Carbon Tracker Initiative

Carbon Clampdown

Closing the Gap to a Paris-compliant EU-ETS

April 2018

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 Carbon Tracker, Mark was Managing Director and 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. For the last 15 years, Mark's research has focused on the overlap between energy and climate change. His work on power, gas, and carbon 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 and environmental markets.

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Preface: the EU-ETS and Why Carbon Pricing Matters

Carbon pricing, whether via cap-and-trade schemes or taxes, is not sufficient on its own to achieve the objective of the Paris Agreement. However, if the world is to stand a chance of restricting the increase in the average global temperature to "well below 2°C" versus pre-industrial levels, then many leading international agencies and institutions argue that a much more concerted and widespread global take-up of carbon pricing will be necessary.[1]

While acknowledging that carbon pricing needs to be complemented by a wide range of other approaches and solutions – policies, technologies, and investor action – we agree with this assessment. The space left in the atmosphere for storing greenhouse gases is the ultimate scarce resource, and it needs to be priced accordingly.

It is in this context that the recent reform of the European Emissions Trading scheme (EU-ETS) – and in particular the introduction of the new mechanism for modulating supply, known as the Market Stability Reserve (MSR) – is so interesting: it has thrust the issue of carbon pricing back into the headlines, not least owing to the 200% increase in EU carbon prices since May last year.

Established in 2005 as the cornerstone of the EU's emissions-reduction strategy, the EU-ETS has been plagued since 2009 by chronic oversupply, with prices languishing in single figures for most of the last six years. This has called into question the credibility not only of the EU-ETS itself, but also of the very idea of using cap-and-trade schemes as a tool for reducing emissions. This is because the EU-ETS is the largest carbon market in the world, and as such a bellwether for the effectiveness of cap-and-trade schemes more generally in mitigating climate change.

1 *In particular, the Carbon Pricing Panel, a body launched in April 2016 under the auspices of the World Bank and the IMF, brings together a number of leading international agencies and national governments to push for much more widespread adoption of carbon pricing in order to achieve the goal of the Paris Agreement. In the press release announcing the launch of the Carbon Pricing Panel, the agencies and governments participating in the initiative "declared that carbon pricing needs to be implemented faster and further on a global scale to keep to the Paris COP21 commitment of holding the increase in the global average temperature to well below 2°C above pre-industrial levels, and drive efforts to keep the rise to no more than 1.5°C." The Intergovernmental Panel on Climate Change (IPCC) has also stated that cap-and-trade schemes can be effective tools for mitigation if they are designed properly (see, for example, the Summary for Policymakers of the IPCC's Fifth Assessment Report, 2014, page 28).*

Against this backdrop, our aim in this report is to examine two key questions relating to the recent reform of the EU-ETS:

1 **Will this reform, with the introduction of the MSR, deliver a tighter market and hence the sustained higher carbon prices that will be necessary to deliver the deep decarbonisation to which the EU is committed over the long term? Or is it destined to disappoint, as previous reforms have done?**

Our analysis indicates that the MSR reform will indeed deliver a tighter market, particularly over 2019-23, and that this is likely to see the price of Eurpean carbon allowances – known as European Allowances, or EUAs – continue to rise over the next two to three years. We would emphasize that our aim in this report is not to offer formal price forecasts as such, but rather to indicate what price levels seem likely based on the supply squeeze we see the MSR creating, and based on the current forward curves for coal and gas. The reason forward coal and gas prices matter is that fuel switching in the power sector is the most readily available source of large-scale emissions abatement in the short to medium term. As a result, if large-scale abatement is required, EUA prices will be determined by the cost of fuel switching.

With EUAs currently trading at €13/tonne, our analysis implies prices of €15/t by year-end 2015, €20/t in 2019, and €25-30/t over 2020-21.

Moreover, and although we do not give implied price indications for EUAs for 2022 and beyond, we think it reasonable to assume that prices would remain in this range after 2021 under current legislation.[2]

2 **How far does the recent reform get the EU-ETS towards an emission trajectory consistent with the Paris Agreement, and what would be the potential pricing implications over the next decade of a Paris-compliant cap in the EU-ETS?[3]**

To estimate at what level the EU-ETS cap would have to be set over 2021-30 in order to be consistent with a Paris-compliant trajectory, we adopt both a top-down and bottom-up approach to our modelling.

On a top-down basis, we take the study by the Netherlands Environment Assessment Agency published last October,[4] which argues that an EU-wide emissions target of -55% versus 1990 levels would be consistent with the objective of the Paris Agreement. From this EU-wide target we derive an implied cap for the EU-ETS by 2030 of 943Mt.[5]

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2 *On our modelling assumptions the MSR will keep removing surplus allowances from the market until 2023, by which point the surplus will on our numbers have fallen to below 500Mt, a level which – given power generators' hedging requirements – is consistent with an ongoing need for fuel-switching.*

3 *As we explain below, this question is now no longer a theoretical one, as the EU Council last month requested the European Commisison to devise a strategy for aligning the EU-s long-term emissions trajectory with the Paris Agreement.*

4 *The study in question is entitled The Implications of the Paris Climate Agreement for the Dutch Climate Objectives, and was published by the Netherlands Environment Assessment Agency (NEAA) in October 2017 (authored by Detlef P. van Vuuren, Pieter A. Boot, Jan Ros, Andries F. Hof, and Michel G.J. den Elzen).*

5 *The current EU-wide emissions-reduction target for 2030 is -40% versus 1990, with the EU-ETS taking a greater relative share of the burden for achieving this than the non-ETS sector of the economy.*

On a bottom-up basis, we take the International Energy Agency's implied carbon budget for the EU power sector under its Sustainable Development Scenario (SDS),[6] and find that it is consistent with the EU-ETS making the same relative contribution to a Paris-compliant 2030 EU-wide target relative to the non-ETS sector as it does under the current EU-wide 2030 target.[7]

Based on our top-down and bottom-up approaches, we estimate that the EU-ETS cap over 2021-30 would have to be tightened much more significantly than is the case even after the recent MSR reform.

On our numbers, cumulative emissions in the EU-ETS over 2021-30 would have to be 1,595Mt lower than we are currently projecting under our base-case scenario. This is almost equivalent to one year's current emissions in the scheme (the initial verified data for 2017 indicates emissions last year were 1,764Mt).

We estimate that this would imply significantly higher prices than those indicated under our base-case scenario, as with an extra 160Mt of abatement required per year over 2021-30, this would require all fuel-switching options to come into play.

Our modelling indicates that EUA prices would need to trade in a range of €45-55/t over Phase 4 of the EU-ETS (which covers the period 2021-30) under a Paris-compliant cap.

In short, we conclude that the recent reform of the EU-ETS will indeed tighten the EU-ETS to the extent necessary to re-establish meaningful price tension, and that this should drive emissions abatement from fuel switching. As such, we think the European institutions – the EU Commisison, Council, and Parliament – deserve a lot of credit for re-establishing the credibility of the EU-ETS as a vital tool in reducing emissions.

At the same time, our modelling indicates that the MSR still only gets the EU-ETS one quarter of the way towards where it would need to be by 2030 under a -55% EU-wide target compared with where the cap has been set under the current -40% EU-wide target.[8]

This suggests that there will be difficult negotiations ahead as and when the EU is ready to start discussing the alignment of its emissions targets for 2030 and beyond with a Paris-compliant trajectory, with the EU's position of global leadership on climate – against a likely backdrop of growing concern later this year that

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6 *The SDS was published for the first time in the IEA's World Energy Outlook 2017 (WEO 2017) last November, and the climate-change assumptions it takes are based on its established 450-scenario. With regard to the SDS, the WEO 2017 states (p.134): "By 2040, emissions in the SDS are at the lower end of a range of estimates drawn from the most recently available emissions scenarios, all of which project a mean global average temperature rise in 2100 of between 1.7°C and about 1.8°C." Accordingly, we take the carbon budget implied for the EU power sector under the SDS to be a Paris-compliant trajectory, and the fact that the implied 2030 EU-ETS cap that we derive from the SDS on a bottom-up basis is consistent with the cap we derive on a top-down basis using the NEAA study is reassuring in this respect.*

7 *We think this is a reasonable assumption to make, as it implies that the EU-ETS would have to make 54% of the reductions required under a Paris-compliant cap, and the non-ETS sector 46%, the same ratio as under the current EU-wide cap for 2030.*

8 *This flows from our assumption that the EU-ETS would have to make the same proportional contribution to a 2030 EU-wide target of -55% as it does to the current -40% target.*

the international community is not doing enough to keep global warming to "well below 2°C"– at issue again here.[9]

What about a carbon-floor price?

Notwithstanding the impending start-up of the MSR and the trebling of EUA prices since last May, scepticism remains in some EU capitals about whether the EU-ETS can ever really deliver the long-term strength and predictability in EUA prices necessary to drive the deep decarbonization by 2050 to which the EU is committed.

Given earlier false dawns following previous reforms (especially the original backloading reform), some policy-makers think the time is right for a carbon price floor for the EU power sector, albeit most likely via a mechanism that would operate outside the framework of the EU-ETS in the same way that the UK's carbon-support price mechanism has operated since 2013.

As has been seen with the UK's carbon-support price, while such a policy can be highly effective in the country that imposes it, without remedial action by the UK to offset the impact of its domestic support price across the rest of the EU such a policy has had the effect of increasing the supply of EUAs to all non-UK based ETS players, thereby lowering EUA prices. Governments can address this by purchasing EUAs in the market and then retiring them, but this is both technically and politically complicated. For these reasons, we think the EU carbon market would be nervous about the impact on EUA prices of any carbon-floor price established in one or more member states outside the ETS.

As a result, if policymakers really want to pursue the idea, then what is needed is a floor-price mechanism compatible with, and supportive of, the EU-ETS. If such a mechanism could be devised – and the issue is much more politically complicated than simply imposing a minimum auction price for EUAs, as the EU-ETS Directive prohibits this – then we think a carbon-floor price could be an effective way of reinforcing the impact of the recent EU-ETS reform.

We will examine this issue in greater detail in a forthcoming report.

