand will react to the impact of the MSR over 2019-23 and beyond.

Our post-abatement modelling assumes that 60Mt of emissions reductions occur in 2019, 90Mt per year over 2019-22, and then back to 70Mt in 2023 and 30Mt in 2024 as auction levels start to normalize again with the MSR no longer removing allowances from the market after 2024. If our assumptions here were to prove correct and EUA prices were indeed to reach the fuel-switching level, this would also increase power prices as well, thereby creating a greater incentive for energy-efficiency savings.

Accordingly, we expect two thirds of the emissions reductions we are factoring in to our post-abatement modelling over 2019-23 to be driven by fuel switching itself and one third by efficiency savings on the demand side in response to the higher power prices caused by fuel switching. The level of CO2 reductions we are factoring in from fuel-switching over 2019-23 implies that coal plants with an efficiency rate of 38% and below will be displaced by gas plants with an average efficiency rate of 48% and above in 2019, but that over 2020-22 gas plant with a lower efficiency rate of 45% will have to run ahead of 38%-efficient coal in order to achieve the 60Mt of emissions reductions from fuel switching we are assuming over these years.

The implied EUA prices to make all this happen are €35/t in 2019, €40/t over 2020-21, and then back to €35/t over 2022-23.[7]

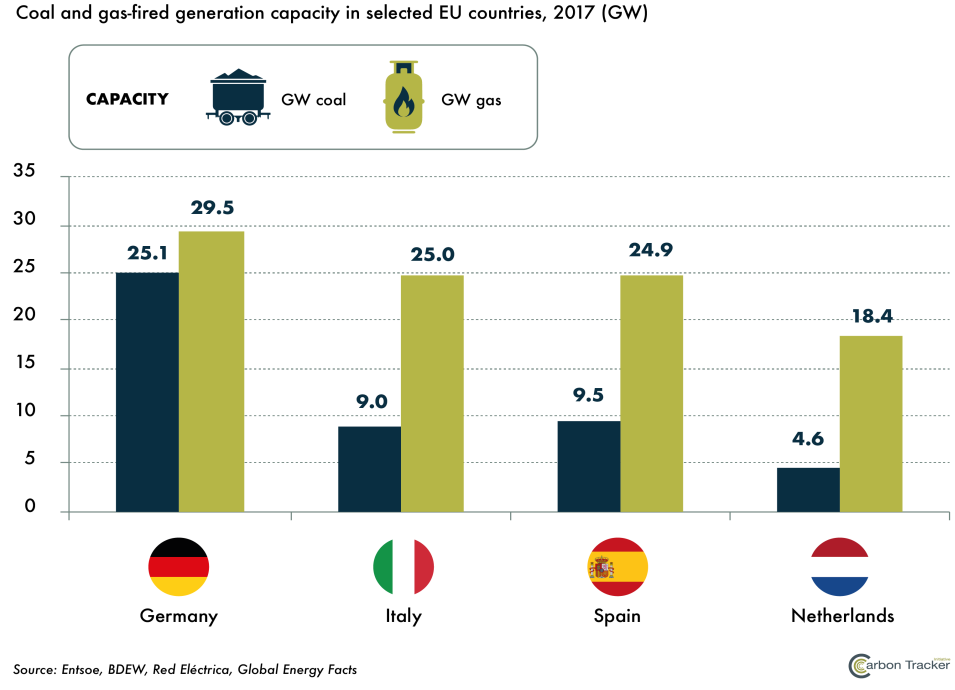
Figure 3: Breakdown of assumed emissions reductions in Carbon Tracker post-abatement modelling of EU-ETS and implied EUA prices, 2019-23

	2019	2020	2021	2022	2023
CO2 saved from fuel switching (Mt)	40	60	60	60	47
CO2 saved from energy efficiency (Mt)	20	30	30	30	23
Marginal gas plant efficiency	48%	45%	45%	45%	46%
Total CO2 saving (Mt)	**60**	**90**	**90**	**90**	**70**
Implied EUA price	**€35/t**	**€40/t**	**€40/t**	**€35/t**	**€35/t**

Source: Bloomberg

Fuel-switching potential and implied pricing: Significant levels of switching between coal and gas-fired generation capacity can only happen in the five EU countries with large portfolios of both – Germany, the UK, Italy, Spain, and the Netherlands – but the UK already has gas running ahead of coal in any case owing to its domestic carbon top-up price.[8]

Figure 4: Coal and gas-fired generation capacity in selected EU countries, 2017 (GW)



[7] These CO2 prices are calculated on the basis of the forward curves for coal and gas as set out in Figure 26 in Section 2 below.
[8] For a detailed primer on the UK carbon-price floor see the paper published by the UK house of Commons Library on 18 January 2018, Carbon Price Floor (CPF) and the Price-Support Mechanism.

This means that the amount of spare gas-fired capacity, and the respective efficiency rates of coal and gas-fired capacity in Germany, Italy, Spain, and the Netherlands, will be key to determining how much fuel switching can happen at any given carbon price.

Figure 4 and Figure 5 show the amount of coal and gas-fired capacity and output respectively in these four countries in 2017. As can be seen from Figure 4, Germany has broadly similar levels of coal and gas-fired capacity, whereas Italy, Spain, and the Netherlands have much more gas than coal.

In terms of 2017 output (Figure 5), coal-fired production was slightly greater than gas-fired production in Germany and Spain, whereas in Italy and the Netherlands the situation was the reverse, with Italy's gas-fired output three times higher than its coal-fired production.

Figure 5: Coal and gas-fired generation output in selected EU countries (TWh)

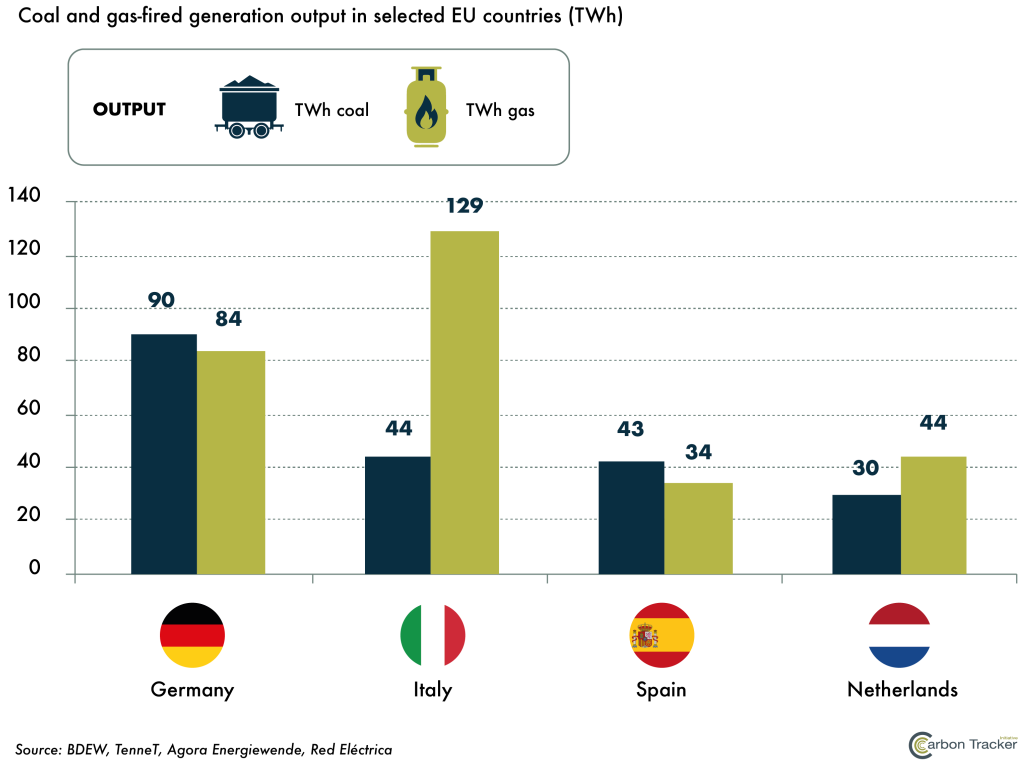


Figure 6 then shows the average load factors for coal and gas-fired capacity in these four countries in 2017 based on the data in Figures 4 and 5. As can be seen, Italy was the only country in which gas ran at a higher load factor than coal in 2017, with Germany, Spain, and the Netherlands all having low utilization rates for their gas-fired capacity.

Figure 6: Load factors of coal and gas-fired generation in selected EU countries, 2017

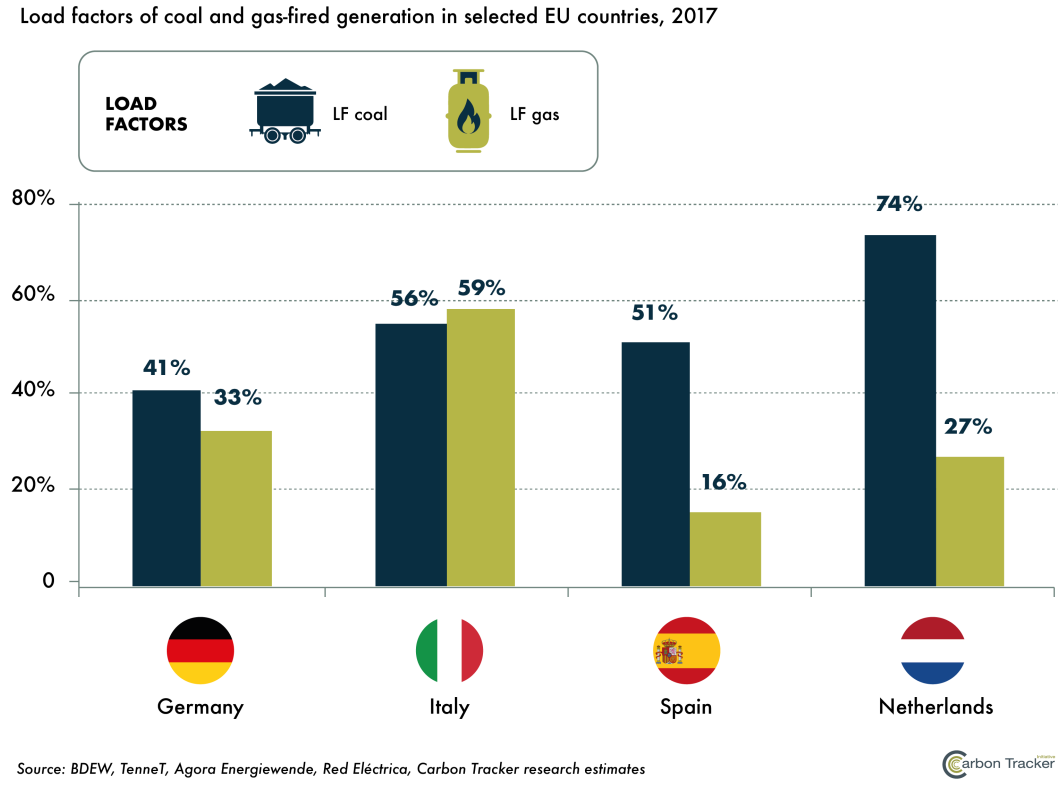
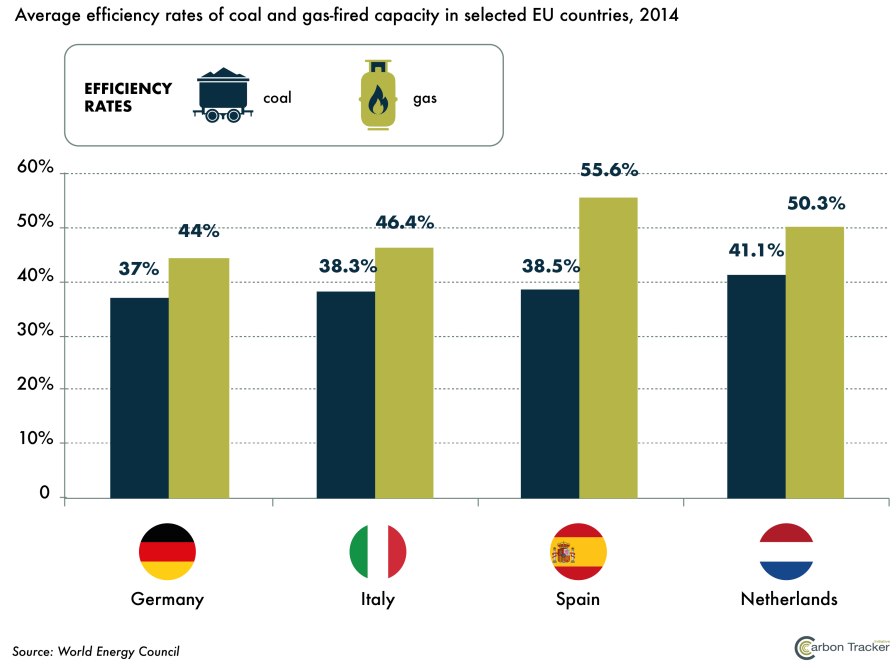


Figure 7 then shows the average thermal-efficiency rates for the coal and gas-fired fleets in these countries as of 2014 based on the data in the World Energy Council's interactive portal.

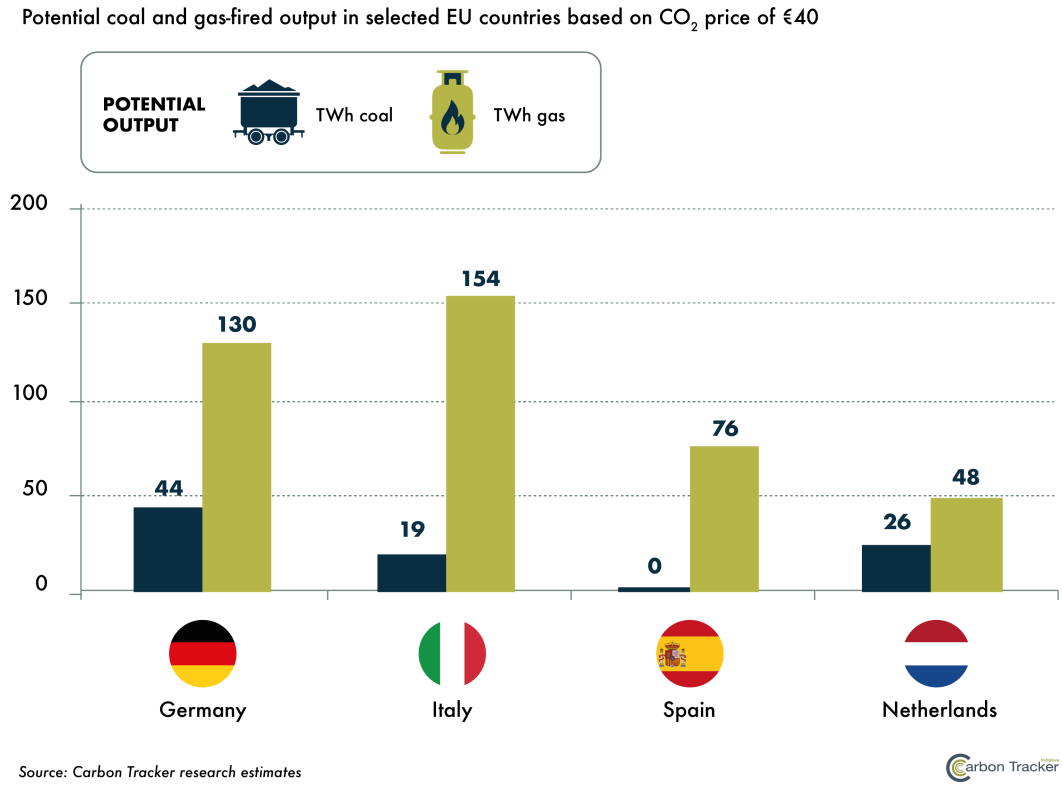
Figure 7: Average efficiency rates of coal and gas-fired capacity in selected EU countries, 2014



The efficiency rates for coal are broadly similar, with the exception of the Netherlands, where coal plants had an average efficiency rate of 41% in 2014.[9] By contrast, the efficiency rates for gas plants vary significantly, with Spain's efficiency rate the highest (55.6%), and Germany's the lowest (44.5%).

Based on the spare gas-fired capacity, the average efficiency rates of the respective fleets, and the current forward curves for coal and gas over 2020-22, we think that EUA prices of €40/tin 2020 and 2021, and €35/t in 2022, would have the potential to flip the merit order across Germany, Italy, Spain, and the Netherlands and push ~120TWh of gas-fired generation ahead of coal (Figure 8).

Figure 8: Potential coal and gas-fired output in selected EU countries over 2020-21 at an EUA price of €40/t



If we then compare Figure 8 with Figure 5 above, we can see the incremental gas-fired output in each country at an EUA price of €40/t, and the amount of CO2 saved relative to the level of emissions from coal and gas-fired output in 2017 (Figure 9). Compared with actual 2017 numbers, we estimate that at a carbon price of €40/t over 2020-21, and €35/t in 2022,Germany would get an extra 46TWh of gas generation, Italy an extra 25TWh, Spain an extra 42TWh, and the Netherlands an extra 4TWh. This would reduce emissions versus 2017 levels by 60Mt. This assumes that 0.5t of CO2 is saved for every 1MWh of electricity production switched from coal to gas.[10]

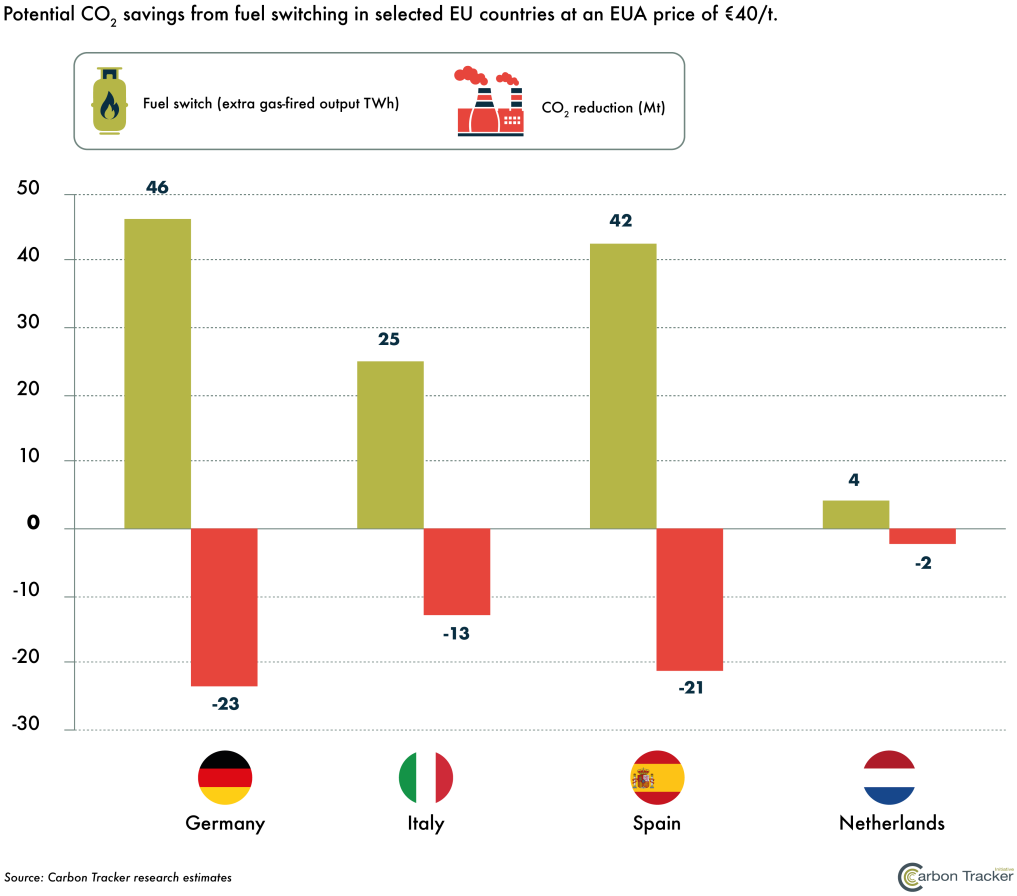
Accordingly, this is the delta in emissions from fuel switching between our pre-abatement and post-abatement schedules over 2020-22 as set out in Section 1 and Section 3 of this report respectively below.[11]

[9] The Netherlands currently has five coal-fired power plants, two older ones with efficiency rates of 40-43% (Hemweg and Eemshaven°, and three new ones with efficiency rates of 44% or higher. The two older plants must shut down by 2024 at the latest, and the three newer ones by 2030 at the latest.

[10] This will vary slightly from case to case depending on the respective efficiency rates of the coal and gas plants in question, but for our purposes here it is it is a perfectly reasonable stylized assumption.

[11] Note that with gas prices in steeper backwardation than coal prices between 2021 and 2022, the same level of emissions reductions from fuel switching in these countries (60Mt) versus 2017 levels could be achieved in 2022 at a lower carbon price of €35/t.

Figure 9: Potential CO_2 savings from fuel switching in selected EU countries at an EUA price of €40/t



The delta for 2019 and 2023 is slightly lower but follows exactly the same logic and methodology. It is just that we expect slightly lower levels of fuel switching in these years than over 2020-22 (in 2019 because we do not expect the full extent of the supply squeeze and forward-hedging gap to be priced in yet, and in 2023 because we think by then the pressure will start to soften as the forward-hedging gap for generators and airlines declines with higher auction volumes).

2. From implicit to explicit market balance by 2030

In *Carbon Clampdown*, we implicitly assumed that the market would need to balance by 2030, but our projections actually showed a cumulative deficit of -266m EUAs for the EU-ETS as a whole (i.e. including aviation) by 2030. This methodology was designed to show the amount of abatement that would be needed to bring emissions into balance with the cap over 2021-30, and we were clear to point out that in reality there could never be a cumulative deficit in the EU-ETS overall (i.e. including aviation) at the end of a given trading period as the EU-ETS Directive prohibits the borrowing of allowances from a future trading period into an earlier one.

In this report, by contrast, we are now working back from the need for the market to balance by 2030. This means we now have the market explicitly in balance by 2030, rather than implicitly so, as was the case in *Carbon Clampdown*.

Given that we have not changed our projections for the aviation sector's emissions out to 2030 – we are still projecting a cumulative deficit for aviation of 600Mt by 2030 – this means that the cumulative surplus for fixed installations (otherwise known as the TNAC) cannot fall below 600m by 2030, as otherwise the EU-ETS overall would be in deficit by 2030, and since allowances may not be borrowed from a future trading period this cannot happen.