9 *In October of this year, the IPCC will publish the first of its reports in the cycle leading up to the final Sixth Assessment Report (AR6). The final AR6 itself will be published over 2021-22, and will be the latest in its series of comprehensive updates on the science of climate change and how best to address the challenges it poses. As stated on the IPCC website dedicated to the AR6 cycle, the report to be released in October of this year will be "an IPCC special report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse-gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty". At the same time, COP-24, the latest annual Conference of the Parties meeting of the United Nations Framework Convention on Climate Change (UNFCCC) will take place in Poland in December. This means that the science and politics of climate change will be centre stage in EU policy-makers' minds over the last quarter of this year, just as the Commission is preparing its response to the EU Council concerning a strategy for aligning the EU's long-term emissions trajectory with the Paris Agreement.*

Foreword

Anthony Hobley, CEO of the Carbon Tracker Initiative

This report on the recently reinvigorated EU carbon market (EU-ETS), written by Carbon Tracker's new Head of Research, Mark Lewis, is a timely reminder of the importance of policy in the fight against climate change. Whilst Carbon Tracker's work has always factored in the impact of relevant policy approaches, this is our first dedicated piece on the subject of carbon pricing, and I would therefore like to explain why we think the time is now right for such a report.

Carbon Tracker has made its name through its pioneering research on carbon budgets. Our approach has always focused on the intrinsic disconnect between the business-as-usual development of the fossil-fuel sector on the one hand, and the low-carbon pathway necessary to achieving a climate-secure energy system on the other. Our objective has always been to illuminate the financial risks inherent in fossil-fuel capex plans that ignore the increasingly intertwined policy, technology, and shareholder-driven constraints on the future development of coal, oil, and gas resources.

Against a backdrop of escalating scientific concern about climate change, we see the signals from policy-makers regarding the need for stronger instruments to mitigate the dangers. Carbon pricing is one of the most important of these instruments; and no serious authority or expert contests that putting a material price on carbon around the world is the most economically efficient way in which to speed up the global energy transition already underway.

This report therefore aligns with what we see as an important part of Carbon Tracker's mission: to translate climate-related financial risks – whether of a policy, regulatory, or technological nature – into terms that the financial and investment community can act upon. In keeping with Carbon Tracker's raison d'être, the report examines the connection between the EU-ETS and the EU's overall carbon budget under a Paris-compliant pathway.

As Mark explains, following the recent reform of the EU-ETS the EU carbon market is now on an upward trajectory. Yet as Mark's report also makes clear, if the EU ultimately acts to align its emissions targets for 2030 and beyond with the Paris Agreement, then the cap on emissions in the EU-ETS will have to be tightened significantly further over the next decade.

Given that some member states are already calling for action to align the EU's 2030 emissions target with Paris, and that the European Commission is now required to devise a long-term strategy for reducing the EU's long-term emissions in line with Paris by the end of Q1 next year, this means that there are material latent risks to investors in coal-fired generation in Europe that go above and beyond those already brought into stark relief by the recent EU-ETS reform.

And looking at policy initiatives in other key jurisdictions around the world – such as China's recent decision to establish a national emissions-trading system – the importance of carbon pricing as a policy and regulatory tool is only likely to grow over the next decade and beyond.

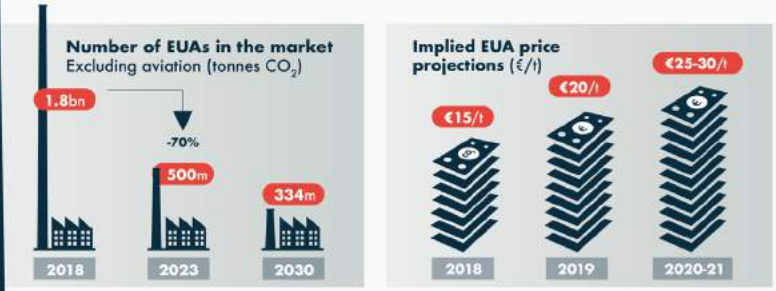
As such, our venture into in-depth research on carbon pricing is an explicit recognition of the importance of policy in the fight to keep the increase in the average global temperature to "well below 2°C" as stated in the Paris Agreement, and from now on we will be keeping a close eye on carbon-pricing initiatives globally as they continue to unfold.

What is the Market Stability Reserve (MSR)?

MSR is a reform of the EU-ETS market which will start operating in January 2019.

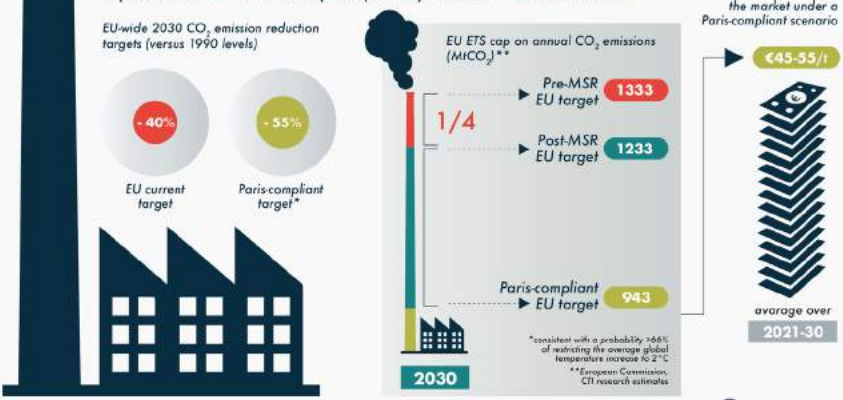
It will address the current surplus of **carbon allowances (EUAs)** by transferring to the reserve the 900 million EUAs that were back-loaded in 2014-16 instead of auctioning. In addition, all unallocated EUAs left over in 2020 will also go into the reserve.

The MSR is prompting the biggest supply squeeze the EU carbon market has ever seen



The Paris Agreement and the EU-ETS: closing the gap to 2030

The MSR already gets the EU-ETS one quarter of the way towards a 2030 cap consistent with a Paris-compliant pathway. But more needs to be done.



Source: Carbon Clampdown. Closing the Gap to a Paris-compliant EU-ETS, Carbon Tracker report, April 2018

Carbon Tracker

Executive Summary

Carbon Clampdown: the EU-ETS, the MSR, and the Paris Agreement

European carbon allowances[10] are the best performing energy commodity in the world over the last 12 months, having risen 200% since their 2017 low in May last year and more than 60% since the beginning of this year (Figure 1). But in our view EUA prices look set to go higher still over the medium term, and potentially much higher over the next decade should the EU align its emissions targets for 2030 and beyond with the ultimate objective of the Paris Agreement.

The price performance of EUAs over the last 12 months has been driven by the structural reform of the EU-ETS, a legal process that was two years in the making and that was formally completed earlier this month with the transposition of the final reform package into EU Law.[11] More specifically, the recent price performance of EUAs has been driven by one particular element of this reform, namely the introduction of a new mechanism from January of next year that for the first time will enable the supply of EUAs to the market to be modulated. This mechanism is called the Market Stability Reserve (MSR), and it is set to transform the supply-demand dynamics of the EU-ETS by creating the biggest supply squeeze the EU-ETS has ever seen over 2019-23.

Figure 1: EUA price (front-year contract), June 2013-April 2018 (€/t)

Source: Bloomberg

10 European carbon allowances are formally known as European Allowances, or EUAs. Each EUA gives the right to emit one metric tonne of CO_2 in the EU-ETS.

11 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.

Our modelling of this supply squeeze implies EUA prices of €15/t by year-end 2018,[12] €20/t in 2019, and €25-30/t over 2020-21.

At the same time, with the EU Council having last month formally requested that the European Commission draw up a proposal by the end of Q1 2019 for a long-term emissions-reduction strategy aligning the EU's emissions trajectory with the Paris Agreement, a process has now been started that could ultimately lead to a tightening of the EU-ETS cap for 2030 and beyond in line with Paris.

Under a Paris-compliant scenario for the EU-ETS, our modelling indicates that sustained average EUA prices of €45-55/t would be necessary to clear the market over Phase 4 of the EU-ETS.[13]

Against this backdrop, our aim in this report is to offer a detailed examination of the supply-demand and pricing dynamics in the EU-ETS under two scenarios:

1. **Our base-case scenario:** this sets out our modelling of the outlook for the EU-ETS from today's vantage point after taking into account the impact of the MSR from next January under the currently mandated EU-wide emissions target of reducing total EU-wide emissions by 40% by 2030 versus 1990 levels;

2. **Our Paris-compliant scenario:** This sets out our modelling of what the cap for the EU-ETS over 2021-30 would look like if at some point in the next three to five years it were to be tightened so as to align with the objective of limiting the increase in the global average temperature to "well below 2°C".

Our modelling shows that although the MSR will tighten the EU-ETS very materially – we estimate it will remove 3 Gigatonnes' (Gt) worth of EUAs from the market over 2019-23[14] – it still only gets us one quarter of the way towards a Paris-compliant cap by 2030 compared with the current EU-ETS cap under the existing EU-wide target of -40% by 2030. Indeed, we estimate that the extra tightening of the EU-ETS cap required to align with a Paris-compliant EU-wide trajectory for 2030 and beyond would require incremental emissions reductions of 1.6Gt over 2021-30 versus our base-case scenario under the current cap.[15]

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12 *With EUAs already having traded above €14/t for the first time in six years in the last month, it might look overly conservative to suggest prices of €15/t by year-end, but the speed of the rally since the start of the year so far suggests to us that at some point there will be a more meaningful correction before prices can push sustainably higher over the second half of the year.*

13 *Phase 4 of the EU-ETS covers the period 2021-30.*

14 *To put this into context, 3 Gigatonnes equates to nearly two years' worth of emissions in the EU-ETS.*

15 *Our modelling of a Paris-compliant EU-ETS cap to 2030 is based on both a top-down and a bottom-up approach. Our top-down approach is based on a recent study published by the Netherlands Environment Assessment Agency (NEAA), The Implications of the Paris Climate Agreement for the Dutch Climate Objectives, October 2017 (authored by Detlef P. van Vuuren, Pieter A. Boot, Jan Ros, Andries F. Hof, and Michel G.J. den Elzen). Specifically, the NEAA study states (see p.18) that a 2030 EU target of -55% in CO_2 emissions (as opposed to GHG emissions as a whole) versus 1990 levels would be consistent with a probability of >66% of restricting the average global temperature increase to 2°C, and that as such a -55% target could be said to meet the "well below 2°C" wording of the Paris Agreement. Our bottom-up approach is based on our reading of the IEA's modelling of a Paris-compliant emissions trajectory for the EU power sector over 2013-30 as set out in its World Energy Outlook 2017.*

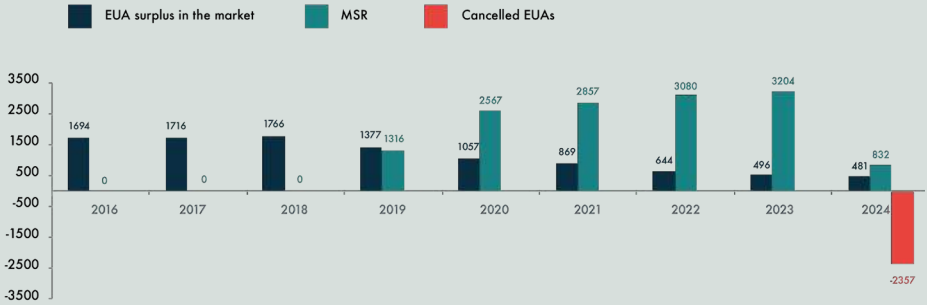
Moreover, all of this 1.6Gt of extra abatement would have to come from lower coal-fired power generation. This explains the much higher carbon prices implied under our Paris-compliant scenario versus our base case: EUAs would likely need to rise to levels that would bring all fuel-switching options into play, thereby making even the most efficient coal and lignite power plants unprofitable by 2030. As such, our analysis in this report underlines the conclusion of our recent report on EU coal generation, Lignite of the Living Dead: the medium to long-term outlook for coal and lignite in the EU is very bleak.

In this Executive Summary we first outline the main arguments put forward in this report, and then give a summary of our key modelling assumptions. As our report is structured into four main sections, the summary below outlines the key point in each section in the same order as they appear in the main body of this report below.

1. MSR = Massive Supply Reduction

The recently completed overhaul of the EU-ETS will see the MSR start up in January 2019, thereby prompting the biggest supply squeeze the EU carbon market has ever seen. As shown in Figure 2, our projections indicate that the MSR, operating at an initial injection rate of 24%, will slash the EU-ETS surplus for fixed installations[16] – technically known as the Total Number of Allowances in Circulation (TNAC) – from 1,776m to 496m over 2019-23, a drop of 1,270m (70%) (Figure 2).

Figure 2: CTI base case for EU-ETS surplus (TNAC), MSR, and cancellations over 2016-24, EUAs (m)



Source: European Commission, EU Council, CTI research estimates

16 *The EU-ETS was established in 2005 with coverage from the beginning of fixed installations in the main energy-intensive industries (power generation, cement, iron and steel, oil refining, pulp and paper, ceramics, and so forth). Since 2012 the aviation sector has also been included in the EU-ETS, but the rules relating to aviation are different in certain key respects from those governing fixed installations. Although emissions from fixed installations are many times greater than those from aviation – in 2016 they broke down as 1,750Mt and 62Mt respectively – aviation is nonetheless crucial to understanding the dynamics of the EU-ETS as it is structurally short allowances and its emissions continue to grow strongly.*

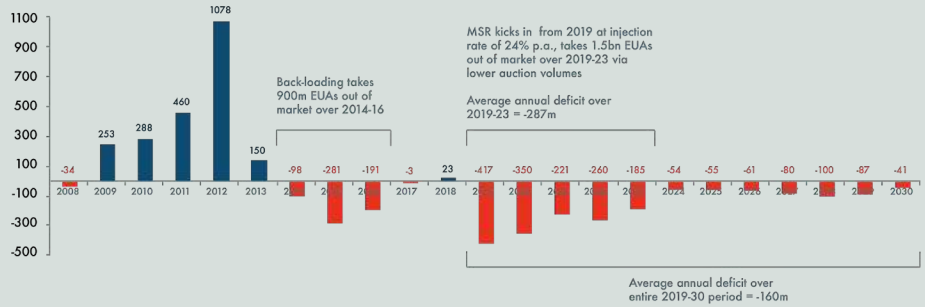
We project an average annual deficit for the fixed installations in the EU-ETS over 2019-30 of -120m EUAs, with the supply squeeze at its most acute over 2019-23. Over these five years we see the market short by an average of -254m per year, and over the two years 2019-20 by an average -354m per year.

The EU-ETS has never before seen such large or sustained annual deficits against the backdrop of such a sharply declining surplus, and the upshot will likely be a need for large-scale fuel switching in the power sector from 2019 onwards to plug the supply gap.[17]

2. Aviation and total system dynamics in the EU-ETS to 2030

The aviation sector's structural and growing short position will exacerbate the supply shortfall in the EU-ETS over 2019-23, and bringing together our modelling of EU-ETS dynamics for both fixed installations and aviation we project the system-wide deficit over 2019-23 will average -287m per year, and over 2019-30 as a whole -160m per year (Figure 3).

Figure 3: CTI base-case EU-ETS total system annual deficit/surplus, 2008-30, EUAs/EUAAs (m)



Source: European Commission, EU Council, CTI research estimates

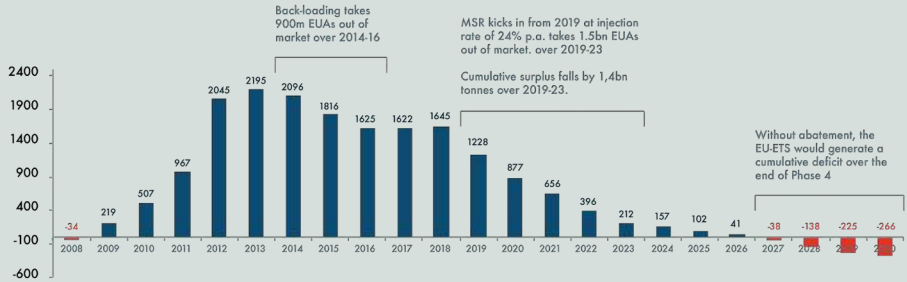
And as shown in Figure 4, this means that the system-wide surplus falls more sharply than the surplus for fixed installations only, from 1,645m in 2018 to only 212m in 2023, a drop of 1,433m (~90%). Indeed, on a system-wide basis, our modelling shows that after taking into account the supply-demand dynamics of the aviation sector, the residual cumulative balance by

17 *Note that despite the supply squeeze we project for fixed installations in the EU-ETS over 2019-23, our modelling projects a much more gradual decline in the surplus for fixed installations thereafter, such that they still have a cumulative residual surplus by 2030 of 334m EUAs.*

2030 for fixed installations – a surplus of 334m – becomes a cumulative deficit for the EU-ETS overall of -266m.

think EUA prices could break €15/t over H2 2018 as both compliance entities and speculators continue to anticipate the

Figure 4: CTI base-case EU-ETS total system cumulative deficit/surplus, 2008-30, EUAs/EUAAs (m)



Source: European Commission, EU Council, CTI research estimates

However, since it is physically impossible for the system to accumulate a deficit over a given trading period – EUAs may be banked from one period into another but may not be borrowed from a future trading period into an earlier one – we think the supply gap our model is projecting in the EU-ETS over 2019-30 in general, and over 2019-23 in particular, will have to be plugged by physical emissions reductions.

In our view, that means large scale fuel-switching in the power sector from coal to gas.

3. Base-case EUA prices: fuel switching implies €20/t in 2019 and €25-30/t over 2020-21

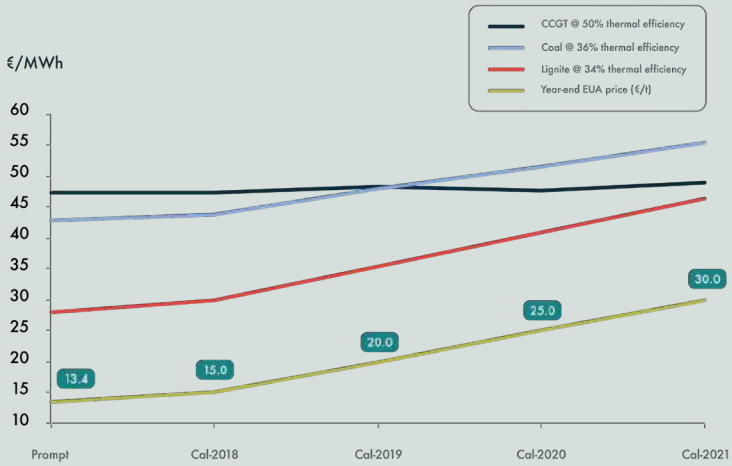
Based on the current forward curves for coal and gas, the fixed mining costs for lignite, and the level of fuel switching likely required over 2019-23 as indicated by our modelling of the MSR's impact, we

coming supply squeeze. Thereafter, we think prices could break €20/t in 2019, and then reach €25-30/t over 2020-21 as the supply squeeze itself really starts to bite.

Of course, 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 2018-21 comes with a number of caveats.

In particular, depending mainly on (i) exactly how much abatement might be required over 2019-23, (ii) the amount and availability of combined-cycle gas-turbine (CCGT) generation capacity with the required efficiency levels, and (iii) the evolution of commodity prices between now and 2021, the carbon price required to plug the supply gap could be lower or higher than the levels we have imputed from our modelling of the supply-demand dynamics in the EU-ETS over 2019-23,

Figure 5: Stylized German merit order for FF generators with EUAs rising to €30/t by y/e 2021



Source: Bloomberg, CTI

and the fuel-switching price levels implied by current forward curves.

Nonetheless, from today's vantage point we think that with significant levels of fuel switching likely required to plug the supply gap created by the impact of the MSR from 2019 onwards, a range of €20-30/t seems a reasonable estimate of where EUA prices will have to go over 2019-21 to effect the abatement necessary to clear the EU carbon market over 2019-21.