Section 1. Updated EU-ETS modelling over 2018-30: the pre-abatement schedule

In this section we set out our updated projections for the EU-ETS on a pre-abatement basis, looking at the impact of the MSR over 2019-23 and the market balance this gives rise to all the way out to 2030 *before* the emissions reductions that we think will ultimately be necessary to clear the market over 2019-23 are factored in.

In other words, this section sets out how the annual and cumulative EU-ETS balances would look over 2018-30 assuming no change in the merit order for fossil-fuel (FF) generation over 2019-23. The point of the exercise here is to show (i) how big the forward-hedging gap for generators and airlines is over 2019-23, and (ii) to explain how we think this gap will have to be covered.

On our revised pre-abatement numbers, we project an average annual deficit for the EU-ETS over 2019-30 of -133m EUAs (fixed installations and aviation combined), with the supply squeeze at its most acute over 2019-23. Over these five years we see the market short by an average of -277m per year.

This matters for two main reasons: (i) generators do not hold enough of the outstanding market surplus of EUAs – technically known as the Total number of Allowances in circulation (TNAC) – themselves to cover their deficit over 2019-23, and (ii) as a result, in order to acquire the EUAs they need to cover their residual cumulative deficit over this period we think generators will have to bid up EUA prices to whatever level the holders of the rest of the TNAC – mainly industrials but also speculators – are willing to sell at. In particular, it is the forward–hedging pattern of generators' electricity sales that explains why we think higher EUA prices will likely be needed over 2019-23 despite the TNAC being large enough to accommodate both generators' deficits and the growing demand from airlines over this period.

Generators typically hedge their forward power sales on a rolling basis for two to three years forward at a time. This means they should be able to meet most if not all of their 2019 and 2020 compliance obligations with EUAs already purchased in 2016, 2017, and 2018, i.e. when they were hedging forward to cover 2019 and 2020. Out of the total 2017 TNAC of 1,655m, we estimate that generators and airlines combined hold ~50% (750-800m, of which 700-750m is with generators, and 50-100m with airlines), and industry and speculators the other ~50% (industry ~700m, speculators ~150m).

We base our estimate on (i) the fact that industrials' emission over 2008-17 were a combined 1.4Gt lower than their free allocations and offset use over the same period,[12] and (ii) the assumption that ~600m of this surplus has been sold in the market and acquired by generators and airlines since 2008.

At the same, however, it follows from this standard forward-hedging behaviour that by the time we get to 2019 and 2020 generators would ordinarily be starting to hedge forward power sales for 2021, 2022, and 2023, and hence also the fuel inputs associated with these forward power sales, including CO2.

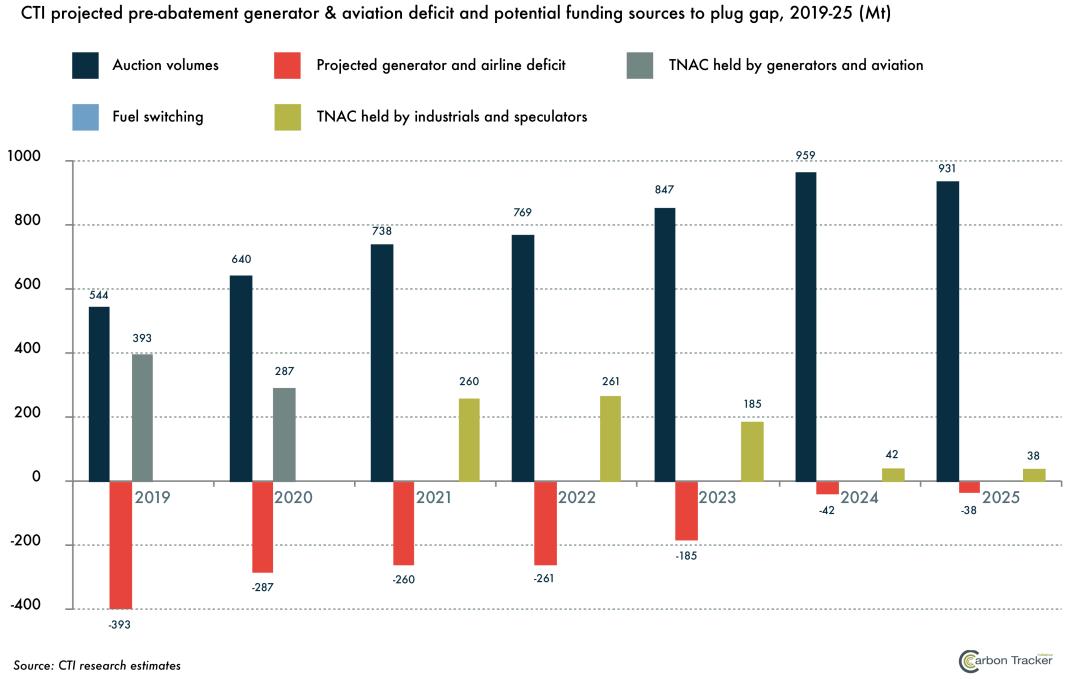
Ordinarily, the supply for this rolling hedging demand for CO2 on the part of generators would come from the auction volumes, but as we have just seen these will drop sharply from 2019 owing to the start-up of the MSR. So, in the absence of the volumes removed by the MSR, the key questions are (i) how big is the forward-hedging gap, and (ii) where will generators get the allowances they need in 2019 and 2020 to plug this gap over 2021-23?

Figure 10 shows our projected annual deficits for fixed installations in the EU-ETS over 2019-23. We think this deficit can reasonably be seen as being incurred 100% by power generators and airlines, as industry is generally still receiving more or less 100% of its requirements for free and will therefore be largely unaffected by the reduction in auction volumes over 2019-23.[13]

[12] Our numbers here come from Sandbag's EU-ETS Dashboard: http://sandbag-climate.github.io/EU_ETS_Dashboard.html

[13] This is something of a stylized assumption as with the tightening of benchmarks and reduction in the EU-ETS cap from 2021 onwards at the increased linear rate of 2.2% per year from 2021 industry will have to start paying for a limited but growing portion of its allowances over the course of Phase 4. Nonetheless, for our purposes here this remains a valid premise for our argument.

Figure 10: CTI projected pre-abatement generator & aviation deficit and potential funding sources to plug gap, 2019-25 (Mt)



The cumulative deficit over this period for generators and airlines is 1,466Mt, but it follows from our assumption about where the TNAC is held that this actually comprises two distinct kinds of deficit:

1. First, there is the deficit in 2019-20, totalling 679Mt (393Mt in 2019 and 287Mt in 2020), which we think has already been largely hedged by power generators and airlines, and that in any event if not already formally hedged can nonetheless almost certainly be funded in full with EUAs they already hold. Accordingly, we think this deficit over 2019-20 will be funded by that part of the TNAC currently held by the power and aviation sectors.

2. Second, there is the deficit over 2021-25, totalling 787Mt (260Mt in 2021, 261Mt in 2022, 185Mt in 2023, 42Mt in 2024, and 38Mt in 2025), which effectively represents generators' and airlines' forward-hedging requirements to be contracted over 2019-23, and which would ordinarily be covered by auction volumes over 2019-23. However, with the auction volumes significantly reduced over 2019-22, our pre-abatement modelling shown above assumes that this is covered by allowances from that part of the TNAC held by other parties (industry and speculators).

The other key point to note in Figure 10 is that auction volumes are back to being 300Mt higher by 2023 compared with 2019, and 400Mt higher by 2024, such that beyond 2024 we do not see any further annual deficits for generators in the EU-ETS (rather, it is the growing short position of the aviation sector that keeps the EU-ETS in double-digit annual deficit all the way out to 2030).

In short, the supply squeeze is greatest when auction volumes are lowest and the forward-hedging gap is still significant, i.e. over 2019-22, and our assumption is that in order for generators and airlines to acquire the EUAs they need to fill this hedging gap, prices will have to rise further to encourage other holders of the TNAC – industrials and speculators – to sell allowances and thereby balance the market.

The question is, how much further and how quickly?

We see seven ways in which the generators' supply gap over 2019-23 could be filled:

(i) Generators' using their own share of the TNAC
(ii) Industrials' selling of part of their TNAC share[14]
(iii) Speculators' selling of part/all of their TNAC share
(iv) Physical emissions abatement via fuel switching in the power sector from 2019 onwards
(v) Reduced hedging timeframes for power generators
(vi) The risk of an accelerated shutdown of old coal and lignite plants owing to BREF[15]
(vii) Political intervention in response to higher prices

In reality, we would expect a combination of (i), (ii), (iii), and (iv) to plug the supply gap, with (vi), and (vii) as wild cards that could relieve upward pricing pressure if EUAs rise too far too quickly. On balance, while (v) could also come into play, we think that if we are right about prices rising over 2019-23, generators' industrial customers may actually want to lock in their electricity prices further out, thus extending rather than reducing generators' hedging horizons.

In short, the EU-ETS has never before seen such large or sustained annual deficits against the backdrop of such a sharply declining surplus as we are projecting over 2019-23, and we think the upshot will be a need for fuel switching from 2020 onwards in order to bid prices up to levels that incentivize the re-allocation of market length from industry and speculators to generators and airlines).[16]

The question is, at what price would this happen?

Section 2. Updated EUA pricing analysis

With our updated pre-abatement modelling in Section 1 re-affirming that significant emissions abatement via fuel switching will be required to clear the market over 2019-23, this section examines the implications for EUA prices. As in *Carbon Clampdown*, our approach to projecting EUA prices examines the carbon price necessary to invert the current fossil-fuel merit order in continental Europe and thereby push gas-fired generation capacity ahead of coal.

However, given our revised assumption on the range of thermal efficiencies that will be required to achieve the fuel-switching necessary to clear the market, the implied price levels EUAs will need to reach over 2019-23 are now higher than those we were assuming in *Carbon Clampdown*. Based on the current forward curves for coal and gas, and the fixed mining costs for lignite, the level of fuel switching likely required as indicated by our modelling of EU-ETS dynamics over 2019-23 implies to us that EUA prices could reach €25/t by the end of this year as both compliance entities and speculators continue to anticipate the coming supply squeeze.

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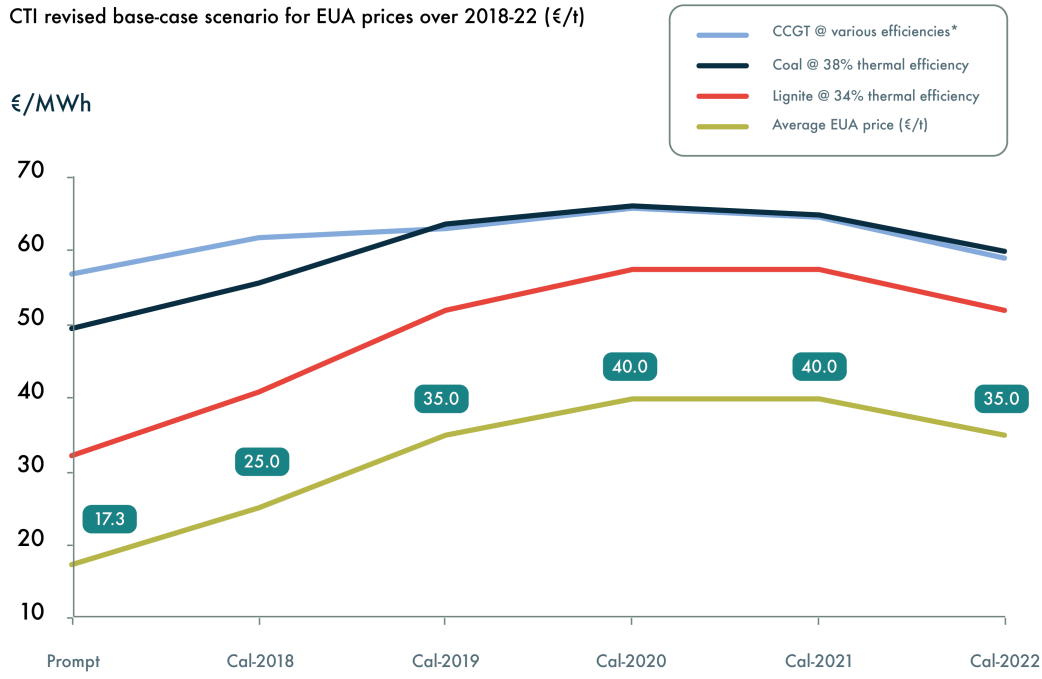
[14] As we explain in Section 1 below (see the sub-section entitled *Filling the supply gap: how will it happen, and what are the implications for EUA prices?*), we think industrials will be reluctant to sell large volumes below €30/t, but that above that level they will sell in increasing volume the higher the price goes. This is for three main reasons: (i) there will in our view be opportunities for industrial abatement at these levels, making monetization of surplus EUAs the rational choice; (ii) some industrials will no doubt wish to cash in on the monetization of free allowances at a very significant profit; and (iii) industrials will also be making their own political calculations about how far prices can rise before political intervention becomes a reality, which again in our view would argue for monetization of allowances at prices in the 35-40/t range.

[15] BREF stands for "best available techniques reference document" for Large Combustion Plants, or LCP BREF, under the European Union's Industrial Emissions Directive (IED).

[16] The back-loading of 900m EUAs over 2014-16 also tightened the market significantly, and the EU-ETS experienced an annual average deficit of -172m over 2014-16, with 2015 seeing the highest annual deficit to date of -263m. However, there were at least five significant differences between the situation in the EU-ETS in 2014 and the situation today, and in our view these differences mean that prices will likely respond much more positively over 2019-23 than they did over 2014-16: (i) the fact that generators have now used up their full quota of CERs/ERUs whereas 277m CERs/ERUs were used for compliance purposes over 2014-16; (ii) the fact that the TNAC was 515Mt higher in 2014 than it is today and that it will drop much more sharply over 2019-23 than it did over 2014-16; (iii) the fact that generators' share of the TNAC was some 300-400m higher in 2014 than it is today; (iv) the fact that the aviation sector has a more meaningful and fast-growing deficit today than it did in n 2014; and (v) the fact that the MSR will cancel a huge volume of allowances permanently in 2023. We analyse these differences in detail below (see Section 1, and the sub-section entitled *Filling the supply gap: the lesons from back-loading over 2014-16*).

Thereafter, based on the forward curves for coal and gas, we think generators will likely need to bid up prices to €35/t in 2019 (at which point 48%-efficient CCGTs would start to run ahead of 38%-efficient coal plants), and then €40/t in 2020 and 2021 as the supply squeeze itself really starts to bite and CCGTs with lower efficiency rates of 45% are required to run ahead of 38%-efficient coal plants. The fuel-switching level then reverts to €35/t in 2022 as gas prices drop faster than coal prices (Figure 11).

Figure 11: CTI updated implied EUA pricing trajectory imputed from coal-to-gas fuel-switching levels 2018-22 (€/t)



*Source: Bloomberg, CTI. *This pricing schedule for gas would be consistent with a 49%-efficient CCGT in 2018, a 48%-efficient CCGT in 2019, a 45%-efficient CCGT in 2020 and 2021, and a 46%-efficient CCGT in 2022.*

Of course, and again as emphasized in *Carbon Clampdown*, there are many dynamic variables in play when we consider how EUA prices might evolve over 2019-23, and we would therefore emphasize that our implied indicative pricing range for EUAs over 2018-22 comes with a number of caveats.

In particular, depending on (i) exactly how much abatement might be required over 2019-23, (ii) the amount and availability of CCGTs with the required efficiency levels, and (iii) the evolution of commodity prices between now and 2021, the carbon price required to plug generators' forward-hedging gap could be higher or lower than the levels we have imputed from our modelling of the supply-demand dynamics in the EU-ETS over 2019-23 and the fuel-switching price levels implied by the current forward coal and gas curves.

Nonetheless, from today's vantage point we think the point stands: with significant levels of fuel switching likely required to push prices to levels that will incentivize the re-allocation of market length from those with surpluses (industry and speculators) to those with deficits (power and aviation), €30-50/t seems to us a reasonable estimate of the range EUA prices could trade in over 2019-23, while we think average prices could trade in a narrower range of €35-40/t as imputed from fuel-switching levels.

In short, we view our modelling to be consistent with EUA prices of €25/t by year-end 2018, and then with *average* prices of €35/t in 2019, €40/t over 2020 and 2021, and then back to €35/t in 2022 as gas prices drop and the impact of the MSR on auction volumes softens somewhat (which means that the forward hedging gap for generators over 2023-25 also softens).

We think these prices are consistent with total abatement of 60Mt in 2019, and 90Mt per year over 2020-22, compared with what would happen under the current EUA forward curve.[17] Accordingly, we explicitly factor these lower emissions levels into our post-abatement modelling.

Section 3. Updated base-case scenario for EU-ETS over 2018-30: the post-abatement schedule

Taking our analysis in Section 1 of the forward-hedging gap for the power and aviation sectors over 2019-23 created by the MSR, and our analysis in Section 2 of the price levels necessary to drive fuel switching at scale and thereby incentivize the reallocation of market length from industry and speculators to generators and airlines, we conclude this report with our base-case modelling of how the supply-and-demand dynamics of the EU-ETS out to 2030 look on a post-abatement basis. In other words, in this section we explicitly model the lower emissions of the power sector as a result of (i) the fuel switching and (ii) the enhanced energy-efficiency measures on the demand side that we see as consistent with our updated base-case pricing schedule.

Compared with our pre-abatement emissions projections, our emissions forecasts for fixed installations under our post-abatement schedule are 60Mt lower in 2019, 90Mt per year lower over 2020-22, 70Mt lower in 2023 and then 30Mt lower in 2024 as the pressure eases with the normalization of auction volumes.

The fact that our emissions projections are lower changes materially the dynamics of the MSR compared with our pre-abatement schedule in Section 1. With lower emissions from the power sector leading to lower annual deficits over 2019-23, the TNAC declines more slowly than under the pre-abatement schedule. In turn, this means that the MSR ends up taking out a larger volume of allowances from auctions for a longer period than under our pre-abatement schedule.

In total, our dynamic modelling of the EU-ETS post-abatement projects that the MSR will remove 1.68bn EUAs over the six years 2019-24, compared with the 1.48bn it takes out over the five years 2019-23 under our static modelling of the EU-ETS on a pre-abatement basis. The cumulative deficit over 2019-23 is 1,123Mt.

In short, the supply squeeze for generators and airlines is greatest when auction volumes are at their lowest and the forward-hedging requirement is still significant, i.e. over 2019-21. This is why we think EUA prices will have to go to the fuel-switching level over this period, thereby enabling the market length to be re-allocated from industry and speculators to generators and airlines.

Over the second half of Phase 4 the annual deficits for fixed installations are much smaller, with the aviation sector's growing deficits becoming the main driver of marginal EUA demand and hence of the abatement requirement in the system overall. Indeed, we think there is much less visbility regarding the implied outlook for pricing over 2024-30 than over 2019-23. This is because we expect the cost of both renewables and energy-storage technology to continue falling over the next decade, while the impact of coal phase-out policies across a number of EU member states by the middle of Phase 4 could be greater than we are currently assuming (especially if Germany decides to phase out a significant amount of old coal and lignite capacity by the middle of the next decade)

Accordingly, we think it is an open question as to whether or not fuel switching will actually be required over the second half of Phase 4 at all given that these trends will lead to a structural decline in the power sector's emissions in any case. This raises difficult questions about the visibility of EUA prices from 2025, which in turn explains why some EU governments – and especially the French government – continue to push the idea of a carbon-price floor that would rise over time.

This is a topic we will explore in depth in our next report.

[17] As explained above, we expect two thirds of these emissions reductions to come from fuel switching itself, and one third from energy-efficiency savings.

Main Modelling Assumptions

Key assumptions on market dynamics

Our projections for EU-ETS market dynamics over 2021-30 are based on our assumptions with regard to three key sets of variables: (i) supply-side dynamics; (ii) demand-side dynamics; (iii) commodity prices. Below, we set out our main assumptions across these three sets of variables, as well as the main risks we see to these assumptions.

We would emphasize that the assumptions set out here fare those used in our post-abatement modelling in Section 3 of this report. This takes our pre-abatement modelling as set out Section 1 below and then adjusts for the emissions reductions we factor in over 2019-23.

Supply-side assumptions

Our main assumptions on the supply-side dynamics of the EU-ETS out to 2030 are based on the EU-ETS reform deal transposed into EU Law in March of this year,[18] the most important of which are as follows:

1. We assume that that the MSR removes EUAs from the market at a rate of 24% per year over 2019-23, and then 12% in 2024. From 2023 onwards the (TNAC) is always below the 833m threshold that triggers the MSR to remove EUAs from the market, but at no point does it drop below the 400m threshold below which it would start to release allowances back into the market.[19]

2. We assume that the Linear Reduction Factor used for determining the cap is increased to 2.2% from 2021 versus the current 1.74%, leading to an annual reduction in the cap over 2021-30 of 48Mt.

3. We assume that all unused Phase-3 EUAs are placed in the MSR at the end of 2020 (327m from the Phase-3 New Entrant Reserve, or NER, and 524m from other sources, mostly plant closures), apart from 50m that we assume are auctioned in 2020 as the top-up to the Innovation Fund.

4. We assume that the two key funds over Phase-4 of the EU-ETS – the Modernization Fund and the Innovation Fund – are monetized over different timeframes. We assume that the Modernization Fund's 310m EUAs are auctioned in 10 equal instalments over 2021-30, and that the Innovation Fund's 400m EUAs are auctioned in five equal instalments over 2021-25. For the 50m top-up to the Innovation Fund, we assume these EUAs are auctioned to the market already in 2020.

5. We assume that the cap for the aviation remains fixed at the current level all the way out to 2030. We also assume that the scope of coverage for aviation emissions remains limited to intra-EU/EEA flights all the way out to 2030.

Demand-side assumptions

For the main EU-ETS covering fixed industrial installations, we assume that emissions decline in 2018 by 2.5% (45Mt)[20] and then drop more sharply from 2019 as we start to see the impact of fuel switching and energy-efficiency savings from higher EUA prices. Our post-abatement emissions are lower than our pre-abatement schedule by 60Mt in 2019, 90Mt over 2020-22, 70Mt in 2023, and 30Mt in 2024. We continue to assume a slight rebound in emissions over 2021-23 owing to the culmination of the nuclear phase-out in Germany, but from a lower base than in *Carbon Clampdown* given the emissions reductions from fuel switching and energy efficiency that we are now factoring in.