As such, we think that fuel switching between CCGT plants with efficiency rates of 50% and above and coal plants with efficiency rates of 36% and below will likely be sufficient to clear the EU-ETS over 2019-21 (Figure 5).[18]

As a result, we view our base-case modelling to be consistent with EUA prices of €15/t at year-end 2018,[19] €20/t in 2019, and €25-30/t over 2020-21.

18 *Of course, it is impossible to know precisely how much extra abatement will be required over 2019-23 relative to the situation prevailing in the EU-ETS before the recent reform package, and it is probably fair to assume that at least some of the extra supply gap caused by the impact of the MSR from next year will be covered via a combination of modified hedging horizons on the part of power generators (i.e. lower volumes of forward power sales), and a limited amount of industrials' monetizing part of their collective accumulated surplus. Nonetheless, we think the extra abatement required over 2019-23 versus the status quo ante prior to the MSR reform will average at least 100Mt per year, and could in fact be as much as 150Mt per year or more. The main markets where material fuel switching between coal and gas is possible are Italy, 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 necessitated by the impact of the MSR will have to occur in Italy, Spain, Germany, and the Netherlands.*

19 *With EUAs having already traded above €14/t for the first time in six years in the last month, it might look overly conservative to suggest prices of €15/t by year-end, but the speed of the rally since the start of the year so far suggests to us that at some point there will be a more meaningful correction before prices can push sustainably higher over the second half of the year.*

4. Paris and the EU-ETS: Gauging the Post-MSR Gap

At its most recent meeting last month, the EU Council formally requested that the Commission draw up a plan for aligning the EU's long-term emissions-reduction strategy with the Paris Agreement. This means the Commission now has 12 months to devise a strategy for aligning the EU's emissions trajectory to 2050 with the Paris Agreement,[20] and hence that the process has been set in train that could ultimately at some point in the next three to five years lead to an EU-ETS cap aligned with the objective of restricting the increase in the average global temperature to "well below 2°C".

In order to estimate at what level the EU-ETS cap would have to be set over 2021-30 so as to align with a Paris-compliant trajectory, we adopt both a top-down and a bottom-up approach.

On a top-down basis, we take the study by the Netherlands Environment Assessment Agency published last October and already referenced above, which argues that an EU-wide emissions target of -55% versus 1990 levels would be consistent with the objective of the Paris Agreement. From this EU-wide target we derive an implied cap for the EU-ETS by 2030 of 943Mt.

On a bottom-up basis, we take the International Energy Agency's imlplied carbon budget for the EU power sector under its Sustainable Development Scenario (SDS), and find that its is consistent with the EU-ETS making the same relative contribution to a Paris-compliant 2030 EU-wide target relative to the non-ETS sector as it does under the current EU-wide 2030 target.[21]

Based on our top-down and bottom-up approaches, we estimate that the tightening in the EU-ETS cap consistent with a Paris-compliant trajectory would require a reduction in the volume of EUAs available to the market over 2021-30 of 2,145Mt versus the current EU-ETS cap. However, and despite the massive supply reduction effected by the MSR already in our base case, we estimate that the impact of the MSR in reducing the current EUA cap over 2021-30 will be limited to 550Mt.[22]

This means that under a Paris-compliant scenario, we estimate that the EU-ETS would need to see EUA volumes reduced by a further 1,595Mt over 2021-30 compared with our base-case modelling of EU-ETS supply-demand dynamics after already taking the impact of the MSR into account.

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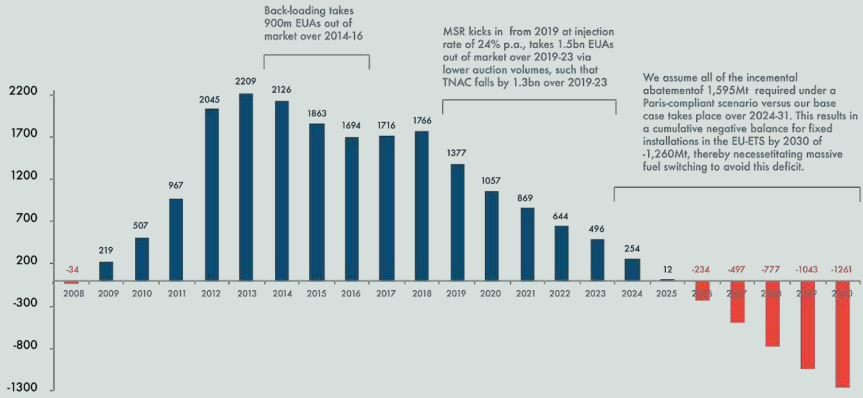
20 *See the press release of the EU Council, 22 March 2018 (paragraph 6)*

21 *In order for the EU-ETS to make the same relative contribution to a -55% EU-wide target for 2030 as it does under the current -40% target, we estimate that the EU-ETS would have to reduce its emissions by 60% versus 2005 levels (compared with 43% under the current target).*

22 *As explained in section 4 of this report below, the discrepancy between the massive volume of EUAs removed from auctioning volumes by the MSR in our base-case modelling (>3Gt over 2019-23) on the one hand, and the much more limited impact it has in bridging the gap to a Paris-compliant trajectory for the EU-ETS (only 550Mt out of a total 2,145Mt required) on the other, is readily explained: most of the volume taken out of the market by the MSR over 2019-23 relates to the huge surplus of allowances accumulated in the EU-ETS between 2010 and 2018.*

Figure 6: CTI scenario analysis of Paris-compliant EU-ETS total system cumulative balance, 2008-30, EUAs/EUAAs (m)*



*Source: European Commission, EU Council, CTI research estimates. *EUAAs are European Aviation Allowances, and are the allowances used for compliance in the EU-ETS by the aviation sector.*

As shown in Figure 6, this would result in a negative cumulative balance by 2030 for the fixed installations in the EU-ETS of 1,260Mt, compared with our base-case scenario of a small cumulative surplus for fixed installations by 2030 of 334Mt.[23]

Figure 7 then shows what our modelling implies for the Linear Reduction Factor (LRF)[24] in the EU-ETS over 2021-30. Under the current EU-wide 2030 target of -40%, the LRF reduces the cap by 1.74% per year until 2020, and then at 2.2% from 2021 onwards (which gives an annual reduction in the cap from 2021 of 48Mt).

Under our Paris-compliant scenario, we estimate that the EU-ETS cap would need to be 943Mt by 2030, implying an LRF of 4% per year from 2020, and an annual reduction in the cap from 2021 of 87Mt.

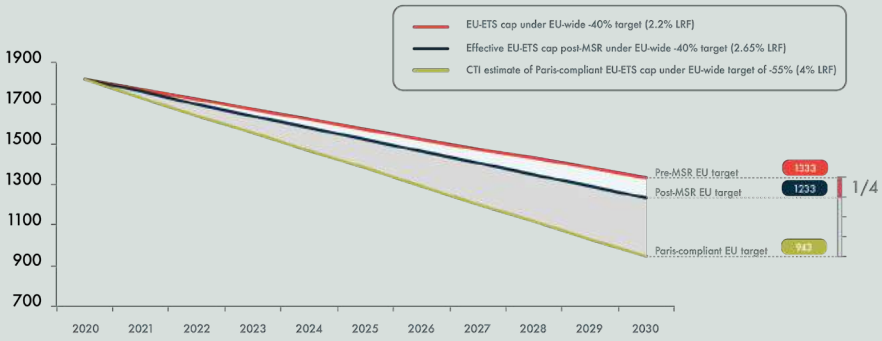
In the meantime, we estimate that the workings of the MSR over 2019-30 will have an impact on EUA volumes equivalent to an LRF of 2.65% from 2021, implying an effective cap by 2030 of 1,233Mt, and an annual reduction in the cap from 2021 of 58Mt.[25]

23 *As already mentioned, since it is physically impossible for the system to accumulate a deficit over a given trading period, the supply gap we project in the EU-ETS over 2021-30 under a Paris-compliant trajectory would have to be plugged by physical emissions reductions. We would also note that as we have not modelled the impact of a. Paris-compliant cap for the aviation sector, our estimate of the extra tightening required in the EU-ETS as a whole – i.e. for both fixed installations and aviation – is likely conservative.*

24 *The Linear Reduction Factor determines the absolute amount by which the EU-ETS cap falls each year over time.*

25 *In the meantime, we estimate that the workings of the MSR over 2019-30 will have an impact on EUA volumes equivalent to an LRF of 2.65% from 2021, implying an effective cap by 2030 of 1,233Mt, and an annual reduction in the cap from 2021 of 58Mt.*

Figure 7: LRF in EU-ETS under current legislation, together with CTI estimate of effective LRF on a post-MSR basis, and CTI estimate of a Paris-compliant pathway (2021-30) (Mt)



Source: European Commission, CTI research estimates

All of which means that on our numbers, the MSR gets us one quarter of the way to bridging the gap between the current EU-ETS cap mandated under the existing -40% EU-wide target for 2030, and the level at which it would need to be set for the EU-ETS to make its proportional contribution to a Paris-compliant EU-wide target of -55% by 2030.

So, what would a Paris-compliant EU-ETS cap mean for EUA prices?

Figure 8 shows our stylized merit order for German fossil-fuel (FF) plant over 2024-28,[26] assuming a much higher increase in EUA prices than under our base case.

This is because we estimate that under this scenario a 50%-efficient gas plant would most likely have to displace even the very limited number of 46%-highest-efficiency coal plants, and also the 43%-highest-efficiency lignite plants.

As can be seen, the 58%-efficient CCGT is already running ahead of a 43%-efficient lignite plant from a carbon price of €40/t, while by contrast the 45%-efficient CCGT is still uncompetitive against both 43%-lignite and 46% coal even at a price of €60/t.[27] Meanwhile, the average-efficiency 50% CCGT displaces 46%-efficient coal between €45-50/t, and then displaces 43%-efficient lignite at €55/t.

26 *As explained in Section 4 in the main body of this report below, as there is not a liquid curve as far out as 2024-28, we take the commodity prices currently shown in the forward curve for 2021 as our fuel-input costs to derive our stylized FF merit order over this period.*

27 *From which it follows that if abatement from 45%-efficient CCGT plant displacing 46% coal or 43%-lignite were needed under a Paris-compliant cap, the EUA price would have to go even higher than €60/t (on our estimates to €68-70/t).*

Figure 8: Stylized German merit order for fossil-fuel (FF) generators in a Paris-compliant scenario over 2024-28 with a range of CCGT efficiency rates, and with EUAs rising to €60/t by year-end 2028

Source: Bloomberg, CTI research estimates

In short, assuming that fuel switching between CCGT plants with efficiency rates of 50% or more and all coal and lignite plants – i.e. even the most efficient coal and lignite plants with efficiency rates of 46% and 43% respectively – would be needed, we derive an implied indicative pricing range for EUAs over Phase 4 of the EU-ETS under our Paris-compliant cap of €45-55/t.

In turn, this means that essentially all of the extra 1.6Gt of abatement required over Phase 4 of the EU-ETS under our Paris-compliant scenario would have to come from reduced coal-fired output.

Caveat to our Paris-compliant scenario: higher EUA prices would accelerate permanent abatement

Our analysis of a Paris-compliant cap for the EU-ETS looks only at the extent to which higher EUA prices would drive large-scale fuel switching between gas and coal/lignite, when in reality higher CO_2 prices would also likely accelerate the development of larger-scale energy-storage and smart-grid technologies, as well as driving greater behaviour change in terms of demand response. This means that in practice EUA prices might not actually need to go as high as €50/t over 2021-30 to clear the market under a Paris-compliant target, as the deployment of renewables at greater scale, energy-storage technologies, smart grids, and demand-side responses would all likely be accelerated.

In other words, the much greater abatement required in the EU-ETS over 2021-30 under a Paris-compliant scenario would in our view likely accelerate permanent abatement solutions. Again, coal-fired generation would be the main loser under such a scenario. As we concluded in Lignite of the Living Dead, the operating cost of coal could be higher than the Levelized Cost of Electricity (LCOE) of onshore wind by 2024 and solar PV by 2027, while battery storage and demand response increasingly provide auxiliary services and peak shaving.

In short, higher carbon prices will only accelerate what is now the inevitable end of coal in the EU generation stack in any case.

Main Modelling assumptions

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.

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 struck between the EU Council and Parliament last November and recently formally transposed into EU Law. We set out the full list of our key assumptions in Section 1 below, but the most important are as follows:

1. We assume that the MSR removes EUAs from the market at a rate of 24% per year over 2019-23. In our model the market surplus is thereafter below the 833m threshold that triggers the MSR to remove EUAs from the market until 2028, at which point the surplus falls below the 400m threshold, thereby prompting us to project releases from the MSR back into the market from 2029 onwards.

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 (369m from the Phase-3 New Entrant Reserve (NER), and 539m 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 sector 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 3% (50Mt)[28] and then drop more modestly in 2018 and 2019 before rising modestly in 2021 and 2022 owing to the impact of the shutdown of the last nuclear power plants in Germany (we assume that at least some of the lost nuclear output will be replaced by fossil-fuel fired generation).[29] Thereafter, we assume that emissions decline by 1.5% in 2023, and from 2024 onwards by 2% per year all the way to 2030.

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 1,764Mt in 2017 (the most recent year for which we have verified data)[30] to 1,440Mt in 2030, a drop of 324Mt, or ~20%.[31] For aviation,[32] 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

28 *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.*

29 *The EU-ETS was set up in 2005 and covers ~50% of the EU's CO2 emissions. The scheme covers CO2 emissions from fixed installations in the following sectors: power generation, and from energy-intensive industry sectors such as iron and steel,, cement, lime, aluminium, metals, glass, ceramics, pulp, paper, cardboard, acids, oil refineries, and bulk organic chemicals. It also covers nitrous-oxide (N20) emissions from the production of certain acids, and PFC (perfluorocarbon) emissions from aluminium production. Since 2012 it has also covered aviation, although currently only emissions from intra-EU/EEA flights are in scope.*

30 *Although we do not yet have the final verified emissions data for 2017, the preliminary information released by the Commission on 3 April covering 94% of the installations in the EU-ETS indicated an aggregate increase of 0.8% (see the article on this on Carbon Pulse). As a result, this is the number we have used to derive our 2017 emissions number of 1,764Mt.*

31 *Crucially, we would emphasise that this is before the impact of any abatement. In practice, given that we see a need for material physical emissions reductions over 2019-30 in order for the system to balance, our base-case emissions forecasts should be considered as the emissions that would prevail if carbon prices did not react to the constraint imposed by the cap and by the workings of the MSR. We explain this point in greater detail in Section 2 of this report below.*

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

needed to make gas more competitive than coal in the merit order, and the lower the coal price, the higher the carbon price required to make gas more competitive than coal (and vice versa with regard to gas prices). For our modelling purposes here, we take the current forward curves for coal and gas out to 2021, and on this basis conclude that in order to incentivise large-scale fuel switching EUAs would need to trade at € 15 by year-end 2018, €20/t in 2019, and € 25-30/t over 2020-21.

Risks to our thesis

Supply-side risks

On the supply side, the main risk to our projections is that some 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. This is a downside risk to our forecasts, but a limited one in terms of its potential impact.

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 the compound -1.5% per year implied by our numbers 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,[33] and (v) the EU's updated Industrial Emissions Directive with its tougher air-quality standards from 2021.

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 € 20-30/t range we calculate will be necessary over 2019-21 on the basis of the current forward curves.

33 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).

1 MSR = Massive Supply Reduction, 2019-23

In this section we set out our base-case EU-ETS model over 2008-30 for fixed installations only (i.e. excluding aviation[34]), looking at the impact of the MSR kicking in from 2019 at an injection rate of 24% over 2019-23.[35]

Our projections indicate that the introduction of the MSR from 2019 operating at an initial injection rate of 24% will lead to a very sharp drop in the market surplus over 2019-23. On our numbers, the EU-ETS surplus – which is technically known as the Total Number of Allowances in Circulation (TNAC) – falls from 1,776m to 496m over 2019-23, a drop of 1,270m, or 70%. It then drops much more modestly each year out to 2028, at which point the TNAC falls below 400m, triggering the release of EUAs back into the market from 2029.

Overall, we project an average annual deficit for the EU-ETS over 2019-30 of -120m EUAs, with the supply squeeze at its most acute over 2019-23. Over these five years we see the market short by an average of -254m per year, and over the two years 2019-20 by an average of -354m 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 plug the supply gap as industrials long of EUAs start to focus more on their own future compliance obligations in the knowledge that the cap will continue to tighten over time.

34 We look at the dynamics for the aviation sector in the next section of this report. Aviation is structurally short in the EU-ETS, and we expect its short position to increase over time as its emissions continue to grow out to 2030. However, 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, which is why we look at it separately. As explained in the next section, 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 market surplus is reduced more quickly than it would be if the aviation sector's balance were also taken into account.

35 Our modelling of the overall level of supply and demand out to 2030 is based on the assumptions set out in our Executive Summary above.

Original sin: the surplus banked from Phase 2 into Phase 3

Figure 9 shows the EU-ETS market dynamics over Phase 2 of the scheme which ran over 2008-12), and Figure 10 the dynamics to date in, and our projections for the remainder of, Phase 3 (which runs over 2013-20).

Figure 9: EU-ETS market dynamics over 2008-12 (excluding aviation), EUAs/CERs/ERUs (m)*

	2008	2009	2010	2011	2012
Total cap	**2106**	**2106**	**2106**	**2106**	**2106**
Auctioned EUAs	45	79	92	93	401
Free allocations	1958	1972	1998	2017	2054
Total EUAs	2003	2051	2090	2110	2455
CDM/JI credits	83	82	137	254	490
Total credits	2086	2133	2227	2364	2945
EU-ETS emissions	**2120**	**1880**	**1939**	**1904**	**1867**
Annual surplus/deficit	**-34**	253	288	460	1078
Cum surplus/deficit	**-34**	219	507	967	2045

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

Looking at Figure 9, it can be seen that the market was short in only one year of Phase 2, and that was 2008, the first year. In 2009, the global financial crisis and ensuing recession in the EU led to a sharp reduction in allowances as emissions fell from 2,120Mt in 2008 to 1,880Mt in 2009.

While emissions recovered in 2010, they fell back again in 2011 and 2012, just at the same time as ever-larger volumes of CDM/JI credits were being used for compliance purposes as allowed for over Phase 2 under the EU-ETS Directive.[36]

36 *The Clean Development Mechanism (CDM) and Joint Implementation (JI) Mechanism were project-based mechanisms under the Kyoto Protocol that allowed carbon credits to be created against emissions reductions in qualifying countries (Non-Annexe-1 and Annex-B countries respectively in the Kyoto terminology), with pre-defined types and amounts of these credits then eligible to be used in the EU-ETS. A smaller number of CDM/JI credits are also eligible for use over Phase 3, but the limits have now been almost fully used up and Phase 4 of the EU-ETS does not allow for the use of any CDM/JI credits at all (only EUAs will be eligible for fixed installations over Phase 4, and for aviation only EUAs and European Aviation Allowances, or EUAAs).*

On top of that, 300m EUAs from the Phase-3 NER (the so-called NER300) were auctioned early in 2011 and 2012 to provide funding for low-carbon power projects, and a further ~90m Phase-3 EUAs were auctioned early for logistical and testing purposes. In short, by the end of Phase 2, a total over-supply of 2,045m EUAs had accumulated, all of which was banked into Phase 3.[37]

And as shown in Figure 10, with the scheme already long by over 2bn allowances, the first year of 2013 generated a further excess of 164m EUAs, bringing the surplus (or TNAC) to 2.2bn tonnes by the end of 2013.