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[18] The EU-ETS reform was published in the Journal of the European Union on 19 March, and formally entered into legal force 20 days later, on 8 April 2018.

[19] As explained in Section 1 below, given that we are projecting a cumulative deficit of 600Mt for the aviation sector by 2030, the balance for fixed installations by 2030 must be in surplus by at least 600Mt in order for the system overall to balance.

[20] As we explained in *Carbon Clampdown*, emissions in 2017 rose year-on-year for the first time in the ETS since 2010, in part because of robust industrial growth, but in part also because hydro production was weaker than usual in a number of markets (Spain, Portugal, Italy, Austria, and France) and had to be made up for by increased fossil-fuel generation (see the report published by Sandbag and Agora Energiewende, The European Power Sector in 2017). We assume more normalized weather patterns in 2018.

On the special issue of Brexit, we assume that the UK remains in the EU-ETS after leaving the EU in March 2019, such that the scope of coverage for the EU ETS remains the same all the way out to 2030.

For the main EU-ETS covering fixed industrial installations, this means that on our numbers emissions decline from 1,754Mt in 2017 to 1,387Mt in 2030, a drop of 367Mt, or ~20%.

For aviation,[21] the demand-side dynamics are very different as emissions are projected to continue growing. In our model, we make the simple assumption that aviation emissions covered by the EU-ETS will grow at a fixed rate of 2Mt per year over 2017-30.

Commodity-price assumptions

When looking at the EUA price needed to incentivise large-scale fuel switching over 2019-23, coal and gas prices are key. Other things being equal, the higher the coal price, the lower the carbon price needed to make gas more competitive in the merit order, and the lower the coal price, the higher the carbon price required to make gas more competitive (and vice versa with regard to gas prices). For our modelling purposes here, we take the forward curves for coal and gas out to 2022,[22] and on this basis derive an implied pricing range for EUAs of €30-50/t over 2019-22 as being consistent with large-scale fuel switching, with the implied *average* prices over this period in a narrower range of €35-40/t.

Risks to our thesis

Supply-side risks

On the supply side, the main risk to our projections is that ~120m of the unused allowances left over at the end of Phase 3 could be auctioned off in late 2020/early 2021 rather than going straight into the MSR as we have assumed. If this were to happen it could modestly reduce the effectiveness of the MSR in reducing the surplus over 2020-21, and hence reduce the supply gap in our base case.

Demand-side risks

On the demand side, the generic risks that could lead to a faster rate of reduction in EU-ETS emissions over 2018-30 than we are assuming are (i) prolonged economic weakness across the EU, (ii) rapidly improving levels of energy efficiency over 2021-30, (iii) an acceleration in the continuing build out of renewable-generation capacity across the EU, (iv) mandated coal phase-outs over the next decade in a number of EU member states,[23] and (v) the EU's updated Industrial Emissions Directive with its tougher air-quality standards from 2021.[24]

On Brexit, if the UK were to leave the EU-ETS at the end of Phase 3, then in our view other EU member states would have to take a bigger share of the burden for reducing emissions within the EU carbon market (this is because the UK has a much more ambitious emissions-reduction target out to 2030 than the EU as a whole, and this is reflected in the allocations to UK installations). As a result, such a scenario poses an upside risk to our modelling of the size of the supply gap over 2021-30.

Commodity-price risks

Other things being equal, if coal prices turn out higher than the current forward curve and/or gas prices turn out lower, the EUA price needed to achieve large-scale fuel switching across the EU will be lower than the €35-40/t average price range we calculate will be necessary over 2019-223 on the basis of the current forward curve.

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[21] Aviation has been included in the EU-ETS since 2012, but currently only emissions from intra-EU/EEA flights are in scope.

[22] As explained above, we take the forward curves for coal and gas as of 1 August 2018.

[23] By far the most important country in this respect is Germany, where the future of coal-fired generation will be decided next year when the Government-appointed commission on this issue reports back with its conclusions. We would note, though, that coal remains a highly charged political issue in Germany, and that with the nuclear phase-out culminating in 2022 it is by no means clear at this stage that Germany's coal phase-out will happen as soon as that of other EU member states that have already given an end date (2022 for France, 2025 for the UK and Italy, and 2030 for the Netherlands, Finland, and Portugal).

[24] We consider this point in more detail in Section 1 below (see the sub-section entitled *Filling the supply gap: how will it happen, and what are the implications for EUA prices?*).

1. THE EU-ETS OVER 2018-30: THE PRE-ABATEMENT SCHEDULE

In this section we set out our updated projections for the EU-ETS on a pre-abatement basis, looking at the impact of the MSR over 2019-23 and the market balance this gives rise to all the way out to 2030 *before* the emissions reductions that we think will ultimately be necessary to clear the market over 2019-23 are factored in. In other words, this section sets out how the annual and cumulative EU-ETS balances would look over 2018-30 assuming no change in the merit order for FF generation over 2019-23. The point of the exercise here is to show (i) how big the forward-hedging gap for generators and airlines is over 2019-23, and (ii) to explain how we think this gap will have to be covered.

On our revised pre-abatement numbers, we project an average annual deficit for the EU-ETS over 2019-30 of -133m EUAs (fixed installations and aviation combined), with the supply squeeze at its most acute over 2019-23. Over these five years we see the market short by an average of -277m per year. The EU-ETS has never before seen such large or sustained annual deficits against the backdrop of such a sharply declining surplus, and we think the upshot will be a need for fuel switching in the power sector from 2020 onwards to in order to bid prices up to levels that incentivize the re-allocation of market length from those with surpluses (industry and speculators) to those with deficits (generators and airlines).

Section 2 then looks at the economics of fuel switching over 2019-23, while Section 3 sets out our new base case for the supply-and demand dynamics of the EU-ETS on a post-abatement basis, i.e. with the emissions reductions and energy-efficiency savings we expect to occur in response to higher EUA prices over 2019-23 explicitly factored into our numbers.

Modelling the EU-ETS: why the system has to balance by 2030

We have made two main changes to our pre-abatement forecasts from *Carbon Clampdown*, the first to reflect updated data on key market indicators, the second to reflect a change in our methodology:

(i) We update our projections for both the supply of and demand for EUAs out to 2030 in line with the most up-to date numbers for the 2017 Verified Emissions Data (VED), the Total Number of Allowances in Circulation (TNAC), and the state of the Phase-3 NER.

(ii) We revise our modelling methodology and are now working back from the need for the market to balance by 2030.[25] This means we now have the market explicitly in balance by 2030, rather than implicitly so, as was the case previously. Given that we have not changed our projections for the aviation sector's emissions out to 2030 – we are still projecting a cumulative deficit for aviation of 600Mt by 2030 – this means that the cumulative surplus for fixed installations (otherwise known as the TNAC)[26] cannot fall below 600m by 2030, as otherwise the EU-ETS overall would be in deficit by 2030, and since allowances may not be borrowed from a future trading period this cannot happen.

[25] Previously, we implicitly assumed that the market would need to balance by 2030, but our projections actually showed a cumulative deficit of -266m EUAs for the EU-ETS as a whole (i.e. including aviation) by 2030 (see *Carbon Clampdown*, pp. 39-40). As we explained in *Carbon Clampdown*, this methodology was designed to show the amount of abatement that would be needed to bring emissions into balance with the cap over 2021-30, and we were clear to point out that in reality there could never be a cumulative deficit in the EU-ETS overall (i.e. including aviation) at the end of a given trading period as the EU-ETS Directive prohibits the borrowing of allowances from a future trading period into an earlier one. By contrast of course, it is possible for the system as a whole to have a cumulative surplus of EUAs at the end of a given trading period, as while allowances may not be borrowed from future trading periods into earlier ones, they may be banked from a given trading period into the next one and beyond. Indeed, at the end of Phase 2 the EU-ETS overall (i.e. including aviation) had a huge surplus of 2,045m EUAs, and by the end of Phase 3 we project that the overall system surplus will still be a hefty 915m EUAs.

[26] As we explained in *Carbon Comeback*, the TNAC number is key, as it the TNAC that determines how many allowances will be withheld from the market every year and placed into the MSR. However, and as we also explained in *Carbon Clampdown*, the TNAC calculation ignores the cumulative balance of the aviation sector. This means that the TNAC number systematically overestimates the size of the EUA surplus, as it fails to take into account the demand for EUAs from aviation.

As there is currently no way for the aviation sector to reduce its own emissions in the short to medium term, this means that on our numbers the aviation sector will have to purchase 600m EUAs in the market over the period 2013-30, with the vast majority of this amount (>500m) needed to cover the projected deficit over 2018-30. This means that the aviation sector's demand for EUAs will force prices higher for fixed installations as well, such that abatement in the power sector will be needed to bring the market into balance. In simple terms, the emissions of the inflexible sector (aviation) will determine the emissions of the flexible sector (power) so that the market can balance.

As a result of this change in our modelling methodology, our projected pre-abatement emissions for fixed installations over 2021-30 are now 366Mt lower than previously, at 15,453Mt compared with 15,829Mt in *Carbon Clampdown*.[27] This means we are now projecting a compound annual reduction in fixed installations' emissions over 2021-30 of 2.7% (versus 1.8% previously), and that our projected emissions now fall more quickly than the cap over Phase 4 (the cap falls at a linear rate of 2.2% per year from 2021).

A final observation worth noting in connection with our revised methodology is that we now think it practically impossible for the MSR to drop below 400m EUAs – the threshold below which the MSR starts to release EUAs back into the market – once the cumulative deficit of the aviation sector reaches 400m.

This is because once the cumulative deficit of the aviation sector reaches 400m there must be at least that number in the TNAC to prevent the system overall going into cumulative deficit. On our unchanged projections for aviation, the cumulative deficit for the sector passes 400m in 2026. This means that we think it impossible for the TNAC to drop below 400m after 2025.[28]

Market dynamics 1: Why aviation is key to modelling the EU-ETS out to 2030

As we explained in *Carbon Clampdown*, aviation is structurally short allowances in the EU-ETS,[29] and we expect its short position to increase over time as its emissions continue to grow out to 2030. Indeed, our projections for the aviation sector's emissions over 2018-30 have not changed, which means that we continue to project a cumulative deficit for aviation by 2030 of 600Mt.

However, and as we also explained in *Carbon Clampdown*, the impact of aviation on the EU-ETS system balance is ignored by the Commission for the purposes of calculating the annual amount of EUAs that will be injected into the MSR from 2019 onwards. This means that the impact of aviation on EU-ETS dynamics over 2019-30 is doubly bullish: the sector has a growing short position over time, but the fact that this is ignored by the Commission when calculating the amount of EUAs to be injected into the MSR annually means that the overall EU-ETS surplus as of today will be reduced more quickly than would be the case if the aviation sector's balance were also taken into account.

[27] As explained below, this means that while on the basis of the assumptions we have made about aviation emissions out to 2030 it is possible for the emissions of fixed installations over Phase 4 to be lower than the 15,453Mt we are now projecting (this would simply mean that the EU-ETS as a whole would still have a cumulative surplus by 2030), it is impossible for this number to be higher than 15,453Mt (as this would imply a cumulative deficit in the EU-ETS overall by the end of Phase 4).

[28] It might be argued that it would be theoretically possible for the EU-ETS overall to enter into cumulative deficit in any year over Phase-4 apart from 2030 itself, as 2030, being the last year of Phase 4, is the only year in which the EU-ETS overall is legally required to be at least in balance on a cumulative basis (it may also be in cumulative surplus at the end of a given trading period, but never in cumulative deficit). In reality, however, we think the market would pre-empt an overall cumulative system deficit in any given year by pushing prices higher in order to drive the abatement necessary to ensure the system overall remained at least in balance. And in any case, on our updated projections the TNAC does not drop below 400m at any point over Phase 4 (i.e. not even in the early part of Phase 4 when the aviation sector's cumulative deficit is below 400m).

[29] The allowances allocated and auctioned to airlines are known as European Aviation Allowances (EUAAs). Crucially, airlines are also permitted to buy standard EUAs in the market and use them for their own compliance obligations, but EU-ETS fixed installations are not permitted to use EUAAs for their compliance obligations.

Moreover, the aviation sector cannot reduce its own emissions meaningfully based on current technology, and we do not expect this fundamental fact to change materially before 2030. This is absolutely crucial in terms of the impact of aviation on EU-ETS dynamics more broadly, as it means that the greater the aviation sector's cumulative deficit by 2030, the higher the cumulative surplus for fixed installations will have to be by 2030 in order to ensure that the system overall can be balanced by the end of Phase 4.

On this logic it follows that with a projected cumulative deficit of 600Mt for aviation by 2030, fixed installations will have to post a cumulative surplus of at least 600Mt[30] by 2030 for the system overall to balance.

The balancing mechanism will be the EUA price. Demand for EUAs on the part of airlines – whose emissions cannot be flexed in the short and medium-term – will push EUA prices to the level required to bring emissions for fixed installations – whose emissions, given fuel-switching potential in the power sector, *can* be flexed in the short and medium term – into line with the level that balances the system. In other words, airlines' demand for EUAs over Phase 4 will prompt fuel switching in the power sector so as to produce the emissions abatement that balances the market overall.

With this said, we now offer a brief re-cap of our unchanged projections for aviation emissions out to 2030 before then looking in greater detail at our updated supply-and-demand projections for fixed installations.

Modelling the aviation sector out to 2030

We continue to make the same key assumptions in our modelling of the aviation sector out to 2030 as we set out in *Carbon Clampdown*, namely:

1. That the cap for aviation remains fixed at the current level all the way out to 2030. We would note, however, that the rules for 2021-30 are not yet finalised, and ultimately the Phase-4 cap for aviation might well be subject to the same linear-reduction factor as the EU-ETS cap for fixed installations from 2021, namely 2.2%.[31]

2. That the distribution of EUAAs over 2021-30 retains the current split between freely allocated and auctioned allowances, but with no CDM/JI credits permitted for compliance from 2021 onwards.[32]

3. That the scope of coverage for aviation emissions remains limited to intra-EU/EEA flights all the way out to 2030.[33]

4. That aviation emissions grow at a rate of 2Mt per year over 2017-30, reaching 89Mt by 2030 versus 53Mt in 2013, an increase of ~70% over the 18 years of Phases 3 and 4 combined. To derive this number we have simply looked at the growth of aviation emissions over the last four years and extrapolated the same absolute growth rate.

[30] We say "at at least 600Mt" here because this is the amount that on our numbers would be required to offset the deficit of the aviation sector. It would be possible for the surplus for fixed installations to be higher than this (in which case the system overall would be banking allowances into Phase 5), but it could never be smaller, as otherwise the system would not balance.

[31] As such, our assumption here is on the conservative side in that the aviation cap over Phase 4 might ultimately decline by 2.2% per year rather than remaining fixed as we are assuming. If we assume the same projected level of emissions as in our base case above but a cap declining at 2.2% per year over 2021-30, then the average annual deficit would be ~5Mt higher over Phase 4, an the cumulative deficit by 2030 would be ~650Mt rather than the 600m in our base case.

[32] Again, it may well be that the aviation sector ends up with a lower level of free allocations over 2021-30 than we are assuming, but we would note that if this does turn out to be the case it will not have any impact on the supply-demand balance, and hence no impact on prices either.

[33] Whether this remains the case will ultimately depend on the EU's assessment nearer the time of the progress made by the International Civil Aviation Organization (ICAO) regarding a market-based mechanism for global aviation emissions. However, even if the EU were ultimately to conclude that the ISAO's efforts to tackle global aviation emissions were inadequate, in practical political terms we find it hard to believe that the EU would face down countries like the United States, China, and India and ultimately include all flights entering and leaving the EU within the EU-ETS (not least as it has already shied away from this fight once before).

Against this backdrop, Figures 12 and 13 show the unchanged projections for the aviation sector's annual and cumulative balances respectively over 2008-30 that our assumptions give rise to.[34]

As can be seen in Figure 12, the aviation sector has been short EUAAs from the start of Phase-3, running an annual average deficit (after also taking into account their allowed use of CDM/JI credits) of 18Mt over 2013-17, and accumulating a deficit of -94m in the first five years of Phase 3. We project that the sector's annual deficit will continue to increase over the second half of Phase 3 and over the course of Phase 4, reaching -31Mt in 2020 and -51Mt, by 2030.

Figure 12: CTI base case for aviation in the EU-ETS, annual deficit, 2008-30, EUAAs/EUAs (m)

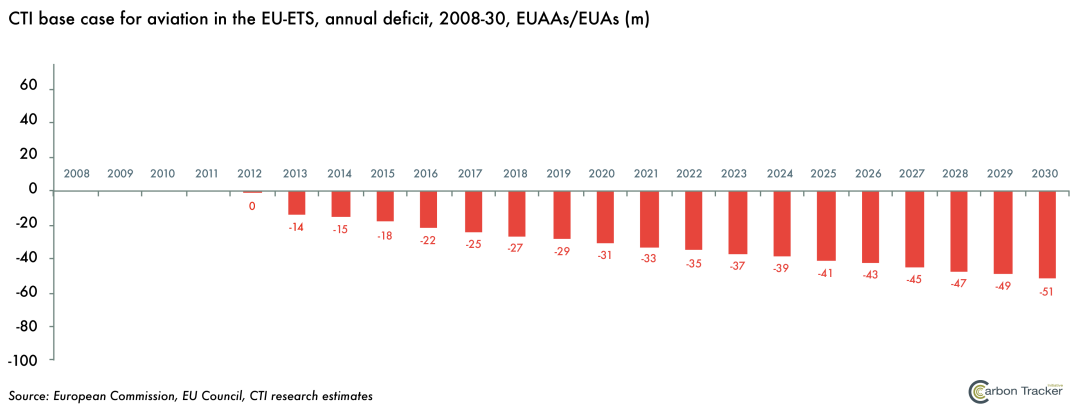
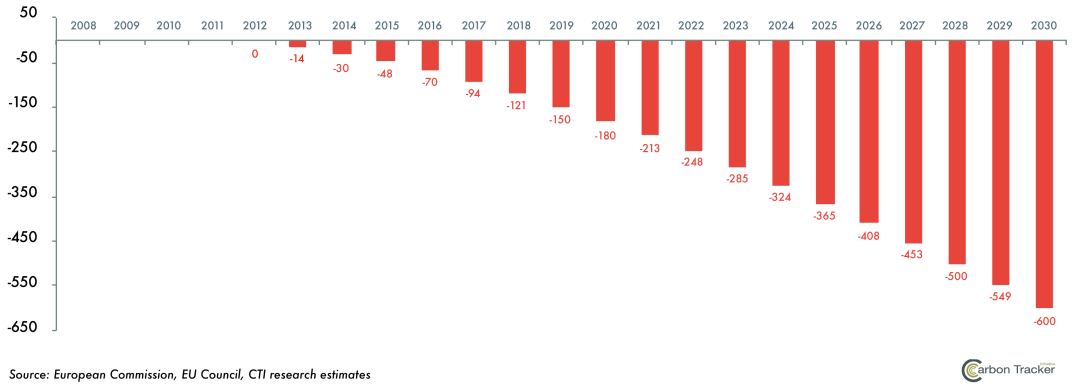


Figure 13 then shows our projections for the aviation sector's cumulative deficit over Phases 3 and 4: by the end of Phase 3, we project that the sector's deficit will be 180Mt, and by the end of Phase 4, 600Mt.

Figure 13: CTI base case for aviation in the EU-ETS, cumulative deficit, 2008-30, EUAAs/EUAs (m)



Given the very limited scope for the aviation sector to reduce emissions in the short to medium term, we project that all of this deficit will have to be compensated via the purchase of EUAs from the main EU-ETS market, with the sector becoming an increasingly important source of demand for EUAs over time as its deficit increases year on year over Phase 4.

In short, we continue to project a cumulative deficit for aviation by the end of Phase 4 of 600Mt, which will have to be offset by an equivalent surplus for fixed installations.

[34] Although the aviation sector was not included in the EU-ETS until 2012, showing the dynamics from 2008 allows for an easier understanding of its impact on total system dynamics in our synthesis of the aggregated EU-ETS balances below.

Market dynamics 2: huge pre-abatement supply squeeze for fixed installations, 2019-23

Figure 14 shows our updated projections for the market dynamics for fixed installations (i.e. excluding aviation) over Phase 3 of the EU-ETS on a pre-abatement basis, and Figure 15 our projections for Phase 4 (again, excluding aviation), again on a pre-abatement basis.

Figure 14: Updated CTI EU-ETS pre-abatement market dynamics over 2013-20 (fixed installations only), EUAs/CERs/ERUs* (m)

	2013	2014	2015	2016	2017	2018	2019	2020
Total cap	2,084	2,046	2,008	1,970	1,931	1,893	1,855	1,816
Auctioned EUAs	916	528	633	733	951	940	544	640
Free allocations	1,012	938	872	821	777	790	751	748
NER	12	12	12	25	25	26	21	20
Total EUAs	1,940	1,478	1,517	1,579	1,753	1,756	1,316	1,409
CDM/JI credits	132	252	23	2	11	15	15	15
Total credits	2,072	1,730	1,540	1,581	1,764	1,771	1,331	1,424
EU-ETS emissions	1,908	1,813	1,803	1,750	1,754	1,710	1,695	1,680
Annual surplus/deficit	164	-83	-263	-169	-39	61	-364	-256
Cum. surplus (TNAC)	2,209	2,126	1,863	1,694	1,655	1,715	1,351	1,095

*Source: European Commission, CTI research estimates. *CERs and ERUs are the carbon offsets generated from the Kyoto Protocol's CDM and JI project mechanisms.*

Figure 15: Updated CTI EU-ETS pre-abatement market dynamics over 2021-30 (fixed installations only), EUAs/CERs/ERUs* (m)

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Total cap	1768	1720	1671	1623	1575	1526	1478	1429	1381	1333
Auctioned EUAs	738	769	847	959	931	917	889	861	834	806
Free allocations	720	700	679	658	637	616	596	575	554	533
NER	15	15	15	15	15	15	15	15	15	15
Total EUAs	1,473	1,484	1,541	1,632	1,583	1,548	1,499	1,451	1,403	1,354
CDM/JI credits	0	0	0	0	0	0	0	0	0	0
Total credits	1,473	1,484	1,541	1,632	1,583	1,548	1,499	1,451	1,403	1,354
EU-ETS emissions	1,700	1,710	1,689	1,635	1,580	1,528	1,477	1,428	1,381	1,335
Annual surplus/deficit	-227	-226	-148	-3	3	20	22	23	22	19
Cum. Surplus (TNAC)	868	642	493	490	493	513	535	558	581	600

Source: European Commission, CTI research estimates

The 2017 data: modest changes in our updated numbers

Our revised assumptions take into account the most up-to-date information from the Commission in terms of (i) the VED in 2017, (ii) the publication of the 2017 TNAC number on 15 May, and (iii) the latest numbers for EUAs either already distributed or earmarked for future distribution from the Phase-3 NER. Based on the most up-to-date information in the European Transaction Log (EUTL) as shown on the European Environment Agency's website,[35] we now have 2017 VED as 1,754Mt (1,764Mt previously), but we have not changed our emissions projections over the remainder of Phase 3.[36]

[35] See the EEA's EU-ETS data viewer at: https://www.eea.europa.eu/data-and-maps/dashboards/emissions-trading-viewer-1

[36] This means that our cumulative emissions forecasts for Phase 3 are only 10Mt lower than then previously. As explained below, however, our cumulative emissions forecasts over Phase 4 are now 376Mt lower owing to the change in our modelling methodology.

For the TNAC, we take the number published by the Commission in its communiqué of 15 May (1,655m versus the 1,703m we were previously assuming in *Carbon Clampdown*),[37] while noting that this does not fit with the 2017 VED of 1,754Mt shown in the EUTL.

That is to say, the implied annual increase in emissions shown in the TNAC calculation of 15 May is 1,803Mt, rather than the 1,754Mt shown in the EUTL. We understand from the Commission that the discrepancy arises owing to the fact that the aggregate data shown in the TNAC calculation for all verified emissions since 2013 includes restatements of the figures shown in earlier years at the time of their initial publication.

In any event, and notwithstanding the lack of transparency around the precise reasons for this 49Mt discrepancy, to the extent that the 2017 TNAC figure of 1,655Mt will be the one that determines the number of allowances to be withheld from auctions and fed into the MSR over January-August 2019,[38] this is the number we are now using in our model.

For the NER, the most recent update from the Commission published on 16 July shows that of the initial Phase-3 NER of 480m EUAs, 112m have already been put into circulation over 2013-18, with a further 41m earmarked for distribution over 2019-20.[39] We update our estimates for NER distributions out to 2020 accordingly, and lower our forecast for the number of allowances that will be left in the NER at the end of Phase 3 to 327m from 370m previously.

Key supply-side assumptions for Phase 4 mostly unchanged

Beyond Phase 3, our updated supply projections for fixed installations over 2021-30 remain based on the EU-ETS reform deal agreed in November 2017 as set out in the European Council's communiqué of 22 November 2018.[40]

This means our key assumptions on the supply side continue to be as follows:

1. That the MSR removes EUAs from the market at a rate of 24% per year for the first five years (i.e. over 2019-23).

2. That from 2023 onwards, EUAs in the MSR are cancelled in an amount equivalent to the excess of EUAs in the MSR over the previous year's auctioning level (previously we were assuming that the cancellation of allowances would happen from 2024 onwards).[41]

3. That the two funds carved out of the total pool of Phase-4 allowances – the Modernization Fund and the Innovation Fund – are monetized as follows:

- **The Modernisation Fund:** 310m EUAs auctioned in ten equal instalments over 2021-30 (this has already been decided);

- **The Innovation Fund:** 400m EUAs plus a top up of another 50m. We assume the 400m will be front-loaded and auctioned in five equal instalments over 2021-25 (this has yet to be decided). For the 50m top-up (which are taken from the unused allowances left over from Phase 3), we assume that these are auctioned already in 2020 as a top-up to the Modernisation Fund (this has not yet been confirmed but looks likely).

This means we continue to assume a total of 760m EUAs are auctioned over 2020-30 from the two funds, of which 710m are taken from the Phase-4 cap, and 50m from the Phase-3 cap's leftovers.

[37] See https://ec.europa.eu/clima/sites/clima/files/ets/reform/docs/c_2018_2801_en.pdf

[38] We provide a reminder of exactly how the MSR works below.

[39] See https://ec.europa.eu/clima/sites/clima/files/ets/allowances/docs/status_table_ner_en_0.pdf

[40] See Reform of the EU-ETS – Council endorses deal with European Parliament, 22 November 2017.

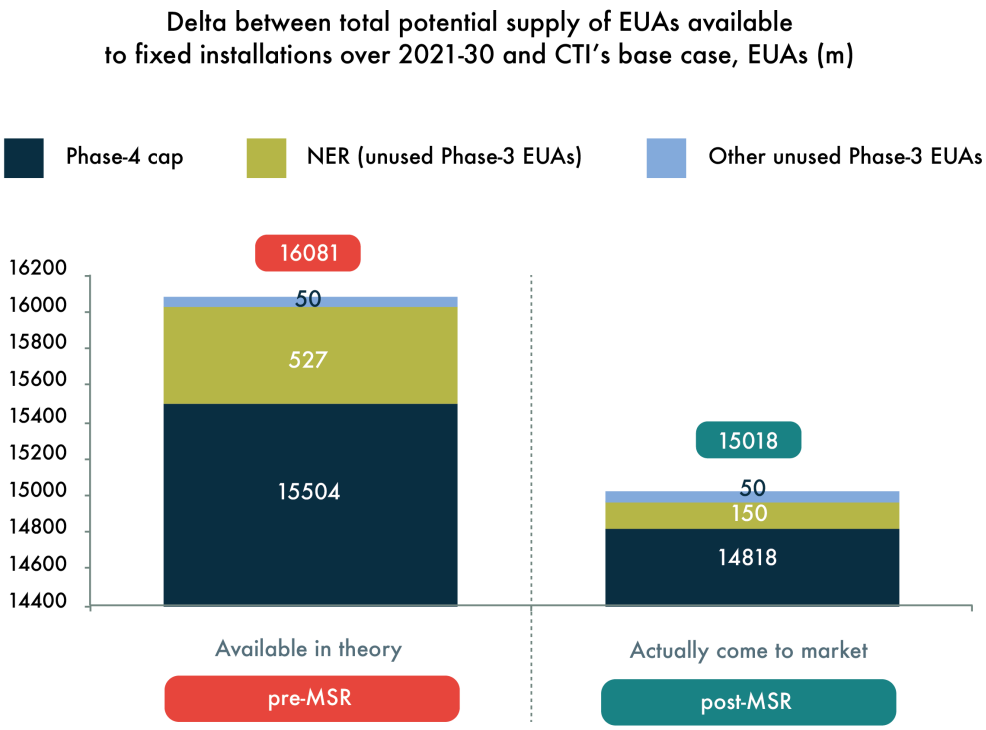
[41] That said, after an initial cancellation of a very large number of allowances in 2023 – 2,359m on our updated numbers versus 2,357m previously – our model continues to see no need for any further cancellations thereafter.

4. That the Phase-4 New Entrant Reserve is initially established with the EUAs left over in the NER at the end of Phase 3 (327m on our update numbers versus 370m previously, with an extra 200m available from the MSR on top of this if required (i.e. also taken from the unused allowances left over from Phase 3 rather than from the Phase 4 cap).

5. That the buffer of 465m EUAs set aside for industries at risk of carbon leakage is not needed and that these EUAs are therefore auctioned over 2026-30.[42]

Putting all this together means that on our updated pre-abatement numbers we are now modelling a total potential supply over 2021-30 of 16,081m, comprising (i) the Phase-4 cap itself of 15,504m, plus (ii) the NER of 527m (sourced from unused Phase-3 EUAs), and (iii) an extra 50m EUAs for the Innovation Fund (also sourced from unused Phase-3 EUAs).

Figure 16: Delta between total potential supply of EUAs available to fixed installations over 2021-30 and CTI's base case, EUAs (m)



Source: European Commission, EU Council, CTI research estimates

However, and as shown in Figure 16, we assume that only 150m allowances from the NER are needed to satisfy new entrants' actual demand,[43] and with the MSR removing EUAs from the market over the

[42] In order to protect the industries covered by the EU-ETS at risk of carbon leakage, the EU-ETS reform deal has set aside a buffer equating to 3% of the total Phase-4 cap (i.e. 465m allowances) from the pool of EUAs that would ordinarily be auctioned. These EUAs will be distributed for free to industries at risk of carbon leakage as a top-up to their Phase-4 allocation if the so-called cross-sectoral correction factor (CSCF) is triggered. Whether the CSCF is triggered or not will depend on the level of production in these industries over pre-defined periods ahead of 2021-5 and 2026-30 respectively. On our modelling, the CSCF is not triggered over either of these two periods, so we assume that all of these 465m EUAs are auctioned back to the market over 2026-30 in five equal instalments.

[43] In this respect, we would emphasise that this means our emissions forecasts are more conservative than they look. This is because although we have emissions trending down every year from 2022, this number implicitly incorporates 15Mt of emissions per year from 2021 onwards that were not there in 2020, and which are satisfied by EUAs from outside the scope of the Phase-4 cap (i.e. with unused EUAs from Phase 3). This means that on a like-for-like basis the starting point in 2021 for our annual emissions forecast over Phase 4 is lower by an extra 15Mt versus the 2020 level than might at first sight be obvious.

first three years of Phase 4, the total number of EUAs that actually comes to market over 2021-30 on our updated numbers is 15,018m: 14,818m from the Phase-4 cap itself, and 200m from unused Phase-3 EUAs (150m from the NER, and 50m to top up the Innovation Fund[44]).

Figure 17 then shows our revised modelling of the MSR over 2019-30, and Figure 18 shows diagrammatically the impact of the MSR over the crucial 2019-23 period. The impact of the MSR is actually greatest in 2019 and 2020, because the TNAC is by definition at its highest point at the end of the year before which the MSR starts up.

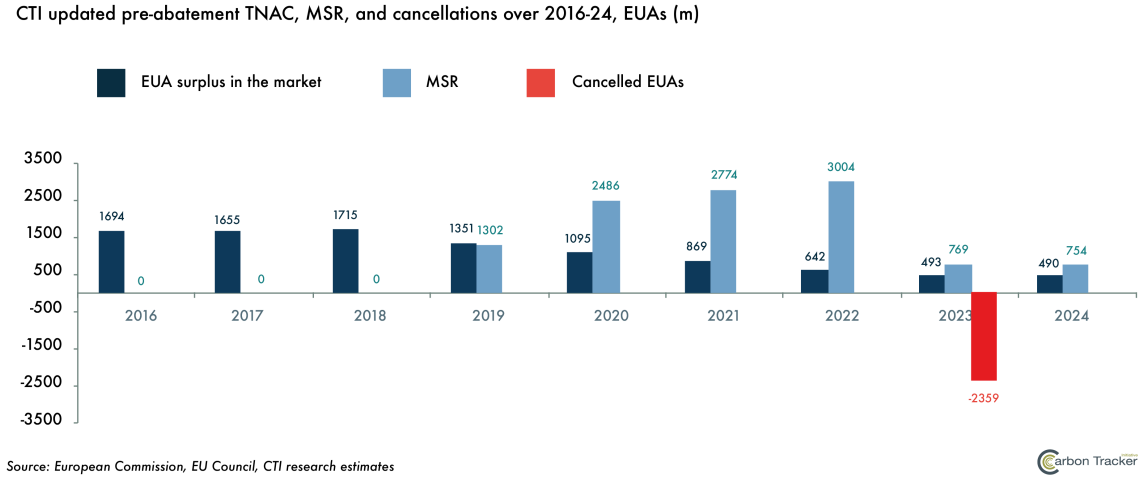
Figure 17: CTI updated pre-abatement MSR dynamics over 2019-30 (EUAs, m)

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Normal inflow	402	383	304	245	139	0	0	0	0	0	0	0
Normal outflow	0	0	0	0	0	0	0	0	0	0	0	0
Leftover Phase-3 EUAs	900	801	0	0	0	0	0	0	0	0	0	0
NER	-15	-15	-15	-15	-15	-15	-15	-15	-15	-15	-15	-15
Cancellations	0	0	0	0	-2 ,359	0	0	0	0	0	0	0
Annual change	1 ,302	1 ,184	289	230	-2 ,235	-15	-15	-15	-15	-15	-15	-15
CUM. POSITION	1 ,302	2 ,486	2 ,774	3 ,004	769	754	739	724	709	694	679	664

Source: European Commission, CTI research estimates

As we explained in *Carbon Clampdown*, EUAs are fed into the MSR on a September-August basis, because each year's TNAC number is only published by the Commission in May of the following year. So, for 2019, the amount fed into the MSR equates to 8/12 of the 2017 TNAC as published in May 2018 (1,655m, which is then fed in each month over January-August of 2019 in eight equal instalments), plus 4/12 of the 2019 TNAC to be published in May 2019 (fed into the MSR over September-December 2019, again in equal monthly instalments).

Figure 18: CTI updated pre-abatement TNAC, MSR, and cancellations over 2016-24, EUAs (m)



Source: European Commission, EU Council, CTI research estimates

The process is then repeated each year in the same fashion until the TNAC falls to 833m, after which no more allowances are removed from the market unless the TNAC reverts to a level above 833m in any subsequent year.

[44] Note that our assumption is that these 50m are actually auctioned in 2020 rather than in Phase-4 itself.

Conversely, if in any given year the TNAC drops below 400m, the MSR starts to release allowances back into the market at a rate of 100m per year.[45]

Accordingly, with the 2017 TNAC as published by the Commission on 15 May standing at 1,655m, and our estimate for the 2018 TNAC now being 1,715m (Figure 14 above), the normalised inflow into the MSR in 2019 on our updated projections is 402m. Thereafter, we project the normalised inflow to be 383m in 2020, 304m in 2021, 245m in 2022, and 139m in 2023.

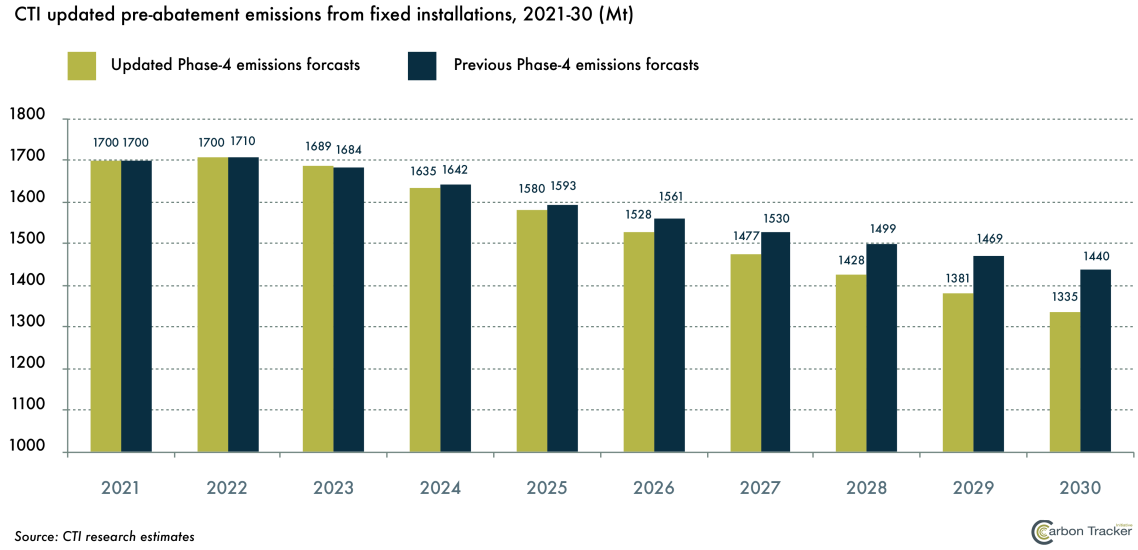
On top of this, 2019 sees the 900m back-loaded EUAs added to the MSR, and 2020 a further net inflow of 801m unused EUAs from Phase 3. This number comprises two inflows, and one outflow. The inflows are: (i) 327m of unused EUAs from the NER; and (ii) 524m unused EUAs from other sources (mostly from closures, but also from the pool of derogated EUAs set aside for modernisation of the power systems in certain eastern European Member States). The outflow is of the 50m unused EUAs that are auctioned to top up the Modernization Fund.

In 2023, the cancellation of a number of allowances equating to the difference between (i) the number of EUAs in the MSR and (ii) the previous year's auctioned amount kicks in, such that 2,359m EUAs are cancelled.[46] Thereafter, if the number of allowances in the MSR is greater than the previous year's auctioning amount, a number of allowances equal to this difference is cancelled (this eventuality does not arise in our modelling).

Revised assumptions on pre-abatement demand for fixed installations over Phase 4

Whereas in *Carbon Clampdown* we had total EU-ETS emissions – i.e. emissions from fixed installations and aviation combined – exceeding the total available cap by 266Mt over Phase 4, we now explicitly model the need for the market to be at least in balance by 2030.[47]

Figure 19: CTI updated pre-abatement emissions from fixed installations, 2021-30 (Mt)



And because (i) we have not changed our emissions forecasts for the aviation sector out to 2030, and (ii) the aviation sector itself cannot reduce its emissions meaningfully on the basis of current technology, it is fixed installations in general, and the power sector in particular, that will have to reduce their emissions in order to enable the market to balance.

[45] For the reasons already explained above relating to the growing structural deficit of the aviation sector, under our revised modelling methodology we no longer see the TNAC falling below 400m at any point over Phase 4.

[46] This represents the sum of the 2022 auction level of 769m minus the previous year's MSR balance of 3,004m minus the MSR inflow in 2023 of 139m, plus the MSR outflow to new entrants in 2023 of 150m.

[47] As explained above, previously, we were only implicitly assuming the market would have to come into balance by abating the deficit of -266Mt that we were actually showing in our model (compare *Carbon Clampdown*, pp. 39-40).

Overall, our projected pre-abatement emissions for fixed installations over Phase 4 are now 366Mt lower than previously, at 15,463Mt versus the 15,829Mt we were modelling in *Carbon Clampdown* (Figure 19).

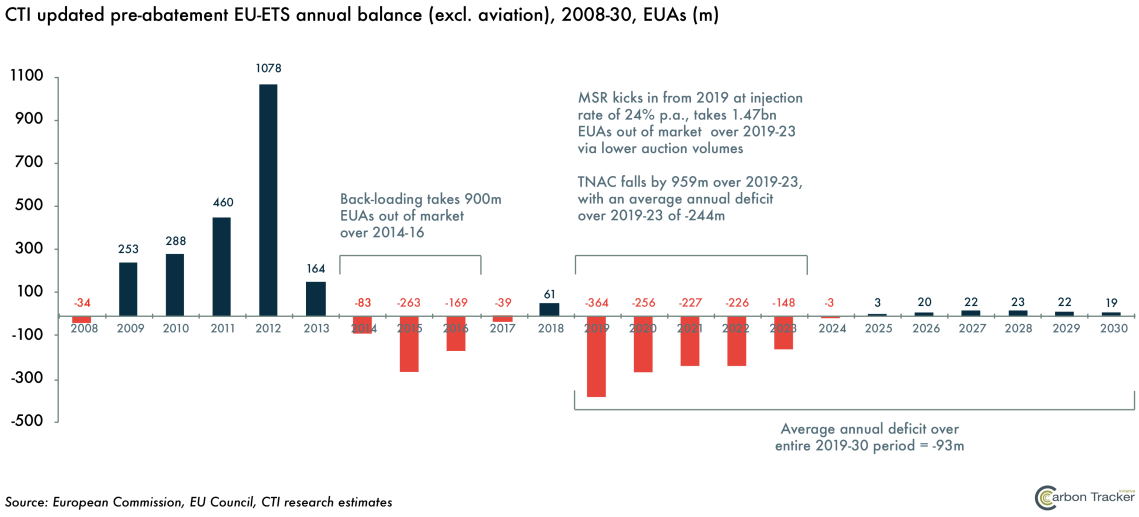
As explained above, in keeping with our revised modelling methodology the reduction in our projected Phase-4 pre-abatement emissions is driven by the need to balance the EU-ETS overall by the end of Phase 4 after taking into account the cumulative deficit of aviation.

Having set out our modelling of EU-ETS dynamics and the operation of the MSR over 2019-30, the all-important question is what all of this means for the annual supply-demand balance for fixed installations over this period.

Updated market balance for fixed installations over 2018-30, pre-abatement

Figure 20 shows our revised projections for the annual surplus/deficit for fixed installations out to 2030 on a pre-abatement basis. The sheer amount of EUAs that we project will be taken out of the market by the MSR on a pre-abatement basis over 2019-23 – 1.47bn – will be greater than anything the EU-ETS has ever seen before.[48]

Figure 20: CTI updated pre-abatement EU-ETS annual balance (excl. aviation), 2008-30, EUAs (m)



Source: European Commission, EU Council, CTI research estimates

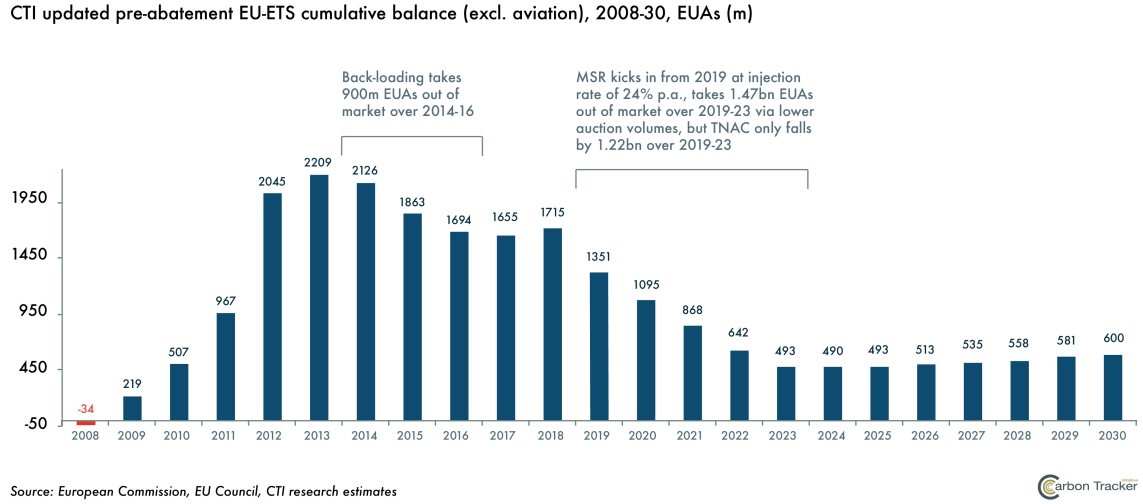
Overall, we project an average annual deficit over 2019-30 of -93m EUAs on a pre-abatement basis, with the supply squeeze at its most acute over 2019-23: over these four years fixed installations are short by an average of -244m, and over the two years 2019-20 by an average of -310m.