Owing to the negative impact this surplus was having on EUA prices, in 2012 the Commission proposed a measure to allow for the so-called back-loading of 900m EUAs over Phase 3, with these allowances to be removed from the volumes to be auctioned in 2014 (-400m), 2015 (-300m), and 2016 (-200m).[38]

As can be seen, the removal of 900m EUAs from auction volumes over 2014-16 did create annual deficits over each of these three years, and the -263m deficit in 2015 remains the highest annual deficit so far in the history of the EU-ETS since its inception in 2005.[39]

Figure 10: EU-ETS market dynamics over 2013-20 (excluding aviation), EUAs/CERs/ERUs (m)*

	2013	2014	2015	2016	2017	2018	2019	2020
Total cap	**2084**	**2046**	**2008**	**1970**	**1931**	**1893**	**1855**	**1816**
Auctioned EUAs	916	528	633	733	936	940	530	630
Free allocations	1012	938	872	831	820	790	746	700
NER	12	12	12	15	15	15	15	15
Total EUAs	1940	1478	1517	1579	1771	1745	1291	1345
CDM/JI credits	132	252	23	2	15	15	15	15
Total credits	2072	1730	1540	1581	1786	1760	1306	1360
EU-ETS emissions	**1908**	**1813**	**1803**	**1750**	**1764**	**1710**	**1695**	**1680**
Annual surplus/deficit	**164**	**-83**	**-263**	**-169**	**22**	**50**	**-389**	**-320**
Cumulative surplus/deficit	2209	2126	1863	1694	1716	1766	1377	1057

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

37 From the start of Phase 2 of the EU-ETS in 2008, all EUAs issued are bankable in perpetuity into future years and future trading periods. The 'original sin' of the EU-ETS was the fact that the initial design did not allow for regulating supply in the face of this building surplus. As explained below, the Market Stability Reserve is the Commission's solution to this problem, in that it is a mechanism designed to modulate supply via withholding allowances from auctions if the outstanding surplus of allowances in the market exceeds the level of 833m.

38 The back-loading measure was subsequently formally adopted as an amendment to the EU-ETS Auctioning Regulation in February 2014

39 Phase 1 of the EU-ETS covered the three years 2005-07, but EAUs issued in Phase 1 were not bankable into Phase 2, so the market dynamics of Phase 1 are not relevant to the subsequent history of the EU-ETS.

However, the surplus when back-loading was introduced was extremely high (2.2bn), and when originally proposed it was only intended as a temporary measure (the 900m allowances taken out over 2014-16 were originally meant to be returned to the market over 2019-20). As a result, the pricing impact was limited in both intensity and duration.

As shown in Figure 1 above, while EUA prices did rise from below €4/t in Q3 2013 to nearly €9/t in Q4 of 2015, they fell sharply again in Q1 2016, in part because the market knew that 700m of the 900m had already been removed, and in part because it also knew that auction volumes would be returning to normal in 2017 and 2018.

In the meantime, however, in January 2014, the Commission had proposed a more sustainable measure for dealing with the problem of over-supply in the EU-ETS, namely the establishment of a so-called Market Stability Reserve (MSR).

Beyond back-loading: the genesis of the MSR

In January 2014, the Commission proposed that a Market Stability Reserve should be established in the EU-ETS in order to reduce the surplus and enable the market to generate a meaningful long-term carbon-price signal. As justification for the measure, the Commission said the following (page 2 of the Proposal):

> *"The EU-ETS[40] was set up to deliver EU emissions reduction goals in a harmonised and cost-effective manner. While the environmental objective is guaranteed by the cap, the presence of a large surplus reduces the incentives for low-carbon investment and thereby negatively affects the cost-efficiency of the system. Where economic actors take investment decisions against the background of an over- supply of allowances in the market and the corresponding price signal, overall costs relevant for the climate change challenge are bound to increase when considered over the mid- and long-term. In short, if not addressed, these imbalances will profoundly affect the ability of the EU-ETS to meet the ETS target in future phases in a cost-effective manner, when significantly more demanding domestic emission objectives than today would have to be reached."*

The Commission's proposal to establish the MSR was officially adopted in October 2015, with a start date of 1 January 2019 and an initial design that would see the market surplus (or TNAC in the Commission's terminology) reduced by 12% per year via the withholding of EUAs from auction until such time as the TNAC dropped to 833m. At this point, the MSR would stop transferring allowances from the market into the MSR, and if and when the TNAC dropped below 400m the MSR would then start to return allowances to the market at a rate of 100m per year until there were no more allowances left in the MSR.

40 See Proposal for a Decision of the European Parliament and of the Council concerning the establishment and operation of a Market Stability Reserve, published by the European Commission, 22 January 2014.

In the meantime, however, in July 2015, the Commission had launched the process to reform the EU-ETS in time for Phase 4 (2021-30) in order to make it as effective and efficient as possible in helping the EU achieve its overall climate and energy targets for 2030.

This reform process then required the Parliament and the Council to adopt their own positions on the MSR proposal, with both endorsing a 24% rate of reduction in the TNAC via the MSR for the first few years of its operation, rather than the 12% proposed by the Commission.

The Parliament's position was that the special 24% rate should apply for the first four years (i.e. over 2019-22), while Council argued for the 24% rate to apply for the first five years (2019-23). On top of this, the Council argued that from 2024 onwards *"allowances held in the MSR above the total number of allowances auctioned during the previous year should no longer be valid"* (page 13 of the Council's General Approach).

In other words, the Council's position was that from 2024 onwards, all EUAs held in the MSR above the previous year's auctioning level should be cancelled. The Commission had not proposed any cancellations at all, while Parliament has been arguing for a one-off cancellation of 800m EUAs in 2021.

In the end, the final deal agreed between Council and Parliament on 9 November last year was closer to the Council's position than that of Parliament. As set out in the Council's official communiqué on the EU-ETS Reform,[41] the final deal agreed will see the MSR start up from January 2019 with a mandate to reduce the surplus at a rate of 24% per year for the first five years, with the vast majority of the accumulated balance of EUAs in the MSR then being cancelled in 2024.

The start-up of the MSR from January next year will therefore radically tighten the market balance in the EU-ETS from 2019 onwards.

A closer look at the MSR and its impact: our key assumptions and modelling

Our projections for EU-ETS market dynamics over 2021-30 are based on the EU-ETS reform deal agreed last November as set out in the Council's communiqué of 22 November 2018 just referred to. This means our key assumptions on the supply side are as follows:

1. That the MSR removes EUAs from the market at a rate of 24% per year for the first five years.

2. That from 2024 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.

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

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

- **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).

Overall, this means we are assuming 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 leftover allowances from the Phase-3 cap.

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 (370m on our numbers), 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 we are modelling a total potential supply over 2021-30 of 16,124m, comprising (i) the Phase-4 cap itself of 15,504m, plus (ii) the NER of 570m (sourced from unused Phase-3 EUAs), and (iii) an extra 50m EUAs for the Innovation Fund (also sourced from unused Phase-3 EUAs).

However, and as shown in Figure 11, we assume that only 150m allowances from the NER are needed to satisfy new entrants' actual demand,[43] and with the MSR both (i) removing EUAs from the market over the first three years of Phase 4, and (ii) injecting EUAs back into the market over 2029-30 once the TNAC falls below 400m, the total number of EUAs that actually comes to market over 2021-30 on our numbers is 15,156m (of which 14,956m come 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]).

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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 (at 1.5% in 2023, and then at 2% per year over 2024-30), 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.

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

Figure 11: Delta between total potential supply available over 2021-30 and CTI's base case, EUAs (m)

Source: European Commission, EU Council, CTI research estimates

Figure 12 then sets out our projections for the EU-ETS market dynamics over 2021-30.

In order to understand the impact of the MSR, we need to look not only at our projections for Phase-4 dynamics as shown in Figure 12, but also at our projections for the end of Phase 3 (Figure 10).

This is because the MSR starts operating in 2019, i.e. at the end of Phase 3. Indeed, 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 13 then shows our modelling of the MSR itself over 2019-30.

Figure 12: EU-ETS market dynamics over 2021-30 (excluding aviation), EUAs (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	736	775	847	959	931	917	889	861	867	906
Free allocations	760	695	674	653	633	612	591	570	549	529
NER	15	15	15	15	15	15	15	15	15	15
Total EUAs	1512	1485	1536	1627	1579	1543	1495	1447	1432	1450
CDM/JI credits	0	0	0	0	0	0	0	0	0	0
Total credits	1512	1485	1536	1627	1579	1543	1495	1447	1432	1450
EU-ETS emissions	**1700**	**1710**	**1684**	**1642**	**1593**	**1561**	**1530**	**1499**	**1469**	**1440**
Annual surplus/deficit	**-188**	**-225**	**-148**	**-15**	**-14**	**-18**	**-35**	**-53**	**-38**	**10**
Cum. surplus/deficit	**869**	**644**	**496**	**481**	**467**	**449**	**415**	**362**	**324**	**334**

Source: European Commission, CTI research estimates

Figure 13: MSR dynamics over 2019-30 (excluding aviation), EUAs (m)

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Normalized inflow	416	393	305	239	139	0	0	0	0	0	0	0
Normalized outflow	0	0	0	0	0	0	0	0	0	0	-33	-100
Backloaded/unused Phase-3 EUAs	900	858	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	0	-2 357	0	0	0	0	0	0
Annual change	1 316	1 251	290	224	124	-2 372	-15	-15	-15	-15	-48	-115
Cum. position	**1 316**	**2 567**	**2 857**	**3 080**	**3 204**	**832**	**817**	**802**	**787**	**772**	**724**	**609**

Source: European Commission, CTI research estimates

In terms of the MSR's mechanics, EUAs are fed in 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 (which is then fed in each month over January-August of 2019 in eight equal instalments), plus 4/12 of the 2019 TNAC as published in May 2019 (fed into the MSR over September-December 2019, again in equal monthly instalments).

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. 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 standing at 1,716m on our numbers, and the 2018 TNAC at 1,766m (Figure 10), the normalised inflow into the MSR on our projections is 416m in 2019. Thereafter, we project the normalised inflow to be 393m in 2020, 305m in 2021, 239 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 858m unused EUAs from Phase 3. This number comprises two inflows, and one outflow. The inflows are: (i) 369m of unused EUAs from the NER; and (ii) 589m 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.

45 *Note that as with injections into the MSR, releases from are also on a September-August basis, such that the first release on our numbers is based on the 2028 TNAC number published in May 2029 (362m on our numbers).*

In 2024, we assume that the Council's proposal to cancel the difference between the number of allowances in the MSR and the previous year's auctioned amount kicks in, such that 2,357m EUAs are cancelled. Thereafter, if the number of allowances in the MSR is greater than the previous year's auctioning amount, a number of allowances equal to the difference is cancelled (this eventuality does not arise in our modelling).