Figure 21 then shows the evolution of the TNAC to date, and our projections for the TNAC over 2018-2030. Over the period 2019-23 we project that the TNAC will fall by 1.22bn on a pre-abatement basis.

As a result of our revised numbers and re-worked modelling methodology, we now project a TNAC of 600m in 2030, which exactly offsets the cumulative deficit we are projecting for the aviation sector by 2030 (Figure 13 above).

[48] The back-loading of 900m EUAs over 2014-16 also tightened the market significantly, and the EU-ETS experienced an annual average deficit of -172m over 2014-16, with 2015 seeing the highest annual deficit to date of -263m. However, back-loading was ultimately not successful in re-establishing a meaningful price signal in the EU-ETS. We offer a detailed analysis of the similarities and differences between the impact of back-loading on the one hand, and what we expect the impact of the MSR to be on the other, below (see sub-section entitled *Filling the supply gap: the lessons from back-loading over 2014-16*).

Figure 21: CTI updated pre-abatement EU-ETS cumulative balance (ex. aviation), 2008-30, EUAs (m)

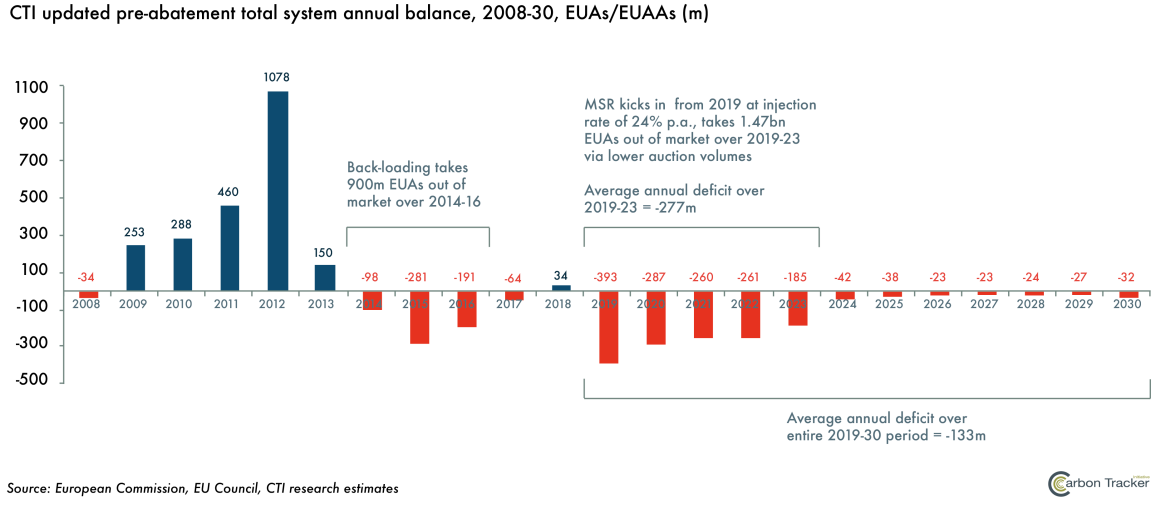


And taking aviation into account means that the market overall would be tighter still pre-abatement.

Market Dynamics 3: EU-ETS total system dynamics over 2008-30, pre-abatement

Figure 22 shows our updated pre-abatement annual system-wide balance for the EU-ETS (i.e. fixed installations and aviation combined). We are now projecting an average annual deficit on a pre-abatement basis over 2019-23 of -277m compared with -244m for the fixed installations, and an average annual system-wide deficit over 2019-30 of -133m (versus -93m for fixed installations only).

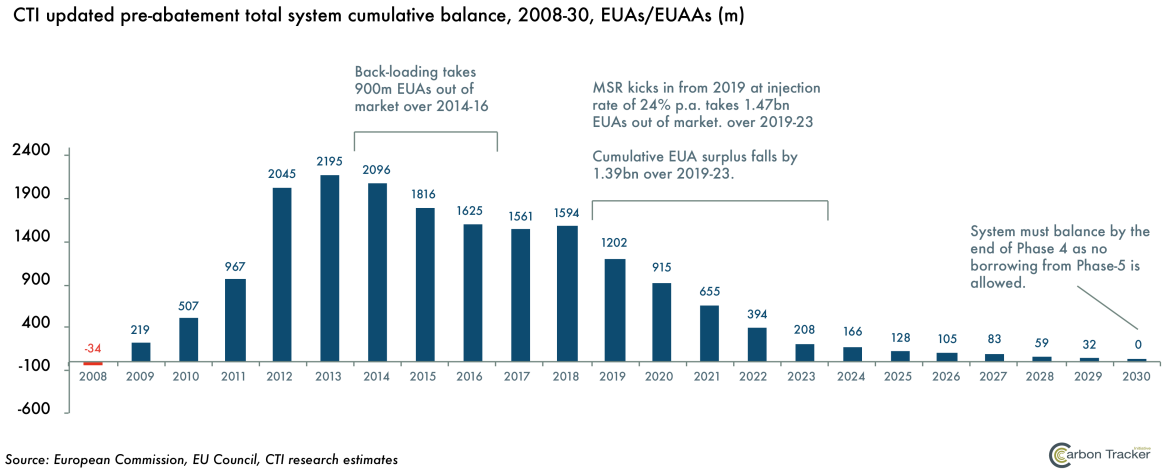
Figure 22: CTI updated pre-abatement total system annual balance, 2008-30, EUAs/EUAAs (m)



And as shown in Figure 23, this means that the system-wide surplus falls much more sharply than the surplus for fixed installations only, from 1,594m in 2018 to only 208m in 2023, a drop of 1,386m (87%) in only five years.

And in keeping with the logic of our revised modelling methodology, as the aviation deficit continues to accumulate over Phase 4, the buying of EUAs by airlines forces prices to the fuel-switching level in the power sector such that emissions for fixed installations would fall to the level required to balance the system overall.

Figure 23: CTI updated pre-abatement total system cumulative balance, 2008-30, EUAs/EUAAs (m)



Accordingly, by 2030 the system-wide surplus falls to zero, with the 600m TNAC balance for fixed installations exactly offsetting the 600m cumulative deficit of 600Mt in the aviation sector.

Filling the supply gap: the lessons from back-loading over 2014-16

The EU-ETS has never before seen such large or sustained annual deficits against the backdrop of such a sharply declining system-wide surplus as our model is projecting from 2019 as just shown above, and this is especially the case over 2019-23.

But why does this matter in any case?

After all, on our pre-abatement numbers above the system overall is never at any point in cumulative deficit over 2019-30, with the TNAC dropping by 1,222m over 2019-23 to accommodate the deficits created by the MSR's removal of 1.47bn EUAs over these five years, and the overall market ending Phase 4 in balance.

The answer is that it matters for two main reasons: (i) generators do not hold enough of the TNAC themselves to cover their deficit over 2019-23, and (ii) as a result, in order to acquire the allowances they need to cover their residual cumulative deficit over this period we think generators will have to bid up EUA prices to whatever level the holders of the rest of the TNAC – mainly industrials but also speculators – are willing to sell at.[49] In particular, it is the forward–hedging pattern of generators' electricity sales that explains why EUA prices will in our view have to rise over 2019-23 despite the TNAC being large enough to accommodate both generators' deficits and the growing demand from the aviation sector over this period.

The importance of hedging to price tension in the EU-ETS

Generators typically hedge their forward power sales on a rolling basis for two to three years forward at a time. This means they should be able to meet most if not all of their 2019 and 2020 compliance obligations with EUAs already purchased in 2016, 2017, and 2018, i.e. when they were hedging forward to cover 2019 and 2020.

Out of the total 2017 TNAC of 1,655m, we estimate that generators and airlines combined hold ~50% (750-800m, of which 700-750m is with generators, and 50-100m with airlines), and industry and speculators the other ~50% (industry ~700m, speculators ~150m).

[49] As explained below, we think this level will be in the fuel-switching range of €35-40/t.

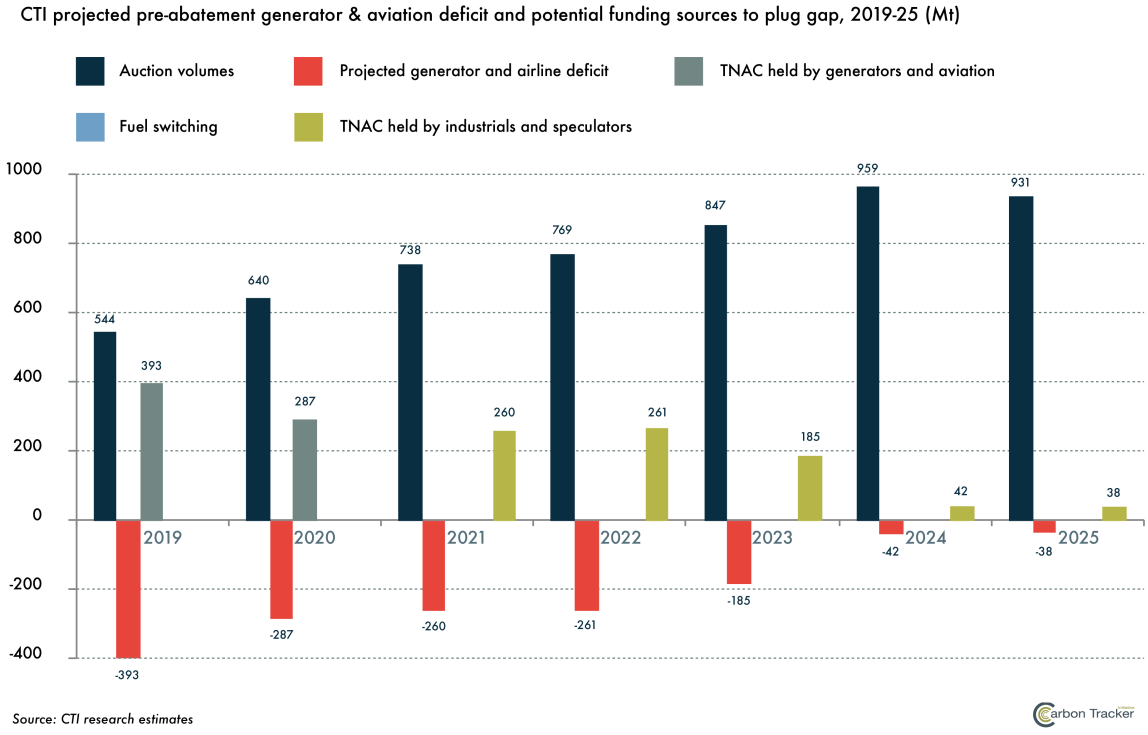
We base our estimate on (i) the fact that industrials' emissions over 2008-17 were a combined 1.4Gt lower than their free allocations and offset use over the same period,[50] and (ii) the assumption that ~600m of this surplus has been sold in the market and acquired by generators and airlines since 2008.

At the same, however, it follows from this standard forward-hedging behaviour that by the time we get to 2019 and 2020 generators would ordinarily be starting to hedge forward power sales for 2021, 2022, and 2023, and hence also the fuel inputs associated with these forward power sales, including CO2.

Ordinarily, the supply for this rolling hedging demand for CO2 on the part of generators would come from the auction volumes, but as we have just seen these will drop sharply from 2019 owing to the start-up of the MSR. So, in the absence of the volumes removed by the MSR, the key questions are (i) how big is the forward-hedging gap, and (ii) where will generators get the allowances they need in 2019 and 2020 to plug this gap over 2021-23?

Figure 24 shows our projected annual deficits for fixed installations and aviation in the EU-ETS over 2019-23 as shown in Figure 22 above. We think this deficit can reasonably be seen as being incurred 100% by power generators and airlines, as industry is generally still receiving more or less 100% of its requirements for free and will therefore be largely unaffected by the reduction in auction volumes over 2019-23.[51]

Figure 24: CTI projected pre-abatement power and aviation deficit and potential funding sources to plug gap, 2019-25 (Mt)



The cumulative deficit over this period for generators and airlines is 1,466Mt, but it follows from our assumption about where the TNAC is held that this actually comprises two distinct kinds of deficit:

[50] Our numbers here come from Sandbag's EU-ETS Dashboard: http://sandbag-climate.github.io/EU_ETS_Dashboard.html

[51] This is something of a stylized assumption as with the tightening of benchmarks and reduction in the EU-ETS cap from 2021 onwards at the increased linear rate of 2.2% per year from 2021 industry will have to start paying for a limited but growing portion of its allowances over the course of Phase 4. Nonetheless, for our purposes here this remains a valid premise for our argument.

1. First, there is the deficit in 2019-20, totalling 679Mt (393Mt in 2019 and 287Mt in 2020), which we think has already been largely hedged by power generators and airlines, and that in any event if not already formally hedged can nonetheless almost certainly be funded in full with EUAs they already hold. Accordingly, we think this deficit over 2019-20 will be funded by that part of the TNAC currently held by the power and aviation sectors.

2. Second, there is the deficit over 2021-25, totalling 787Mt (260Mt in 2021, 261Mt in 2022, 185Mt in 2023, 42Mt in 2024, and 38Mt in 2025), which effectively represents generators' and airlines' forward-hedging requirements to be contracted over 2019-23, and which would ordinarily be covered by auction volumes over 2019-23. However, with the auction volumes significantly reduced over 2019-22, our pre-abatement modelling shown above assumes that this is covered by allowances from that part of the TNAC held by other parties (industry and speculators).

The other key point to note in Figure 24 is that auction volumes are back to being 300Mt higher by 2023 compared with 2019, and 400Mt higher by 2024, such that beyond 2024 we do not see any further annual deficits for generators in the EU-ETS (although as we saw above, the system overall remains in double-digit annual deficit all the way out to 2030 owing to the growing short position of the aviation sector over Phase 4).

In short, the supply squeeze is greatest when auction volumes are lowest and the forward-hedging gap is still significant, i.e. over 2019-22.

As a result, the question is at what price will industrials and speculators be willing to sell EUAs to generators and airlines over this period from their TNAC share?

To help us answer this question, a brief look at the back-loading experience over 2014-16 is useful.

Back-loading and EUA prices over 2014-16

Over 2014-16 900m EUAs were withheld from auction volumes, generating a cumulative deficit over these three years of 515Mt. As a result, the TNAC over this period fell from 2,209Mt at the end of 2013 to 1,694Mt at the end of 2016 (Figure 21 above).

However, not only were the three annual deficits covered easily enough by running down the TNAC, but at the same time the standard forward-hedging pattern of generators continued very smoothly.

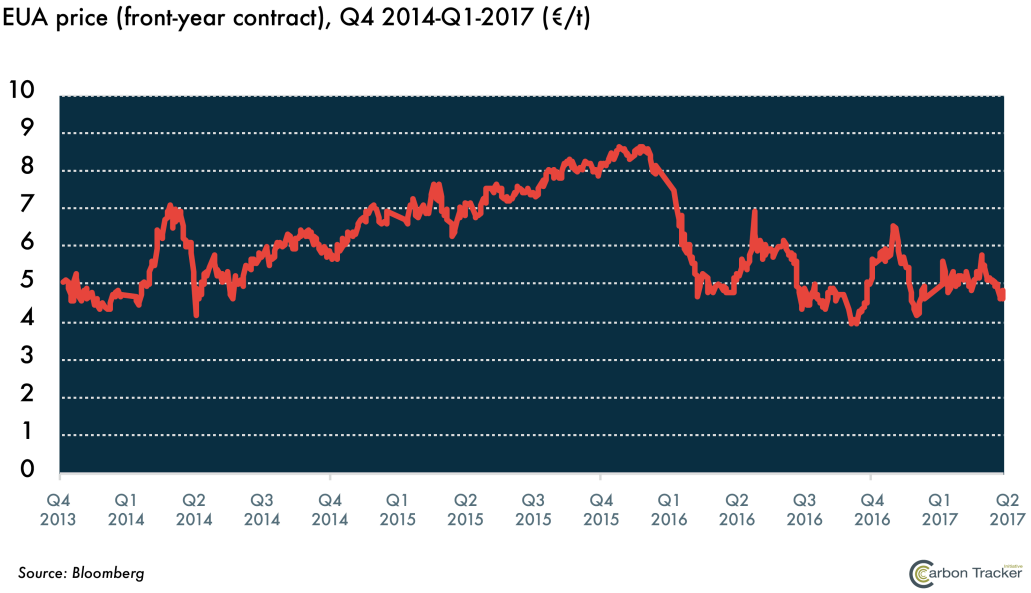
This would suggest that generators met their compliance obligations over 2014-16 with allowances purchased in hedges they had entered into in previous years, while covering their hedging requirements for subsequent years –i.e. 2016-18 – in one or both of two ways:

(i) via surpluses still held on their own balance sheets, and/or
(ii) via the purchase of allowances from industrials' surplus holdings.

In this respect, the price action in EUAs over 2014-16 is instructive (Figure 25). After rising sharply in Q1 2014 from €4/t at the end of 2013 in response to the start of back-loading, EUAs peaked in Q4 2015 at €8.4/t before declining again and ending 2016 at €4/t, exactly the same level they had started before the introduction of back-loading.

The fact that prices did not move to anything like the same extent over 2014-16 as they have over the last 16 months since May 2017 to date suggests that generators did not have to engage in any fuel switching as a result of back-loading.

Figure 25: EUA price (front-year contract), Q4 2013-Q1-2016 (€/t)



As a result, we think it reasonable to infer (i) that generators were able to cover not only their compliance obligations over 2014-16 but also a significant portion of their 2016-18 forward-hedging requirements over 2014-16 with that portion of the TNAC they held themselves, and (ii) that generators were able to cover any shortfall beyond this easily enough by buying EUAs in the market from willing industrial sellers.

In other words, despite a severe supply squeeze engineered by reduced auction volumes – i.e. the same circumstances we are about to see repeated with the start-up of the MSR from January next year – the market absorbed this pressure very smoothly over 2014-16 without the need for fuel switching in the power sector, and hence without the need for prices even to break double figures, never mind rise to the €30-50/t range that would in our view be required to elicit large-scale fuel switching today.

This being the case, might it not also be the case that the market will handle the start-up of the MSR equally smoothly, i.e. without the need for fuel switching?

Given the similarities between back-loading and the impending start-up of the MSR this is a reasonable question to ask, but there are also some crucial differences between then and now:

(i) **No more Kyoto credits available:** Over 2014-16, generators still had a significant amount of CERs/ERUs that they were able to use for compliance purposes. Indeed, and as shown in Figure 14 above, over 2014-16 a total of 277m CERs/ERUs were used for compliance purposes, covering 30% of the shortfall in auctioning volumes over this period (i.e. 277m/900m). Generators have now used up their full quota of CER/ERUs, so this option is no longer available.

(ii) **The TNAC is lower today than over 2014-16 and will drop much more sharply:** When back-loading started in 2014, the TNAC stood at 2,209Mt, ~550Mt higher than the TNAC level today. Moreover, on our pre-abatement projections shown above, the TNAC drops by 1,222m over 2019-23 on a pre-abatement basis, compared with a drop of only 515m over 2014-16. This means that the TNAC fell by only 23% over 2014-16, whereas on our pre-abatement projections it will fally by 70% over 2019-23.

(iii) **The generator's surplus is lower today than it was over 2014-16:** If we assume that the drop in the TNAC over 2014-16 was incurred overwhelmingly via generators' use of their own surpluses (which, as explained above, is the inference we draw from the price action over 2014-16), then generators will be going into 2019 with ~300-400m fewer EUAs than they had when back-loading started.

(iv) **The growing role of aviation:** Aviation will add to the generators' deficits over 2019-23, whereas over 2014-16 airlines' deficits were much smaller.

(v) **The back-loading was originally intended to be only temporary:** When back-loading started in 2014 the intention was that the 900m EUAs removed over 2014-16 would be auctioned back over 2019-20. With the MSR, volumes will fall at 24% for the first five years or until the TNAC drops below 833m, and in 2023 a very significant volume of allowances – 2,359m on our pre-abatement numbers – will be permanently cancelled.

These are material differences, and in our view they are material enough to move the market much more significantly over 2019-23 than back-loading did over 2014-16.

Indeed, the fact that EUA prices have quadrupled over the last 16 months tells us that the market already started to anticipate the impending supply squeeze over 2018-19 from the middle of Q3 last year. How much of this price increase is attributable to compliance buyers wanting to pre-empt the supply squeeze and how much to speculators who see the same supply squeeze as an interesting buying opportunity is open to debate, but the fact is that prices have already increased by much more than they did as a result of back-loading.

For all these reasons, we do not think it is plausible to assume that the hedging shortfall of the power and aviation sectors over 2019-23 can be filled as easily or as smoothly as it was over 2014-16. As a result, our assumption is that in order for generators and airlines to acquire the EUAs they need to fill this hedging gap, prices will have to rise further to encourage other holders of the TNAC – industrials and speculators – to sell allowances and thereby balance the market.

The question is, how much further and how quickly?

Filling the supply gap: how will it happen, and what are the implications for EUA prices?

We see seven ways in which the generators' supply gap over 2019-23 could be filled:

(i) Generators' and airlines' using their own share of the TNAC
(ii) Industrials'selling of part of their TNAC share
(iii) Speculators' selling of part/all of their TNAC share
(iv) Physical emissions abatement via fuel switching in the power sector from 2019 onwards
(v) Reduced hedging timeframes for power generators
(vi) The risk of an accelerated shutdown of old coal and lignite plants owing to BREF[52]
(vii) Political intervention in response to higher prices

In reality, we would expect a combination of (i), (ii), (iii), and (iv) to plug the supply gap, with (vi), and (vii) as wild cards that could relieve upward pricing pressure if EUAs rise too far too quickly. On balance, while (v) could also come into play, we think that if we are right about prices rising over 2019-23, generators' industrial customers may actually want to lock in their electricity prices further out, thus extending rather than reducing generators' hedging horizons.

[52] BREF stands for "best available techniques reference document" for Large Combustion Plants, or LCP BREF, under the European Union's Industrial Emissions Directive (IED).

1. Generators' and airlines' using their own share of the TNAC
As explained above, we think that generators can cover their compliance obligations for 2019 and 2020 with EUAs they have already acquired in previous years, so our modelling already assumes that this is how the annual deficits in 2019 and 2020 will be filled. As a result, the more interesting question is how they plug their hedging gap in 2019-20 for forward sales over 2021-23.

2. Industrials' selling part of their TNAC share
If the market is efficient, then to cover generators' and airlines' forward-hedging demand for EUAs over 2021-23 it will simply re-allocate surplus allowances from industry to generators and airlines, and prices will rise to the level required to incentivize industry to sell the number of allowances generators need.

After all, given that on our pre-abatement modelling shown above the overall system surplus does not disappear entirely until 2030, there are more than enough allowances to cover generators' and airlines' needs. That is to say, there is not a supply problem as such but rather a distribution problem, and price is the mechanism for ensuring the most efficient re-allocation of EUAs from installations with surpluses to those with deficits (i.e. from industry to generators).

The question, then, is one of price, and on this point we have refined the thinking we set out in *Carbon Clampdown* in April.

On the one hand, we are still of the view expressed in *Carbon Clampdown* that for industrials that have so far only ever known surpluses the changing dynamics of the EU-ETS introduced by the MSR will have a strong psychological impact, forcing them to think much more about their own future compliance obligations as the cap continues to tighten over time.

Accordingly, we think this will make them reluctant to sell their current surpluses at prices below the level that would prompt large-scale fuel switching in the power sector. After all, why would industrials sell below the fuel-switching level when they know that generators are short against their forward-hedging requirements and will therefore almost certainly have to bid prices up[53] to the level at which they can start to reduce that hedging requirement themselves (i.e. the fuel-switching level)?

Industrials can calculate the fuel-switching price level just as easily as anybody else, and on the current forward curves for coal and gas large-scale fuel-switching happens in the €30-50/t range[54] (i.e. two to three times the current market price for EUAs). As a result, we would not expect meaningful sales of industrial length below €30/t.

On the other hand, our view has become more nuanced concerning the motives that could prompt industrials to sell surplus EU holdings into the market, and we now think there are at least four good reasons to suppose that industrials will indeed be willing to satisfy generators' demand for allowances from €30/upwards.

First, we have not seen prices trade above €30/t for over 10 years now, and that only lasted for a couple of days, so some industrials might want to grab the opportunity of monetizing surplus allowances received for free at a very substantial profit as soon as it is there.

Indeed, industrials can make their own estimates of when the price squeeze is likely to be at its most acute given the MSR's impact on auction volumes and conclude that selling in 2019 and 2020 – when the squeeze on generators' demand for hedging volumes is at its most acute – might be the best time to sell.

[53] We say 'almost certainly' because there is always the possibility that generators might reduce their hedging demand by reducing the time horizon over which they contract power sales forward. However, for reasons we explain below, on balance we think it unlikely that generators' hedging patterns will change materially over 2019-23.
[54] We go into the economics of fuel switching in detail in Section 2 of this report below.

Second, given the approach of Phase 4 and the tougher benchmarks to which all industrial sectors will be subjected from 2021, we think industry has a much greater incentive to look for abatement opportunities within their own operations today than they did over 2014-16 when prices were much lower and the market surplus was that much higher. In other words, and although we would not venture to put a number on it, we think there is scope for some industrial abatement in the €30-50/t range, which would increase the incentive to sell surplus EUAs to generators.

Third, just as industrials can calculate the fuel-switching level for themselves, so too can they estimate how much fuel-switching potential is available at prices of up €50/t and hence the risk of prices spiking beyond this level once the majority of existing[55] coal-to-gas switching opportunities have been exhausted. We do not think industrials will be comfortable with prices much above this level for very long owing to concerns over the impact on their own competitiveness. Again, this would argue for selling allowances at a substantial profit while enabling the market to return to equilibrium.

Finally, industrials can also make their own political calculations about the pressure politicians would come under in a scenario where prices were spiking above €50/t despite there still being an overall surplus large enough to accommodate generators' and airlines' forward-hedging demand over 2019-23.[56] They might therefore conclude that prices could not stay too high for too long in any case, and hence, again, that monetizing free allowances at fuel-switching levels represented the rational strategy.

All of which being said, it is a fact that industrial companies exist to make a profit from their ongoing business, and they will therefore want to carry on producing their steel, cement, chemicals, pulp and paper, and ceramics, and refining their oil, for as long as possible. As a result, ensuring they have enough EUAs to do this over the short, medium, and long term will be central to their calculations. They will also be aware of the debate within the EU about aligning long-term emissions with the Paris Agreement, and hence the risk of a tighter 2030 EU-ETS cap being agreed at some point in the coming years.

Nonetheless, we think industrials will on balance be willing to sell at levels of €30/t and above given (i) the significant surplus that they still hold, (ii) the scope and incentive for emissions abatement within their own operations from €30/t upwards, and (iii) the temptation to cash in on high prices on at least some of their surplus.

3. Speculators' selling of part/all of their TNAC share

We think the speculators who have entered the EU-ETS market over the last 12 months or so in anticipation of the supply squeeze the MSR will create from January 2019 – and who we estimate hold up to 150m EUAs – have a more straightforward calculus than industrial operators.

On the one hand, and as with industrial operators, we do not see why they would sell below the fuel-switching range, as we think this is anchoring their expectations of where prices will need to go over the next 12-24 months.

On the other hand, and unlike industrial operators, speculators do not have to worry about their future compliance obligations in the EU-ETS. This means they have a much more straightforward calculation to make when it comes to the politics of higher prices, and hence, in our view, that they will be more highly sensitized to the risk of political intervention than industrials. Indeed, we think speculators will be particularly sensitive to potential political arguments about 'market inefficiencies' if prices were to trade above the fuel-switching range against the backdrop of a large enough surplus to accommodate the generators' hedging needs. Indeed, we think that even the threat of political intervention would be enough to bring speculative length to the market.

[55] We say existing because the longer prices were ever to stay above €45/t, the greater the chances that new CCGT capacity would be built and hence that abatement opportunities would increase over the medium to long term. This is particularly relevant in the context of point 6 below, in that the higher carbon prices are for longer, the lower the incentive to upgrade older lignite and coal plants to comply with the BREF regulations on industrial emissions that will kick in from August 2021.

[56] We elaborate on the political dimension to a scenario of higher prices under point 7 below.

In short, we would expect most of the speculative length that has built up over the last 12 months to become available to the market within the fuel-switching price range of €30-50/t.

4. Emissions abatement via fuel switching in the power sector
With fuel-switching from coal to gas in the power sector being the most cost-effective large-scale method for emissions abatement in the EU-ETS over the short to medium term, we see the fuel-switching range as the anchor of price expectations over 2019-23.

We explain our methodology for calculating the fuel-switching range in more detail in the next section of this report,[57] but based on the current forward curves for coal and gas and the amount of coal and gas capacity available across the EU today, we estimate that up to 90Mt per year of CO2 emissions could be avoided by switching from coal to gas at average prices of €35-40/t.

Accordingly, we see prices having to move up into this €35-40/t price range over 2019-20 both (i) in order to drive both physical emissions reductions in the power sector and (ii) in order to incentivize industrials and speculators to sell the EUAs required to clear the market when generators' and airlines' forward-hedging requirement is at its peak.

5. Reduced hedging timeframes for generators
What if instead of hedging forward three or even two years as is their standard practice, generators were to change their hedging patterns and cover their residual forward requirements only out as far as 12 or 18 months? This would significantly reduce their need to buy fresh allowances in 2019 and 2020 to cover their hedging requirements for 2021, 2022, and 2023, and thereby reduce the upward pricing pressure on EUAs.

While this is always possible if it transpires that there is no other way of plugging the gap, we view this as a last-resort measure for generators. This is because the main reason that generators hedge power sales so far forward in the first place is because their customers want to lock in their future electricity costs, and industrial customers will likely be all the more keen to hedge their forward purchases in the face of sharply rising CO2 prices than they would be in an environment of low and stable CO2 prices.

Paradoxically, therefore, if EUA prices do indeed rise to fuel-switching levels of €35/t in 2019, and €40/t in 2020, generators might face increased demand from industrial customers to hedge forward into 2022 and 2023, and far from hedging less volume forward might actually end up hedging more.

6. The risk of an accelerated shutdown of old coal and lignite plants owing to the BREF regulation
In August 2021, new regulations on industrial emissions from the toxic pollutants sulphur–dioxide (SO2) and nitrogen-oxide (NOX), popularly known as SOX and NOX, as well as on emissions from mercury and particulate matter (PM), will come into force across the EU in an amendment to the Industrial Emissions Directive (IED).[58] Tighter limits on emissions of these pollutants will be imposed forcing the owners of the large combustion plants (LCPs) that do not currently meet such standards – mainly coal and lignite plants – to decide in the next couple of years whether it makes sense to upgrade these plants.

In a study carried out on behalf of the European Climate Foundation (ECF) in October 2016, DNV[59] found that at the time they were writing 78% of all coal-fired capacity (65.8GW out of 84.8GW) and 90% of all lignite capacity (47.6GW out of 53.4GW) expected still to be in operation in the EU in 2021 was non-compliant with the LCP BREF emissions limits. The DNV/ECF study estimated the total capex required to upgrade the non-compliant plants in order to meet the LCP BREF standards at ~€15bn, which broke down as €7.9b, €5.8bn, and €900m for SOX, NOX, and PM compliance respectively.

[57] See Section 2 below, *Updated EUA Price Forecasts*.
[58] For a detailed primer on the BREF regulations, see the study published by IEEFA in May 2017, *Europe's Coal-Fired Power Plants: Rough Times Ahead Analysis of the Impact of a New Round of Pollution Controls*.
[59] See *Fact-based scenario to meet commitments under the LCP BREF European Climate Foundation*, ECF, 24 October 2016.

Of the non-compliant hard-coal capacity, nearly one third is located in western-EU member states that have already decided on phasing out coal by the middle or end of the next decade in any case (the UK, Denmark, France, Ireland, Italy, Portugal, and Finland, which together account for 18.4GW [28%] of the non-compliant coal capacity).[60] This means that most of this capacity will probably not be upgraded to comply with BREF in any case, and leaves hard-coal plant operators with non-compliant capacity in Germany (24GW) and Spain (5GW) out of the western-EU member states as the ones facing the tricky decision of whether to upgrade or not. The rest of the non-compliant hard-coal capacity (18GW) is in eastern Europe, with the majority in Poland (13.8GW).

Of the non-compliant lignite capacity, 26.6GW (56%) is in eastern EU member states (Poland has 10GW of this), but it is actually Germany that has the largest concentration of non-compliant capacity (17.8GW), with Greece and Spain the other western EU-member states affected.

Member states have a certain amount of discretion over how rigorously they enforce the BREF regulations (national derogations are possible), and in eastern Europe political factors come into play on top of commercial ones (Poland in particular is wary of phasing out coal in favour of gas owing to security-of-supply considerations).

As a result, we are not suggesting that all of the non-compliant capacity in those countries that have not yet announced coal phase-outs is at imminent risk of not being upgraded for BREF compliance and hence of being retired from August 2021. What we are saying, though, is that given the very high upfront capital investment required to comply with BREF, the owners of non-compliant plants will also need to consider in their decision-making process the higher running costs such plants would face under a scenario of EUA prices in a €35-40/t price range.

The prospect of such a scenario – and more especially the realization of such prices over the next 12-18 months – might well be enough to prevent a meaningful amount of the non-compliant coal and lignite capacity from being upgraded, especially in Germany and Spain. If this were to happen, we think that gas capacity that is currently out of the money in Germany and Spain – would likely be brought in to fill the generation gap, thereby structurally reducing emissions and hence the need for forward hedging. Such a scenario would be bullish for power prices, but bearish for carbon prices.[61]

In short, the LCP BREF regulation is a wild card that under a scenario of EUA prices in the €35-40/t fuel-switching price range over the next 12-24 months could end up precipitating an accelerated phase-out of old coal and lignite capacity in certain countries in the EU (especially Germany and Spain), thereby reducing the forward-hedging demand in the power sector and hence the risk of EUA prices spiking above €40/t for long.[62]

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[60] The Netherlands has also announced that it will phase out coal (by 2030), but the ECF/DNV study found that all of its remaining coal capacity is compliant with the BREF emissions limits.

[61] At the same time, such a scenario might also necessitate the building of new gas capacity in order to meet the generation cap. Again, though, while this would be bullish for power prices, the building of new gas plant to replace retired coal and lignite capacity would, other things being equal, be bearish for carbon prices.

[62] Note that as an EU-wide rather than a country-specific measure, the LCP-BREF legislation would seemingly not allow, on our reading, any individual member state to cancel allowances voluntarily if any coal or lignite-fired capacity were indeed to close as a result of LCP-BREF. Indeed, the Text of Article 12(4) in the revised EU-ETS Directive states that voluntary EUA cancellations may only occur in response to *national* additional mesures: *"In the event of closure of electricity-generation capacity in their territory due to additional national measures, Member States may cancel allowances from the total quantity of allowances to be auctioned by them referred to in Article 10(2) up to an amount corresponding to the average verified emissions of the installation concerned over a period of five years preceding the closure. The Member State concerned shall inform the Commission of such intended cancellation in accordance with the delegated acts adopted pursuant to Article 10(4)."* On the face of it, then, Article 12(4) could apply to mandated coal-phase-outs in individual member states, but not to the LCP-BREF legislation. And even with regard to purely national additional measures, we think that whether governments will actually make use of this provision in practice is an open question given that (i) it would mean giving up revenue, and (ii) they would probably face lobbying from industry to make any spare allowances from capacity closures available to the market. We will analyse the potential role of Article 12(4) in greater detail in our next report when we look at the ongoing debate over carbon-price floors and the EU-ETS, as we think that it is in this context that it has a potential role to play.

7. Political intervention in response to higher prices

In the final analysis, the EU-ETS is a political market, and if prices were too rise too far too quickly we think political pressure would emerge in certain European capitals – especially but not exclusively in eastern Europe – to limit the extent and duration of excessive prices.

Of course, this begs the question of what would constitute an 'excessive' price, but in our view anything over €50/t within the next 12-24 months for more than a couple of months would likely lead to pressure to ease prices. This is not only because of the impact of CO2 prices themselves on EU industry – after all, industry is largely protected from high prices at the moment owing to its accumulated surplus of EUAs and to the fact that it is still receiving the vast amount of its EUAs for free – but also because higher CO2 prices will also raise power prices for both EU industry and residential consumers.

What form could such countervailing measures take? We see two measures already available in the existing EU-ETS legislation:

(i) **Article 29a of the EU-ETS Directive could be invoked:** Article 29a was inserted into the amended EU-ETS Directive in 2009,[63] and reads as follows:

> *"Article 29a Measures in the event of excessive price fluctuations* ***1****. If, for more than six consecutive months, the allowance price is more than three times the average price of allowances during the two preceding years on the European carbon market, the Commission shall immediately convene a meeting of the Committee established by Article 9 of Decision No 280/2004/EC. 5.6.2009 EN Official Journal of the European Union L 140/83 2.*
>
> ***If the price evolution referred to in paragraph 1 does not correspond to changing market fundamentals,*** *one of the following measures may be adopted, taking into account the degree of price evolution: (a) a measure which allows Member States to bring forward the auctioning of a part of the quantity to be auctioned; (b) a measure which allows Member States to auction up to 25 % of the remaining allowances in the new entrants reserve." (Our emphasis)*

In other words, if prices were at any point over 2019-23 to trade for six consecutive months at three times the average of the previous two years, a meeting of the EU's Climate Change Committee would be called and a discussion held about implementing one of these two measures subject to a vote.

As is clear from the text, the key criterion that would come into play would be the extent to which any such price move were deemed to be driven by fundamentals or not, and in our view this would be open to political interpretation.

On the one hand, to the extent that the MSR is what is driving the supply squeeze we foresee over 2019-23 and hence the price rally we have already seen over the last 12 months and that we see continuing into the fuel-switching range of €35-40/t over the next 12-24 months, it can clearly be argued that such an outturn in prices would be based on fundamentals.

On the other hand, and as we already highlighted above, an obvious point for politicians concerned about prices moving too far too quickly over the next 12-24 months to make would be to point to the still very large TNAC that will be out there over the next two years and argue that such price moves should not be happening in an efficient market and hence that the price move is happening for reasons disconnected from fundamentals.

[63] For the full text of the amended 2009 Directive see the Commission's website at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32009L0029&from=EN

Of course, unless or until such the pricing eventuality foreseen in Article 29a were to occur it is impossible to say how the political discussion would play out.

However, the point is that given the very low average EUA price in 2016 (€6/t) and the fact that prices so far this year are still averaging only €13/t, it is not hard to imagine that this eventuality could arise over 2019-20 if prices were indeed to increase sharply once the MSR kicks in from January.

And the volumes that could be released under Article 29a are meaningful. First, with our updated numbers for the Phase-3 NER showing 327m EUAs remaining at the moment, this would allow 82m to be released to the market if Article 29a were to be invoked.

Alternatively, an indeterminate amount of allowances could be brought forward from the pool of auctionable allowances in subsequent years, thereby enabling generators to get over the acute supply squeeze in 2019-20 when the volumes removed by the MSR are at their peak.[64]

(ii) **The auctioning back of leftover allowances under Article 10c at the end of Phase 3:** Article 10c of the EU-ETS Directive allows certain EU Member States (mainly in eastern Europe) to distribute a certain portion of their auctionable allowances to the power sector for free over Phase 3, but not all of these allowances have been allocated, and we expect ~120m EUAs from this pot to be left over at the end of Phase 3.

These allowances may either be sold back to the market at the end of Phase 3 or placed in the MSR, but if prices are high then there will obviously be a big incentive to sell them back as (i) the relevant member-state governments will be keen to cash in on higher prices, and (ii) they will also in our view be keen to dampen pressure on carbon and power prices for their energy-intensive industries.

Our projections assume that these allowances are placed in the MSR at the end of Phase 4, so if they were instead auctioned back in late 2020 or early 2021 this would relieve the forward-hedging pressure on generators in 2020-21 by ~120Mt.

Beyond these measures already available, there is the question of the monetization schedule for the 400m EUAs in the Phase-4 Innovation Fund.

As explained above, our projections assume that these allowances are monetized in five equal instalments of 80m per year over 2021-25, but as the decision on how to monetize these allowances will not be made until 2019 at the earliest, it is possible that significantly higher prices over the next 12 months could tip the Commission's balance in favour of front-loading the sale over the first couple of years (i.e. 2021-22), thereby reducing generators' forward-hedging requirements over 2019-20.

In short, it is important to bear in mind at all times that the EU-ETS is a political construct, and hence that if prices were ever to be deemed 'excessive' by a large enough number of politicians and/or policymakers across the EU, there are measures that could be taken under existing legislation to smooth the impact of lower auction volumes arising from the MSR when it is operating at its peak over 2019-20.

[64] That said, of course, the price-soothing impact of bringing forward allowances in this way would mitigated by (i) the MSR taking 24% of this volume right back out of the market again two years later, and (ii) lower auction volumes being available in subsequent years. Nonetheless, to the extent that releasing allowances from subsequent years' auctionable supplies would help to smooth the forward-hedging gap over time, it could provide valuable price relief in the short term if invoked by politicians.

Conclusion: Fuel switching needed from 2019 to cover generators' forward-hedging gap

In our view, the cheapest and most efficient way for the EU-ETS to achieve significant emissions-reductions in the short to medium term is via fuel switching in the power sector, especially via the displacement of coal-fired generators by gas-fired plants.

And given the sheer size of the power and aviation sectors' forward-hedging gap as shown in our updated pre-abatement projections for the EU-ETS over 2018-30 above, we think that large-scale fuel switching will be needed to drive prices to the level at which industrial and speculative length can be re-allocated to generators and airlines.

With all of this in mind, it is to a more detailed discussion of our pricing methodology for EUAs that we now turn

2. THE ECONOMICS OF FUEL SWITCHING

With our updated pre-abatement modelling in Section 1 re-affirming that significant emissions abatement via fuel switching will be required to clear the market over 2019-23, this section examines the implications for EUA prices. As we explained in *Carbon Clampdown*, our approach examines the carbon price necessary to invert the current fossil-fuel merit order in continental Europe[65] and thereby push gas-fired generation capacity ahead of both coal and lignite.[66] However, given the change in the forward curves for coal and gas over the last three months and our revised assumption on the range of thermal efficiencies that will be required to achieve the fuel-switching necessary to clear the market, the implied price levels EUAs will need to reach over 2019-23 are now higher than those we imputed in *Carbon Clampdown*.

Based on the current forward curves for coal and gas, and the fixed mining costs for lignite, the level of fuel switching likely required as indicated by our modelling of EU-ETS dynamics over 2019-23 implies to us that EUA prices could reach €25/t by the end of this year as both compliance entities and speculators continue to anticipate the coming supply squeeze. Thereafter, based on the forward curves for coal and gas, we think generators will likely need to bid up prices to €35/t in 2019 (at which point 48%-efficient CCGTs would start to run ahead of 38%-efficient coal plants), and then €40/t in 2020 and 2021 as the supply squeeze itself really starts to bite and CCGTs with lower efficiency rates of 45% are required to run ahead of 38%-efficient coal plants. The fuel-switching level then reverts to €35/t in 2022 as gas prices drop faster than coal prices.[67]

Of course, and again as emphasized in *Carbon Clampdown*, there are many dynamic variables in play when we consider how EUA prices might evolve over 2019-23, and we would therefore emphasize that our implied indicative pricing range for EUAs over 2018-22 comes with a number of caveats. In particular, depending on (i) exactly how much abatement might be required over 2019-23, (ii) the amount and availability of CCGTs with the required efficiency levels, and (iii) the evolution of commodity prices between now and 2021, the carbon price required to plug generators' forward-hedging gap could be higher or lower than the levels we have imputed from our modelling of the supply-demand dynamics in the EU-ETS over 2019-23 and the fuel-switching price levels implied by the current forward coal and gas curves.