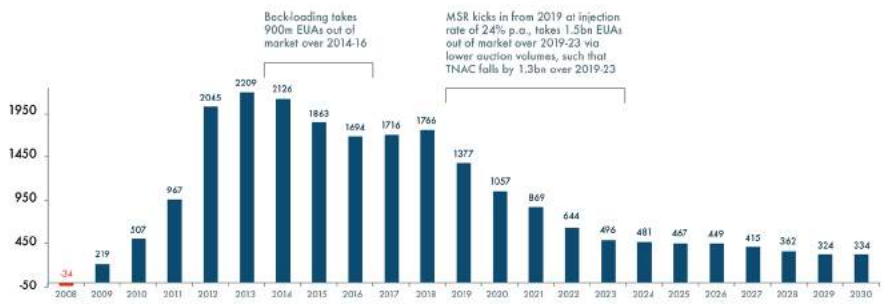
Finally, from 2029, we see the MSR releasing EUAs back into the market because, as can be seen from Figure 12 above, by 2028 we estimate that the TNAC will have fallen below 400m.

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

Figure 14: CTI base case for EU-ETS surplus (TNAC), MSR, and cancellations over 2016-24, EUAs (m)

Source: European Commission, EU Council, CTI research estimates

Figure 15: CTI base case for the EU-ETS (excl. aviation) cumulative deficit/surplus (TNAC), 2008-30, EUAs (m)



Source: European Commission, EU Council, CTI research estimates

Severe supply squeeze looks likely over 2019-23

Figure 16 shows our estimates of the annual supply/demand balance over 2008-30 based on our modelling above.

As already explained, until the back-loading of 900m EUAs over 2014-16 was introduced, the only year in which the EU-ETS had previously experienced an annual deficit was 2008, and even then it was only a very small one (-34m).

Looking forward to the start of the MSR, however, we think there are at least two good reasons for believing that this measure will be more effective in terms of the pricing impact:

1. First, the sheer amount of EUAs that we project will be taken out of the market over 2019-23 will be greater than anything the EU-ETS has ever seen before. Overall, we project an average annual deficit over 2019-30 of -120m EUAs, with the supply squeeze at its most acute over 2019-23:

Figure 16: CTI base-case for the EU-ETS (excl. aviation) annual deficit/surplus, 2008-30, EUAs (m)

Source: European Commission, EU Council, CTI research estimates

Back-loading 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, the TNAC was still extremely high over this period, averaging ~1,900m over these three years, and in our view this limited the effectiveness of the back-loading measure in re-establishing a meaningful price signal.

over these four years we see the market short by an average of -254m, and over the two years 2019-20 by an average of -354m.

2. Second, the TNAC is starting from a lower base than was the case when back-loading was introduced in 2014 (1,716m on our projections for the 2017 TNAC versus 2,209m for the

2013 TNAC the year before back-loading was introduced). In our view, the fact that the TNAC at the start of the MSR is already ~500m lower than it was before the start of back-loading is already having a significant psychological impact on the market.

In particular, for the industrial companies that have been structurally long and have accumulated large EUA surpluses to date (in sectors such Iron-and-Steel and Cement), we think the changing dynamics introduced by the MSR will focus their minds more on their own future compliance obligations, and hence make them more reluctant to sell these surpluses to generators and airlines over 2019-22. We think they will also be concerned about the implications of the cap continuing to tighten over time.

Conclusion: abatement via fuel-switching required over 2019-23

The EU-ETS has never before seen such large or sustained annual deficits against the backdrop of such a sharply declining TNAC as our model is projecting over 2019-23, and we think the upshot will be a need for large-scale fuel switching in the power sector from 2019/20 onwards to plug the supply gap.

Before looking at the pricing implications of all this, however, we first need to consider the impact that the aviation sector will have on the overall dynamics of the EU-ETS over 2019-30. This is because the aviation sector will be an increasingly important source of incremental demand for EUAs over 2019-30.

2 Aviation and Aggregate EU-ETS Dynamics to 2030

In this section we set out our base-case EU-ETS model for the total system, including aviation. The aviation sector operates under a slightly different framework from the rest of the scheme, and therefore needs to be modelled separately before we can derive our aggregated EU-ETS model. After deriving the net position of the aviation sector over 2012-30 we can add this back to our model for fixed installations as set out in Section 1 above and so derive our projections for total EU-ETS system supply-and-demand dynamics out to 2030.

The two key features of the aviation sector as far as its impact on the total EU-ETS balance is concerned are (i) that aviation has been structurally short since it started to be covered by the scheme in 2012, and (ii) unlike any other sector in the EU-ETS the aviation sector's emissions are expected to continue growing all the way out to 2030. This means that after taking into account the aviation sector's net balance, the dynamics for the EU-ETS out to 2030 are even structurally positive than was shown in our modelling of the balance for fixed installations only in Section 1 above.

As a result, bringing together all of our modelling of the EU-ETS dynamics out to 2030 – i.e. for fixed installations as set out in section 1 above, and for aviation as set out below – we derive an even tighter market balance over both 2019-23 and 2019-30 as a whole. Over 2019-23 we project the system-wide deficit to average 287m per year, while over 2019-30 as a whole we expect the systemic shortfall to average 160m per year.

In our view, such large annual systemic deficits will necessitate large-scale physical emissions reductions, and that means large scale fuel-switching in the power sector from coal to gas.

Aviation and the EU-ETS: the essential background

Aviation has been included in the EU-ETS since 2012, but it operates under a slightly different framework from the rest of the scheme. In this respect, we would highlight the following main points:

1. First, unlike the cap for fixed installations in the EU-ETS, the aviation sector's cap is fixed at the same level over 2012-20.[46]

2. Second, the aviation sector receives a higher proportion of its allowances for free, with 85% freely allocated, 12% auctioned, and 3%

46 *The cap for 2012-20 was fixed at 95% of the average annual emissions of the aviation sector over 2004-06.*

set aside for new entrants.[47] This equates to 32m allowances allocated for free, and 6m auctioned (the sector also has a very small CDM/JI entitlement out to 2020 equivalent to 1.5% of its annual emissions).

3 Third, 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.

4 The cap for the aviation sector in the EU-ETS was originally to have covered all flights entering and leaving the EU but after strong objections from many of the EU's largest trading partners, and after the Council of the International Civil Aviation Organisation (ICAO) decided in 2012 that the ICAO would begin developing global market-based measures covering aviation emissions, this was dropped in favour of a cap covering only those flights taking off and landing within the European Economic Area.[48]

Originally, the decision to exclude international flights entering and leaving the EU from the EU-ETS was intended to apply only for the period 2013-16, as explained in the Commission's Aviation Impact Assessment of February 2017 (page 7):

> *"Following the 2013 ICAO Assembly decision to develop a global market-based measure (GMBM) to address international aviation emissions, the EU limited the scope of the EU ETS to intra-EEA flights during the period 2013-2016 to drive forward the ICAO process in relation to international emissions from aviation."*

However, early last year the Commission proposed an extension of this exemption for flights between the EU and third countries until 2020, and Parliament and Council then approved it, with the legislative process finalised in December last year. As such, the current limitation of scope for aviation activities under the EU-ETS is extended until 2020. Thereafter, the EU expects the ICAO to implement a market-based measure for regulating global aviation emissions from 2021.

5 Unlike those of all the other industrial sectors covered by the scheme, the emissions of the aviation sector are expected to continue growing all the way out to 2030. Currently, the European Commission estimates that aviation emissions account for only 3% of the EU's total GHG emissions, but warns that *"GHG emissions from aviation activities are increasing exponentially", and that "In the absence of further measures, CO_2 emissions from international aviation are estimated to almost quadruple by 2050 compared with 2010".*[49]

47 *We assume the aviation sector's NER is fully utilized over Phase 3 and the allowances allocated for free.*

48 *As stated in the Commission's Staff Working Document Impact Assessment of 3 February 2017 on emissions trading for aviation within the EU-ETS (hereafter Aviation Impact Assessment), "As originally designed, the EU-ETS covers 35% of global emissions from domestic and international flights and 50% of all international flights".*

49 *See the Aviation Impact Assessment of 3 February 2017 (page 5, and also Annex-5).*

Aviation modelling assumptions: growing emissions and a growing annual deficit

We make the following key assumptions in our modelling of the aviation sector out to 2030:

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%.[50]

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.[51]

3. That the scope of coverage for aviation emissions remains limited to intra-EU/EEA flights all the way out to 2030.[52]

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.[53]

Against this backdrop, Figures 17 and 18 show the projections for the aviation sector's annual and cumulative balances respectively over 2008-30 that our assumptions give rise to.[54]

As can be seen in Figure 18, 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 17Mt over 2013-16, and accumulating a deficit of -70m in the first four years of Phase 3.

We project that the sector's annual deficit will continue to increase over the second half of Phase 3, reaching -31Mt in 2020, giving rise to a cumulative deficit by the end of the period of -180Mt.

50 As such, our assumption here is conservative, as a lower cap than we are assuming in our projections out to 2030 would, other things being equal, increase the average annual deficit of the sector.

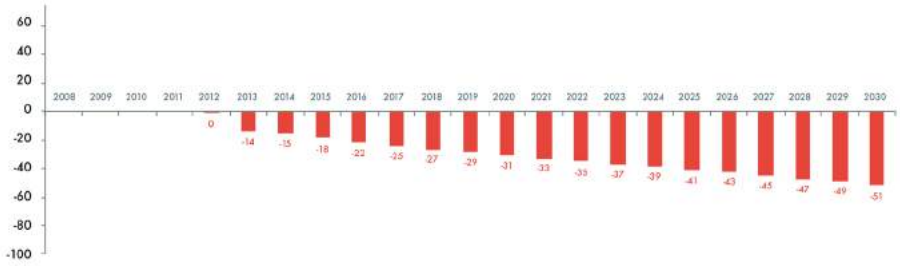
51 Again, it may well be that the aviation sector ends up with a lower level of free allocations over 2021-30 than we are assuming, but we would note that if this does turn out to be the case it will not have any impact on the supply-demand balance, and hence no impact on prices either.