Nonetheless, from today's vantage point we think the point stands: with significant levels of fuel switching likely required to push prices to levels that will incentivize the re-allocation of market length from those with surpluses (industry and speculators) to those with deficits (power and aviation), €30-50/t seems to us a reasonable estimate of the range that EUA prices could trade in over 2019-22, while we think average prices could trade in a narrower range of €35-40/t over this period.

In short, we view our modelling to be consistent with EUA prices of €25/t by year-end 2018, and then with *average* prices of €35/t in 2019, €40/t over 2020 and 2021, and then back to €35/t in 2022 as gas prices drop and the impact of the MSR on auction volumes softens somewhat (which means that the forward hedging gap for generators over 2023-25 also softens).

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[65] Germany has the greatest amount of fuel-switching potential in the EU. According to the Fraunhofer Institute (which takes its numbers from the German Network Regulatory Agency), Germany currently has 21.2 GW of lignite capacity, 25.1GW of coal capacity, 29.6GW of gas-fired capacity (a mixture of both old open-cycle gas-turbine [OCGT] and newer combined-cycle gas turbine [CCGT] capacity), and 4.4GW of oil-fired capacity. Other countries with significant amounts of both coal and gas capacity are the UK, Italy, Spain, and the Netherlands.

[66] As we show, below, though, in addition to the carbon intensity of the fuel itself the thermal efficiency of a given plant is also an important element in determining the merit order amongst FF generators. Highly efficient lignite and coal plants can still be more competitive than old, inefficient gas plants even at high carbon prices.

[67] Note that although forward prices for both coal and gas are in backwardation right along the curve, gas generators' costs fall by more than do those of coal generators as a result of the respective declines in fuel-input costs. Other things being equal, this reduces the carbon price needed to flip the merit order between coal and gas the further out along the curve that we go.

We think these prices are consistent with 60Mt of abatement in 2019, and 90Mt per year over 2020-22, compared with what would happen under the current EUA forward curve.[68]

The carbon price and the merit order: current EUA price too low to push gas ahead of coal

The EUA price determines the merit order for FF generators based on their carbon intensity. Other things being equal, low EUA prices therefore benefit carbon-intensive FF generators (i.e. lignite and coal), and high carbon prices benefit less carbon-intensive generators (i.e. gas).

Figure 26 shows the forward curves for coal, gas and EUAs, and the fixed mining cost of €12/t for lignite over 2018-21, as of 1 August.

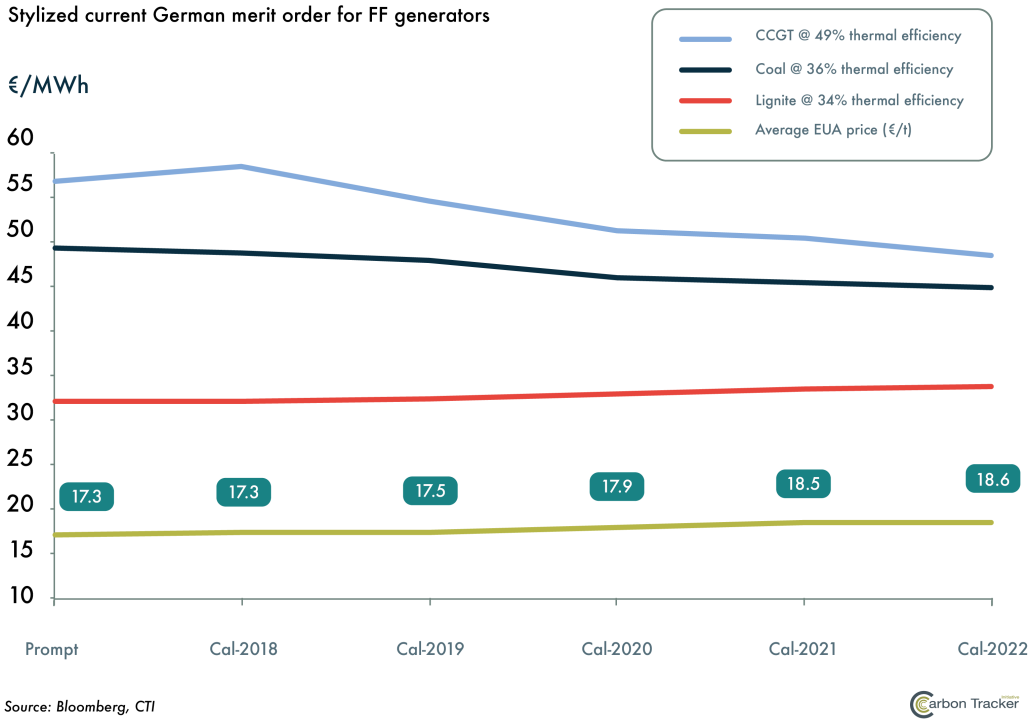
Figure 26: Forward price curves for coal, gas, and EUAs, 2018-22, as priced on 1 August 2018

	Prompt	Cal-2019	Cal-2020	Cal-2021	Cal-2022
Lignite (€/t)	12,0	12,0	12,0	12,0	12,0
ARA Coal* ($/t)	95,2	93,4	89,9	82,5	79,5
TTF Gas (€/MWh)	22.0	20,9	19,4	18,9	18,1
EUAs (€/t)	17.2	17,5	17,9	18,5	18,6

*Source: Bloomberg; *We add €10/t to the landed coal price for transportation costs.*

Figure 27 then shows the resulting short-run marginal cost (SRMC) curves for FF generators in Germany out to 2022 at the moment. We here assume efficiency rates of 34% for lignite (old, inefficient plant), 38% for coal (average-efficiency plant), and 49% for gas (average efficiency plant).

Figure 27: Stylized current German merit order for FF generators



As can be seen, at the moment the lignite plant has by far the lowest SRMC, and while coal and gas are closer together, our 38%-efficient coal plant remains more competitive than our 49%-efficient CCGT on the basis of the current forward curves for coal, gas, and EUAs all the way out to 2022.

[68] In turn, and as explained in Section 3 below, given that these prices are consistent with emissions reductions of 60Mt in 2019 and 90Mt over 2020-22, we explicitly factor these lower emissions levels into our post-abatement modelling.

In short, at current EUA prices – and even after the sharp rally since September last year – we still have the paradoxical situation whereby old, inefficient lignite plants are much more competitive than relatively new, much more thermally efficient, and – crucially – much less carbon-intensive gas plants.

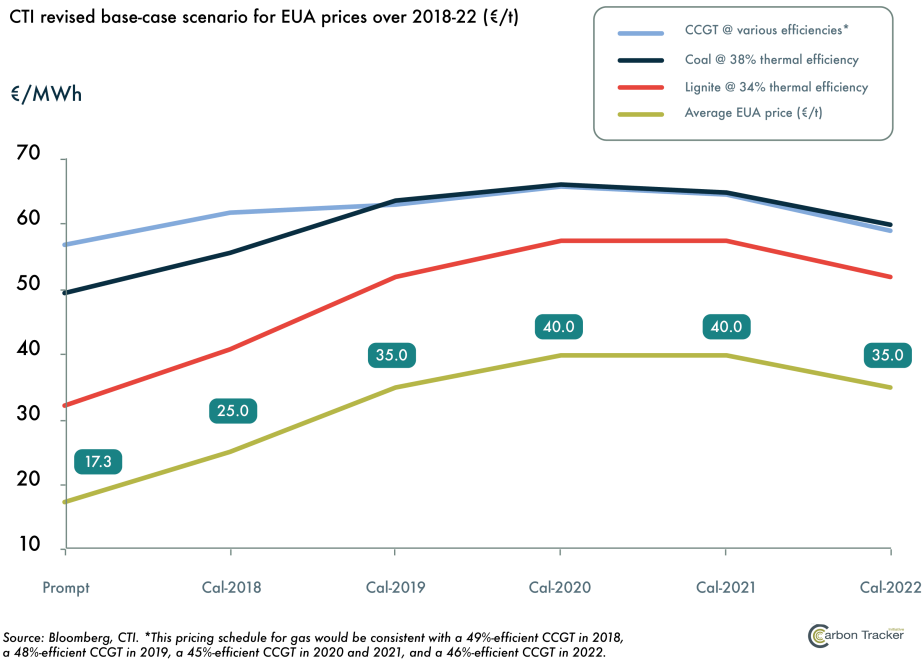
At what EUA price, then, would gas start to move ahead of coal and potentially even start to challenge lignite?

Pricing implications of the MSR squeeze

Figure 28 takes exactly the same inputs for the SRMC of lignite-, coal-, and gas-fired generation as in Figure 27 above, except for the EUA price. Instead of taking the current forward curve for EUAs, Figure 28 assume that prices rise more steeply in response to the tightening of supply caused by the start-up of the MSR, with prices hitting €25/t by year-end 2018, €35/t by mid-2019, and then averaging €40t over 2021 and 2022 before dropping back to €35/t in 2022. It also assumes varying thermal-efficiency rates for CCGTs over 2018-22: 49% in 2018, 48% in 2019, 45% in 2020 and 2021, and 46% in 2022

We assume lower efficiency rates for 2020 and 2021 because in order to re-allocate length between those with surpluses (industry and speculators) and those with deficits (generators and airlines) and clear the market in these years when the supply squeeze is at its most severe, we think EUAs will first have to go to the level necessary to prompt large-scale fuel switching.[69] In order to achieve fuel-switching of 60Mt in 2020 and 2021, we think that less efficient gas plant with efficiency rates of 45% will have to run ahead of coal, thereby bidding the price up to €40/t.

Figure 28: CTI updated implied pricing trajectory for EUAs over 2018-22 imputed from coal-to gas fuel-switching levels.(€/t)



*Source: Bloomberg, CTI. *This pricing schedule for gas would be consistent with a 49%-efficient CCGT in 2018, a 48%-efficient CCGT in 2019, a 45%-efficient CCGT in 2020 and 2021, and a 46%-efficient CCGT in 2022.*

[69] We explained our rationale for this assumption in Section 1 above, but the essential point is that industry and speculators can work out for themselves the price at which the power sector can achieve the right balance between large-scale emissions reductions on the one hand, and politically acceptable prices on the other. In the end, of course, it is impossible to know in advance at what price level EUAs breach the threshold of political acceptability. However, while we think prices might conceivably trade up to as high as €50/t for limited periods in the winter of 2020-21, and 2021-22 (i.e. when gas prices are at their seasonal highs and in those years where we see the supply squeeze on generators to be at its peak), the implied average price range derived from our asssumptions over 2019-23 is €35-40/t. That said, even prices in the range of €35-40/t would in our view greatly increase the political scrutiny of the EU-ETS, but would nonetheless in our view be politically tolerable. Our modeling therefore assumes that industry and speculators make the same judgement and are willing to sell at the prices shown in Figure 28.

As can be seen, on this higher carbon-pricing schedule a 48%-efficient gas plant would start to displace our 38%-efficient coal plant in 2019 at an EUA price of €35/t, while in 2020 and 2021 a carbon price of €40/t is needed to push a 45%-efficient gas plant starts ahead of a 38%-efficient coal plant.

By 2022, with gas prices falling further and the forward-hedging gap for generators starting to ease as auction volumes start to normalize over 2023-25, we think the required level of fuel-switching can be achieved with a carbon price of €35/t.

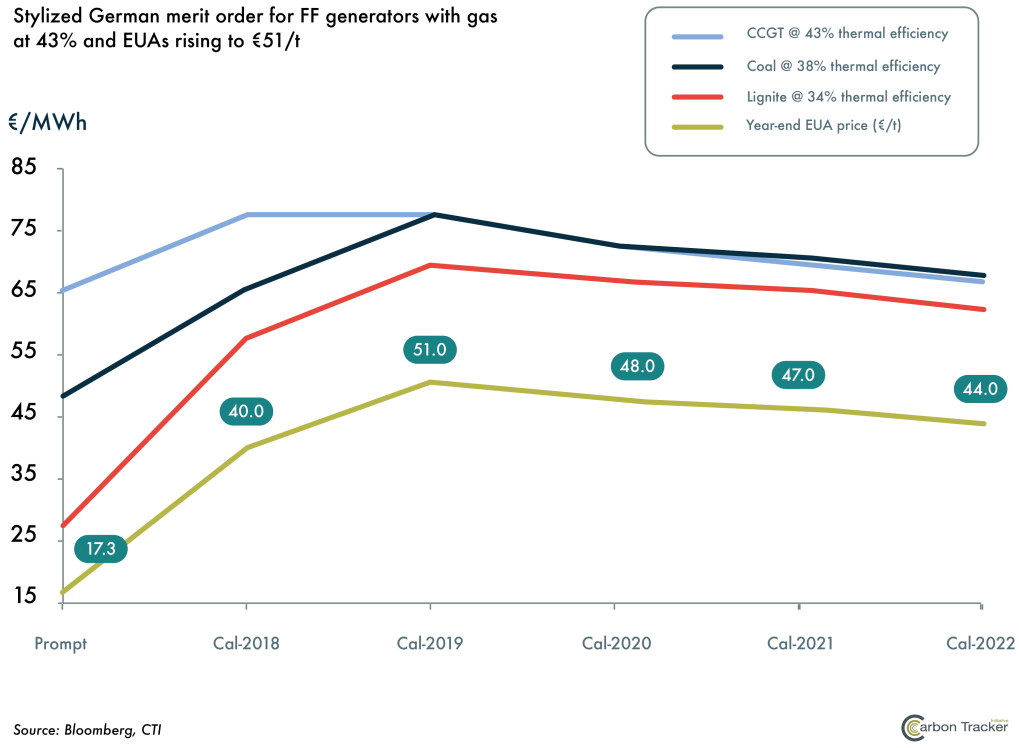
As such, and on the basis of current forward prices for coal and gas the level of fuel switching we see as necessary to clearing the market, the carbon-price schedule shown in Figure 28 is our updated implied EUA pricing trajectory as mputed from our modelling of coal-to-gas fuel-switching levels.

What if more fuel switching is needed?

As can be seen in Figure 28, even at an EUA price of €40/t, a 45% efficient CCGT would still not be close to competitive with an old lignite plant with a thermal efficiency of only 34%, and as we explained above the *average* efficiency rate of gas plant in Germany is actually only 44.4%.[70] So, if even with all 45%-efficient gas plant running ahead of all 38%-efficient coal right across the EU this were still insufficient to bring the EU-ETS into equilibrium over 2020-22, then what price level would be necessary to push a CCGT with a lower efficiency rate of 43% ahead of a 38%-efficient coal plant?

Figure 29 below takes the same forward curves for coal and gas as in our previous two merit-order charts above, but this time assumes a CCGT with an efficiency rate of only 43% (while retaining 34% and 38% for our lignite and hard-coal plants respectively). As can be seen, in this case the EUA price would have to rise to over €50/t before the 43%-efficient CCGT could displace the 38%-efficient coal plant in 2020, and would have to remain in a range of €44-50/t all the way out to 2022.

Figure 29: Stylized German merit order for FF generators with gas at 43% and EUAs rising to €51/t



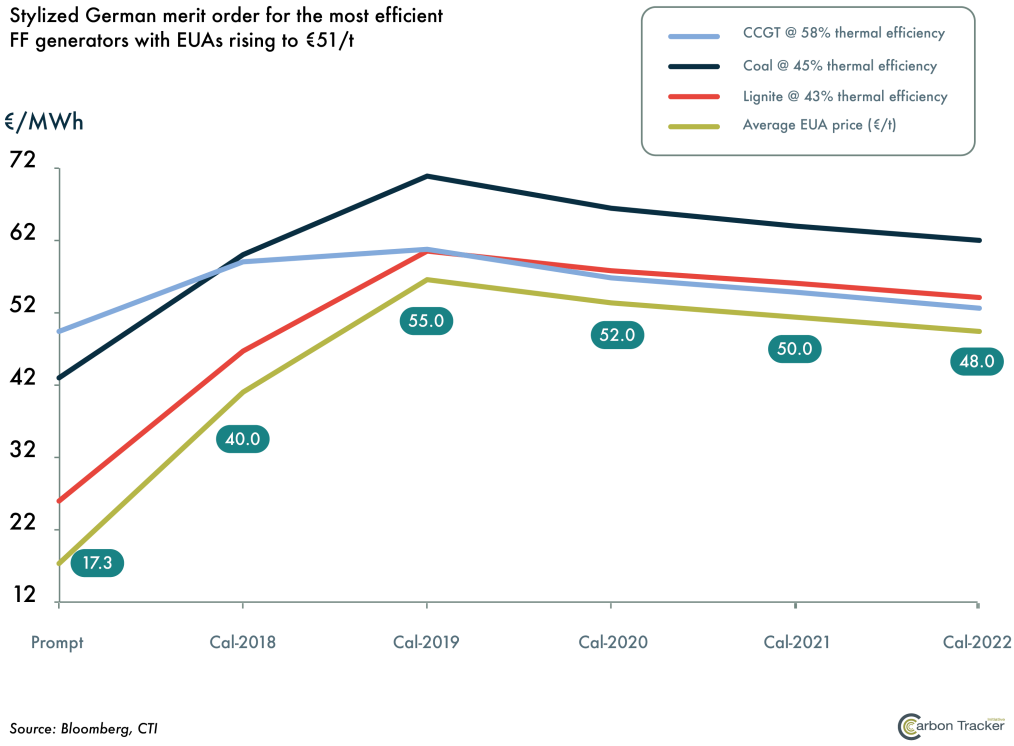
[70] See our Executive Summary above.

However, whilst we think that EUA prices could trade up to €50/t for limited periods over 2020-22, we think that average prices at these levels over a three-year period would be politically very difficult to sustain and would therefore likely lead to use of the mechanisms available under articles 29a and 10c of the EU-ETS Directive as explained in Section 1 above, bringing potentially significant extra supply to the market in order to dampen down prices.

We also think that prices at these levels for any sustained period of time would quickly encourage greater levels of energy-efficiency savings, thereby lowering demand for power and hence for EUAs.

Finally, with a view to showing at what price level the most efficient CCGT plants in the EU today (58% thermal efficiency) would displace the most efficient coal (45%) and the most efficient lignite (43%), Figure 30 shows how the merit order would look for these plants on the the higher trajectory for EUA prices just shown in Figure 29 immediately above.

Figure 30: Stylized German merit order for the most efficient FF generators with EUAs rising to €51/t



As can be seen, on this higher EUA price trajectory, the 58%-efficient plant displaces the 45%-efficient coal plant at €40/t, while in order to displace the 43%-efficient lignite plant prices would need to be in the €48-55/t range.[71]

Conclusion on prices: abatement required implies EUA prices of €25-30/t over 2020-21

Our stylized analysis above illustrates that fuel switching in the power sector is a very dynamic process, dependent mainly on the two key variables of commodity prices (coal, gas, and carbon) and the thermal-efficiency rates of FF plants.

[71] It is also interesting to note that with a SRMC of €48.1/MWh at the current EUA price of €17.3/t 58%-efficient CCGTs would already be running ahead of 38%-efficient coal plants, which have a SRMC of €49.4/MWh at the current carbon price (Figure 27 above). The trouble is that there are very few CCGT plants in the EU with efficiency rates of 58%, so the fuel switching that can happen between coal and gas at current EUA prices is in practice very limited

That said, to these variables can be added the further elements of the level of idle gas-fired capacity that can be ramped up in response to higher EUA prices, and the physical location of different plants across the EU. In other words, whether fuel switching and hence emissions abatement actually occurs in response to higher carbon prices will depend on the availability of lower carbon-intensive plant in a given market or markets.

In other words, while it is clear that there is potential for higher EUA prices to drive material levels of fuel switching within a given market such as Germany (where there is a large amount of gas capacity available to displace coal and lignite), there are obvious physical limitations on, for example, a Dutch gas plant displacing a Polish coal plant.

All of this underlines how difficult it is to make firm projections for the future trend in EU carbon prices, as the number and dynamic nature of the relevant variables – commodity prices, thermal-efficiency rates, the level of abatement required, the level and location of available lower-carbon-intensive generation capacity, and even weather conditions – make for a very complicated exercise.

Nonetheless, we think the point stands: with significant fuel switching likely required to push prices to levels that will incentivize the re-allocation of market length from industry and speculators to power and aviation, €30-50/t seems to us a reasonable estimate of the range EUA prices could trade in over 2019-22, while we think average prices could trade in a narrower range of €35-40/t over this period in order to effect the abatement necessary to close the generators' hedging gap for 2021-23.

As such, we think that fuel switching between CCGT plants with efficiency rates of 45% and above and coal plants with efficiency rates of 38% and below will likely be sufficient to clear the EU-ETS over 2019-23.

As a result, we view our modelling to be consistent with EUA prices of €25/t at year-end 2018, and then average prices of €35/t in 2019, €40/t over 2020-21, and €35/t in 2022.

With this in mind, we now turn tour modelling of EU-ETS dynamics on a post-abatement basis, i.e. after taking into account the emissions reductions and energy-efficiency savings that we think are consistent with our revised base-case trajectory for EUA prices over 2019-22 as shown in Figure 28 above.

3. THE EU-ETS, 2018-30: THE POST-ABATEMENT SCHEDULE

Taking our analysis in Section 1 of the forward-hedging gap for the power and aviation sectors over 2019-23 created by the MSR, and our analysis in Section 2 of the price levels necessary to drive fuel switching at scale and thereby incentivize the reallocation of market length from industry and speculators to generators and airlines, we conclude this report with our base-case modelling of how the supply-and-demand dynamics of the EU-ETS out to 2030 look on a post-abatement basis.

In other words, in this section we explicitly model the lower emissions of the power sector as a result of (i) the fuel switching and (ii) the enhanced energy-efficiency measures on the demand side that we see as consistent with our updated base-case EUA pricing schedule shown in Figure 28 above.

Compared with our pre-abatement emissions projections shown in Section 1 above, our emissions forecasts for fixed installations under our post-abatement schedule are 60Mt lower in 2019, 90Mt per year lower over 2020-22, 70Mt lower in 2023 and then 30Mt lower in 2024 as the pressure eases with the normalization of auction volumes.

The main markets where material fuel switching between coal and gas is possible are Germany, the UK, Spain, Germany, and the Netherlands, but with the UK already at maximum fuel-switching levels as a result of its domestic carbon-support price the incremental switching our post-abatement modelling assumes has to happen in Germany, Italy, Spain, and the Netherlands.

As explained in our Executive Summary above, we estimate that there is enough spare gas-fired capacity with efficiency rates of 45% or above and enough currently active coal plant with efficiency rates of 38% or below to achieve up to 120TWh of incremental gas-fired generation versus our pre-abatement schedule if EUA prices were to rise to the level necessary to effect such a switch.

This level of fuel switching is consistent with the emissions reductions our post-abatement schedule is assuming over 2020-22, while we assume slightly less fuel switching in 2019 and 2023 (80TWh and 94TWh respectively).

The fact that our emissions projections are lower changes the dynamics of the MSR materially compared with our pre-abatement schedule in Section 1. With lower emissions from the power sector leading to lower annual deficits over 2019-23, the TNAC declines more slowly than under the pre-abatement schedule. In turn, this means that the MSR ends up taking out a larger volume of allowances from auctions for a longer period than under our pre-abatement schedule.

In total, our dynamic modelling of the EU-ETS post-abatement projects that the MSR will remove 1.68bn EUAs over the six years 2019-24, compared with the 1.48bn it takes out over the five years 2019-23 under our static modelling of the EU-ETS on a pre-abatement basis shown in Section 1 above.

Over the second half of Phase 4 the annual deficits for fixed installations are much smaller, with the aviation sector's growing deficits becoming the main driver of marginal EUA demand and hence of the abatement requirement in the system overall.

Indeed, with the power sector likely to see the cost of both renewables and energy-storage technology continue falling over the next decade, and with the impact of coal-phase-out policies being felt across a number of EU member states by the middle of Phase 4, we think it is an open question as to whether fuel switching will actually be required over the second half of Phase 4 at all given that these trends will lead to a structural decline in the power sector's emissions in any case.

Post-abatement EU-ETS dynamics, fixed installations, 2018-30: TNAC declines more slowly

Figure 31 shows our updated base-case scenario for the market dynamics for fixed installations (i.e. excluding aviation) on a dynamic, post abatement basis over Phase 3 of the EU-ETS, and Figure 32 our projections for Phase 4 on the same scope.

The difference between these projections and the equivalent ones shown in Figures 14 and 15 in Section 1 above, is that we here assume that emissions over 2019-24 are lower as a result of the fuel-switching and energy-savings that occur in response to the higher prices we think will be necessary to re-allocate market length from industry and speculators to the power and aviation sectors.

Our emissions forecasts are 60Mt lower in 2019, 90Mt lower over 2020-22, and then 70Mt and 30Mt lower in 2023 and 2024 respectively than under our pre-abatement schedule in Section 1 above.

Figure 31: CTI revised base-case EU-ETS dynamics, post-abatement, over 2013-20 (fixed installations only), EUAs/CERs/ERUs* (m)

	2013	2014	2015	2016	2017	2018	2019	2020
Total cap	2,084	2,046	2,008	1,970	1,931	1,893	1,855	1,816
Auctioned EUAs	916	528	633	733	951	940	544	636
Free allocations	1,012	938	872	821	777	790	751	748
NER	12	12	12	25	25	26	21	20
Total EUAs	1,940	1,478	1,517	1,579	1,753	1,756	1,316	1,404
CDM/JI credits	132	252	23	2	11	15	15	15
Total credits	2,072	1,730	1,540	1,581	1,764	1,771	1,331	1,419
EU-ETS emissions	1,908	1,813	1,803	1,750	1,754	1,710	1,635	1,590
Annual surplus/deficit	164	-83	-263	-169	-39	61	-304	-171
Cum. surplus (TNAC)	2,209	2,126	1,863	1,694	1,655	1,715	1,411	1,240

*Source: European Commission, CTI research estimates. *CERs and ERUs are the carbon offsets generated from the Kyoto Protocol's CDM and JI project mechanisms.*

Figure 32: CTI revised base-case EU-ETS dynamic, post-abatement, over 2021-30 (fixed installations only), EUAs/CERs/ERUs* (m)

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Total cap	1768	1720	1671	1623	1575	1526	1478	1429	1381	1333
Auctioned EUAs	716	729	777	886	931	917	889	861	834	806
Free allocations	720	700	679	658	637	616	596	575	554	533
NER	15	15	15	15	15	15	15	15	15	15
Total EUAs	1,452	1,443	1,471	1,559	1,583	1,548	1,499	1,451	1,403	1,354
CDM/JI credits	0	0	0	0	0	0	0	0	0	0
Total credits	1,452	1,443	1,471	1,559	1,583	1,548	1,499	1,451	1,403	1,354
EU-ETS emissions	1,610	1,620	1,620	1,606	1,582	1,555	1,520	1,482	1,437	1,387
Annual surplus/deficit	-158	-177	-149	-47	1	-7	-10	-26	-35	-33
Cum. Surplus (TNAC)	1,082	905	756	709	710	703	693	667	633	600

Source: European Commission, CTI research estimates

As a result of these lower emissions, the annual deficits over 2019-23 are lower, which means that the TNAC falls more slowly than it does under our pre-abatement schedule, from 1,715m in 2018 to 756m inn 2023, a reduction of 959m, whereas under our static, pre-abatement schedule the reduction over the same period is 1,222m (from 1,655m to 493m), as shown in Figure 21 above.

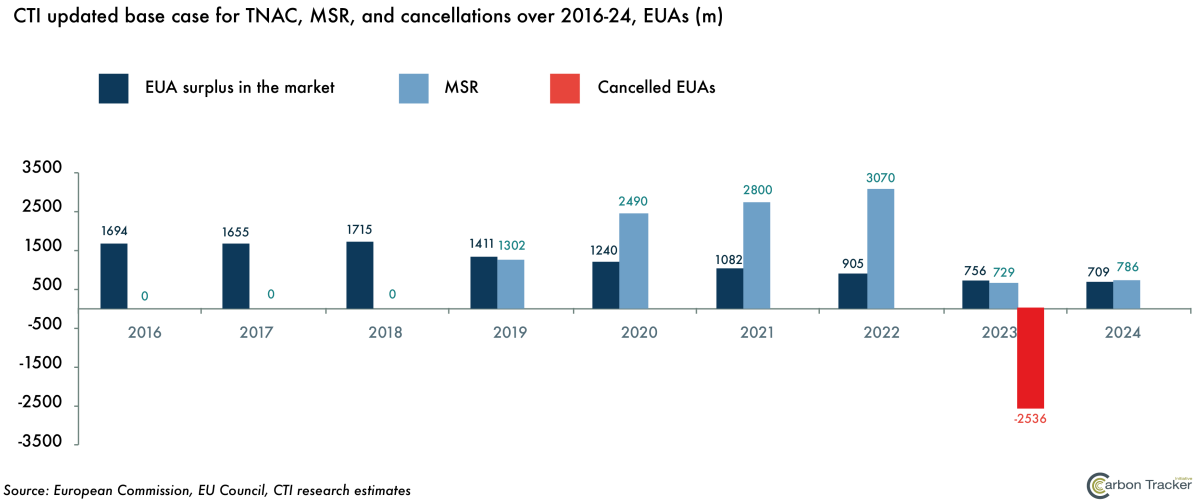
As a result, the volumes withheld from the annual auctions and placed in the MSR are higher than under our pre-abatement schedule. As shown in Figures 33 and 34, on our dynamic modelling, the MSR removes a total of 1.68bn EUAs over 2019-24, compared with 1.47bn on a static, pre-abatement basis.

Figure 33: CTI revised base-case MSR dynamics over 2019-30 (EUAs, m)

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Inflow	402	387	325	285	209	72	0	0	0	0	0	0
Outflow	0	0	0	0	0	0	0	0	0	0	0	0
Ph.-3 EUAs*	900	801	0	0	0	0	0	0	0	0	0	0
NER	-15	-15	-15	-15	-15	-15	-15	-15	-15	-15	-15	-15
Cancellations	0	0	0	0	-2,536	0	0	0	0	0	0	0
YoY change	1,302	1,188	310	270	-2,342	57	-15	-15	-15	-15	-15	-15
CUMULATIVE BALANCE	1,302	2,490	2,800	3,070	729	786	771	756	741	726	711	696

*Source: European Commission, CTI research estimates. *These are EUAs left over from Phase 3 from back-loading, the NER, and Article 10c.*

Figure 34: CTI updated base case for TNAC, MSR, and cancellations over 2016-24, EUAs (m)



Source: European Commission, EU Council, CTI research estimates

This also means that the volume of allowances cancelled in 2023 is nearly 200m higher under our post-abatement schedule (2.536bn versus 2.359bn under our pre-abatement schedule).

Post-abatement market balance for fixed installations over 2018-30

Figure 35 shows our revised base-case projections for the annual surplus/deficit for fixed installations out to 2030 on a post-abatement basis.

Although our projected average annual deficit over 2019-30 is the same as under our pre-abatement schedule at -93m, the emissions reductions prompted by our assumed fuel switching over 2019-23 means that over these five years our post-abatement schedule sees fixed installations short by an average of -192m (compared with -240m on a pre-abatement basis).

Figure 35: CTI revised base-case EU-ETS dynamics, post-abatement (excl. aviation), annual deficit/surplus, 2008-30, EUAs (m)

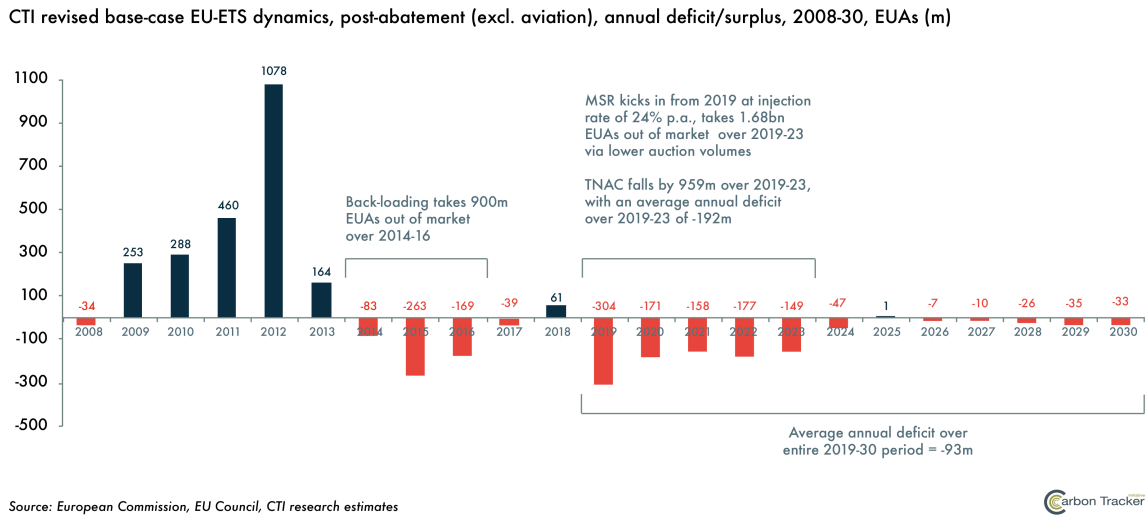
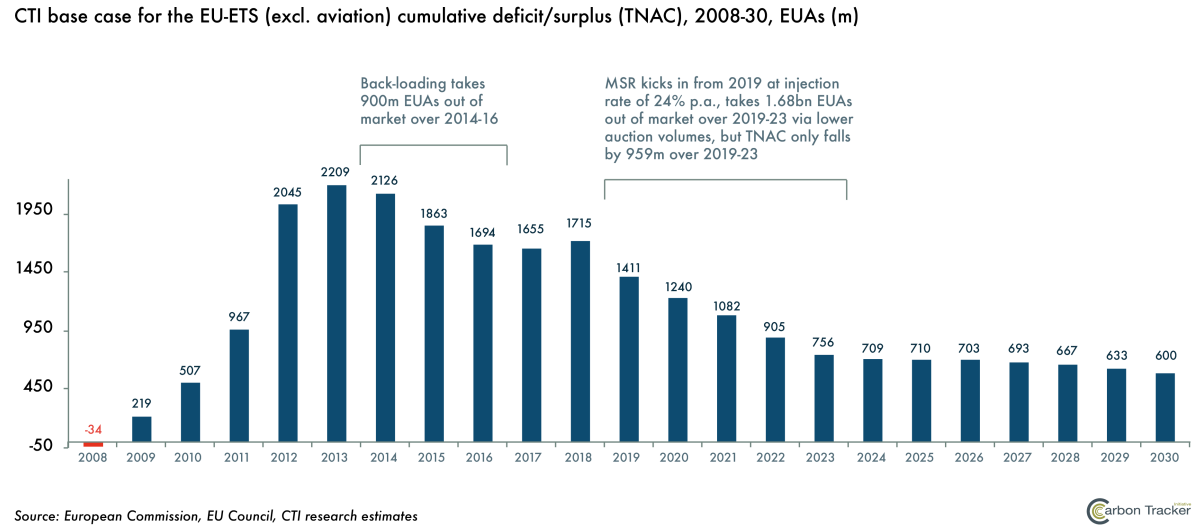


Figure 36 then shows the evolution of the TNAC over 2018-2030 on our dynamic, post-abatement modelling. As was the case with our pre-abatement schedule (Figure 21 above), our post-abatement schedule still projects a TNAC of 600m in 2030, as this is required to offset the unchanged cumulative deficit we are projecting for aviation by 2030. However, the slower reduction in the TNAC over 2019-23 under our post-abatement schedule is clearly visible against the steeper decline shown on a pre-abatement basis (again, compare Figure 21 above).

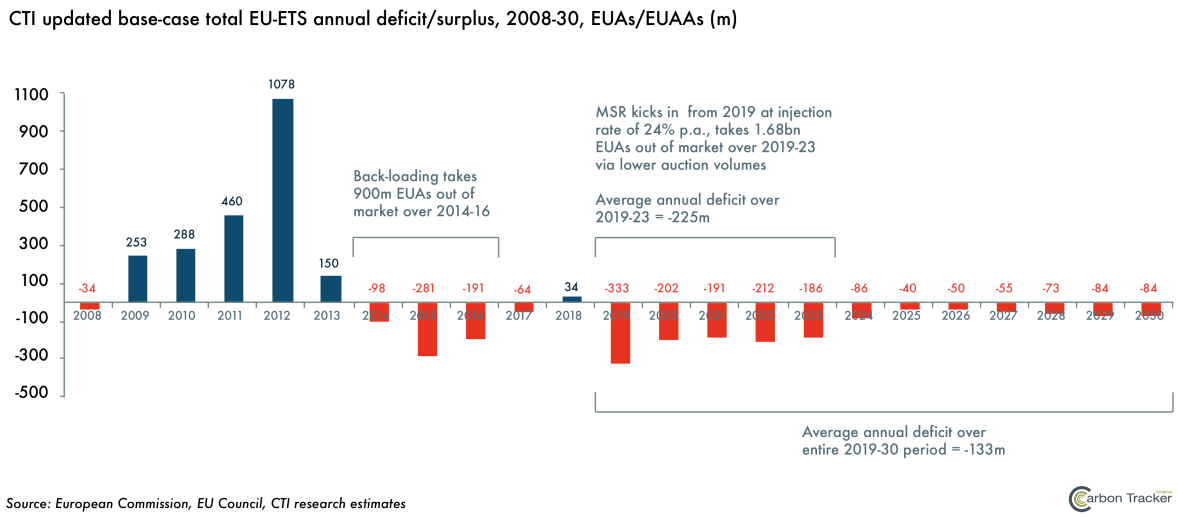
Figure 36: CTI base case for the EU-ETS (excl. aviation) cumulative deficit/surplus (TNAC), 2008-30, EUAs (m)



Post-abatement EU-ETS dynamics 2018-30 including aviation

Figure 37 shows our updated projected annual system-wide balance for the EU-ETS (i.e. fixed installations and aviation combined) on our post-abatement modelling. With the emissions reductions from fuel switching and demand-side efficiency savings that we are now assuming over 2019-24, we project an average annual deficit on a system-wide basis over 2019-23 of -225m (versus -192 m for the fixed installations alone, per Figure 35 above), and an average annual system-wide deficit over 2019-30 of -133m (versus -93m for fixed installations only).

Figure 37: CTI updated base-case total EU-ETS annual deficit/surplus, 2008-30, EUAs/EUAAs (m)

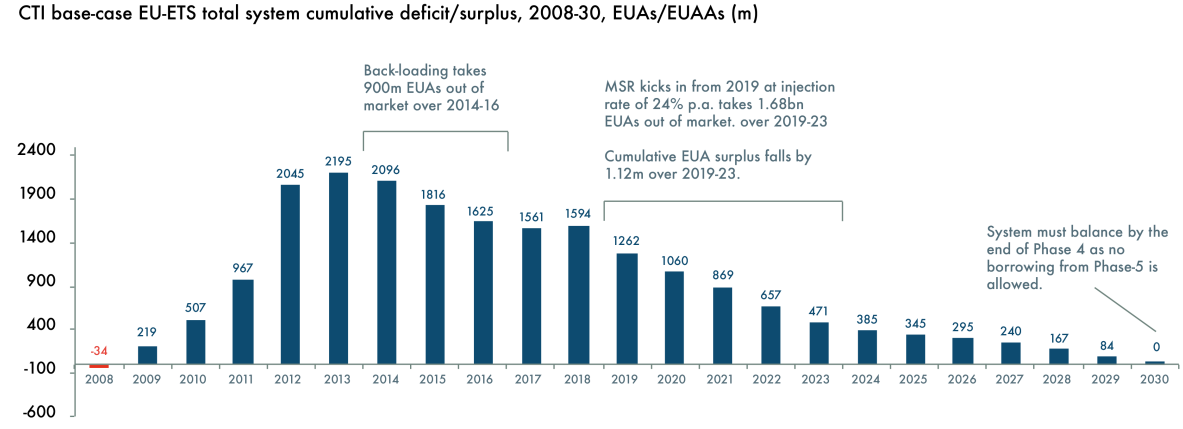


Source: European Commission, EU Council, CTI research estimates

And as shown in Figure 38, this means that the system-wide surplus falls more sharply than the surplus for fixed installations only, from 1,594m in 2018 to 471m in 2023, a drop of 1,123m (70%) in only five years.

As with the pre-abatement schedule shown in Section 1 above, given that allowances cannot be borrowed from Phase 5 into Phase 4 and that our unchanged emissions forecasts for the aviation sector project a cumulative deficit of 600Mt by 2030, the system overall ends in balance by 2030 with emissions for fixed installations falling to the level required to balance the system overall.

Figure 38: CTI base-case EU-ETS total system cumulative deficit/surplus, 2008-30, EUAs/EUAAs (m)



Source: European Commission, EU Council, CTI research estimates

Accordingly, by 2030 the system-wide surplus falls to zero, with the 600m TNAC balance for fixed installations (Figure 36 above) exactly offsetting aviation's cumulative deficit of 600Mt (Figure 13 above).

Conclusion: how the system clears over 2019-23

Figure 39 shows our projected annual deficits in the EU-ETS over 2019-25 on a post-abatement basis as shown in Figure 37 above. Again, we make the stylized but in our view reasonable assumption that these deficits are incurred 100% by the power aviation sectors.

Figure 39: CTI base-case projected power and aviation deficit and potential funding sources to plug gap (post-abatement), 2019-25 (Mt)

Owing to the fuel switching assumed on our post-abatement schedule the average size of the annual deficits is smaller than under our pre-abatement schedule. At the same time, however, because the TNAC decline is slower, the deficits last for longer (compare Figure 24 above).

The cumulative deficit over 2019-23 is 1,123Mt (compared with 1,386Mt on the pre-abatement schedule per Figure 24 above), but again we distinguish between two qualitatively distinct deficits:

1. First, there is the deficit over 2019-201 totalling 726Mt (333Mt in 2019, 202Mt in 2020, and 191Mt in 2021), which we think has already been largely hedged by the power and aviation sectors, or if not formally hedged can nonetheless most likely be funded by EUAs already held by generators and airlines. Accordingly, we think this deficit over 2019-21 will largely be funded by that part of the TNAC currently held by generators and airlines. In other words, on our assumption that the power and aviation sectors hold ~750m of the TNAC, they can cover three years of deficits, one more than under the pre abatement schedule.

2. Second, there is the deficit over 2022-25, totalling 524Mt (212Mt in 2021, 186Mt in 2022, 86Mt in 2024, and 40Mt in 2025), which effectively represents generators' and airlines' forward-hedging requirements to be contracted over 2019-22, and which would ordinarily be covered from auction volumes made available over 2019-22. However, with the auction volumes significantly reduced over 2019-21, our pre-abatement modelling shown above assumes that this is covered by allowances from that part of the TNAC held by other parties (industry and speculators).

The other key point to note in Figure 39 is that auction volumes are back to being 300Mt higher by 2024 compared with 2019, and 400Mt higher by 2025, such that beyond 2024 the annual deficits for fixed installations in the EU-ETS are very much smaller.

However, and as shown in Figure 37 above, the system overall remains in double-digit annual deficit all the way out to 2030 owing to the growing short position of the aviation sector over Phase 4.

In short, the supply squeeze for generators and airlines is greatest when auction volumes are at their lowest and the forward-hedging requirement is still significant, i.e. over 2019-21. This is why we think EUA prices will have to go to the fuel-switching level over this period, thereby enabling the market length to be re-allocated from industry and speculators to generators and airlines.

Over the second half of Phase 4 the annual deficits for fixed installations are much smaller, with the aviation sector's growing deficits becoming the main driver of marginal EUA demand and hence of the abatement requirement in the system overall. As our numbers stand today, therefore, we think that some fuel switching would still be required over 2025-30.

However, we think there is much less visbility regarding the implied outlook for pricing over 2025-30 than we are over 2019-24. This is because we expect the cost of both renewables and energy-storage technology to continue falling over the next decade, while the impact of coal phase-out policies across a number of EU member states by the middle of Phase 4 could be greater than we are currently assuming (especially if Germany decides to phase out a significant amount of old coal and lignite capacity by the middle of the next decade)

Accordingly, we think it is an open question as to whether or not fuel switching will actually be required over the second half of Phase 4 at all given that these trends will lead to a structural decline in the power sector's emissions in any case.

This raises difficult questions about the visibility of EUA prices beyond 2024, which in turn explains why some EU governments – and especially the French government – continue to push the idea of a carbon-price floor that would rise over time.

This is a topic we will explore in depth in our next report.

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