52 Whether this remains the case will ultimately depend on the EU's assessment nearer the time of the ICAO's progress regarding a market-based mechanism for global aviation emissions.

53 Again, this might be considered conservative in that this methodology by definition assumes a lower annual percentage increase every year over 2017-30.

54 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.

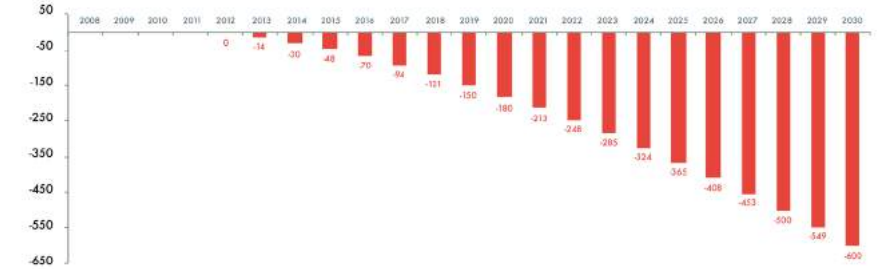
Figure 17: CTI base case for aviation in the EU-ETS, annual deficit, 2008-30, EUAAs/EUAs (m)



Source: European Commission, EU Council, CTI research estimates

Over Phase 4 we expect this trend to continue, with the annual deficit set to reach -51Mt, by 2030, and the cumulative deficit -600m.

Figure 18: CTI base case for aviation in the EU-ETS, cumulative deficit, 2008-30, EUAAs/EUAs (m)



Source: European Commission, EU Council, CTI research estimates

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.

In other words, the aviation sector's demand for EUAs will exacerbate the supply squeeze we project over 2019-23 and over Phase-4 more generally, with the sector becoming an increasingly important source of demand for EUAs over time as its deficit increases year on year over Phase 4.

Moreover, we think our projections are 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.[55]

55 *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 we estimate that the average annual deficit would be ~5m higher over Phase 4 than in*

Conclusion: aviation adds increasing tightness to EU-ETS over time

Our modelling indicates that the aviation sector will exacerbate the supply gap that already exists in the main EU-ETS over 2019-30 in general, and over 2019-23 in particular.

Accordingly, it is to a closer look at the overall system balance – i.e. the EU-ETS balance when the positions of fixed installations and airlines are aggregated – that we now turn.

EU-ETS total system dynamics over 2008-30

When the growing structural deficit of the aviation sector is added back to the market balance for the rest of the EU-ETS that we set out in Section 1 above, the supply squeeze over 2019-23 is exacerbated by ~35m per year, and over 2019-30 by 40m per year. As shown in Figure 19, on a system-wide basis, the average annual deficit over 2019-23 increases to -287m (compared with -254m for the fixed installations alone, per Figure 16), and the average annual system-wide deficit over 2019-30 to -160m (versus -120m for fixed installations only, again per Figure 16).

Figure 19: CTI base-case EU-ETS total system annual deficit/surplus, 2008-30, EUAs/EUAAs (m)

Source: European Commission, EU Council, CTI research estimates

our base- case scenario above, and that the cumulative deficit by 2030 would be ~650m rather than the 600m in our base case.

And as shown in Figure 20, this means that the system-wide surplus falls more sharply than the surplus for fixed installations only, from 1,645m in 2018 to only 212m in 2023, a drop of 1,433m (~90%) in only five years. Indeed, on a system-wide basis, our modelling shows that the accumulated surplus turns into an accumulated deficit of -261m by 2030.

As a result, it is self-evident that the scenario shown in Figure 20 over 2027-30 cannot, in reality, happen and hence that physical emissions reductions will be required (at the very latest by 2027, but in reality very much earlier than that).

Figure 20: CTI base-case EU-ETS total system cumulative deficit/surplus, 2008-30, EUAs/EUAAs (m)

Source: European Commission, EU Council, CTI research estimates

Since it is physically impossible for the system to accumulate a deficit over a given trading period,[56] we think the supply gap our model is projecting over Phase-4 will have to be plugged by physical emissions reductions.

56 *The reason we say it is impossible to accumulate a deficit over a given trading period is that while EUAs can be banked from one period into another, they may not be borrowed from a future trading period into an earlier one (the NER300 auctions – where Phase-3 EUAs were sold over the latter part of Phase 2 – and separate so-called early auctioning of ~90m Phase-3 EUAs over 2011-12 were exceptions to this rule). Note, however, that a limited amount of borrowing within the same trading period is possible on a year-to-year basis. This is because EU-ETS compliance for any given year has to take place by 30 April of the following year while (i) freely allocated EUAs are allocated in February of each year, and (ii) auctioning takes place on a more-or-less equal basis over the course of each year. As a result, it is quite possible for installations to surrender 2018 EUAs against their 2017 obligations if either (i) they have received free allocations in February 2018, or (ii) they have bought 2018 EUAs at auction over January-April 2018. By contrast, it would not be possible to comply with their 2020 obligations using 2021 EUAs, as only Phase-2 or Phase-3 EUAs will be valid for compliance in 2020.*

But what about the industrials' behaviour?

At this point it might be objected that our reasoning with regard to the need for physical emissions reductions over 2019-23 is not water-tight. After all, the market overall still has an accumulated surplus on our projections all the way out to 2027, and what is more this surplus still averages ~700m over the five years 2019-23 when the annual deficits are at their peak.

As a result, as the price rises in response to a tighter market over 2019-23, might it not be argued that the industrial companies holding accumulated surplus allowances (e.g. steel companies or cement companies) will sell these surplus allowances to plug the gap, thereby obviating the need for physical emissions reductions in the power sector?

We think the answer to this question is no, and for two main reasons:

1 If industrials sold surplus allowances they have accumulated over the last decade to avoid the need for physical emissions reductions amongst those entities that are facing a supply squeeze over 2019-23 (overwhelmingly in the power and aviation sector), then this would only accelerate the reduction in the overall system surplus and hence could only be considered a short-term measure;

2 As we have already argued above, for industrials that have so far only ever known surpluses, we think 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, and hence making them more reluctant to sell their current surpluses at prices below the level that would prompt emissions reductions via fuel switching.

A second objection to our argument might be that the utilities are already hedged for a significant portion of their 2019-20 requirements, and that they will be able to hedge themselves for 2021-23 over 2018-20 by buying allowances in the market. Generators will therefore not have a need to physically reduce their emissions over 2019-23 to meet the supply gap over 2019-23.

Of course, it is true that generators have already covered a reasonable portion of their 2019-20 obligations, but this is precisely because they hedge their forward power sales on a rolling basis, typically for two to three years forward at a time. This means that by the time we get to 2019 they will be hedging forward sales for 2022 and 2023.

But where will they find the willing sellers of allowances for delivery in 2022 and 2023?

Ordinarily the forward hedging in the carbon market is linked to the physical market for the current year, but in 2019 the volumes made available for auctioning will be lower by 416m and 393m respectively on our numbers (and thereafter by a further 305m, 239m, and 139m in 2021, 2022, and 2023 respectively).

In other words, there will be much less physical volume available for purchase over 2019-23, with the result that (i) generators and counter-parties willing to buy in the prompt market for future delivery against forward hedges will face significantly reduced supply relative to those forward hedging needs, and (ii) as we have already argued above, the other obvious source of potential supply – industrials who are long EUAs – will probably be much more reluctant to sell in the face of a significantly tighter market and their own future compliance requirements.

In short, we think the scale of supply squeeze our model projects over 2019-23 will prompt a need for material physical emissions reductions already over 2019-23.

Conclusion: Large-scale fuel switching needed from 2019

In our view, the cheapest and most efficient way for the EU-ETS to achieve significant emission-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.

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

3 Fuel Switching and Carbon Pricing

With our modelling in Sections 1 and 2 above indicating that significant physical abatement will be required over 2019-23, this section examines the implications for EUA prices. In our view, the cheapest and most readily available form of large-scale emissions abatement in the EU-ETS is fuel switching in the power sector.

As a result, our analysis here examines the carbon price that would be necessary to invert the current fossil-fuel merit order in Germany[57] and thereby push lower carbon-intensive gas plant ahead of both coal and lignite.[58]

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 break €15/t over H2 2018 – as both compliance entities and speculators continue to anticipate the coming supply squeeze – and could then break €20/t in 2019, before reaching €25-30/t over 2020-21 as the supply squeeze itself really starts to bite.

Of course, 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 2018-21 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 the supply gap could be lower or higher 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 current forward curves.

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57 We look at the German merit order for fossil-fuel plant here because it is the power market with 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. We would emphasize, however, that while no other member state has such a wide variety of FF capacity as Germany, there are many others that have both gas and coal, and some that have coal and lignite, and the economics of fuel switching as set out in our worked examples in this section with regard to the German merit order are applicable across all EU member states with coal and gas and/or lignite in their generation portfolios.

58 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.

Nonetheless, from today's vantage point we think the point stands: with significant levels of fuel switching likely required to plug the supply gap created by the impact of the MSR from 2019 onwards, a range of €20-30/t seems to us a reasonable estimate of where EUA prices will have to go over 2019-21 to effect the abatement necessary to clear the market.

In short, we view our modelling to be consistent with EUA prices of €5/t at year-end 2018, €20/t at y/e 2019, and €25-30/t over 2020-21.

Figure 21 shows the forward curves for coal, gas and EUAs, and the fixed mining cost of €12/t for lignite over 2018-21, as of 11 April 2018.

Figure 22 then shows the resulting short-run marginal cost (SRMC) curves for FF generators in Germany out to 2021 at the moment. We here assume efficiency rates of 34% for lignite (old, inefficient plant), 36% for coal (average-efficiency plant), and 50% for gas (average efficiency plant).

Figure 21: Commodity forward prices, 2018-21

	Prompt	Cal-2018	Cal-2019	Cal-2020	Cal-2021
Lignite (€/t)	12,0	12,0	12,0	12,0	12,0
ARA Coal* ($/t)	83,1	84,3	80,0	76,6	74,3
TTF Gas (€/MWh)	18,8	18,6	18,1	17,0	16,6
EUAs (€/t)	13,4	13,5	13,6	13,6	13,7

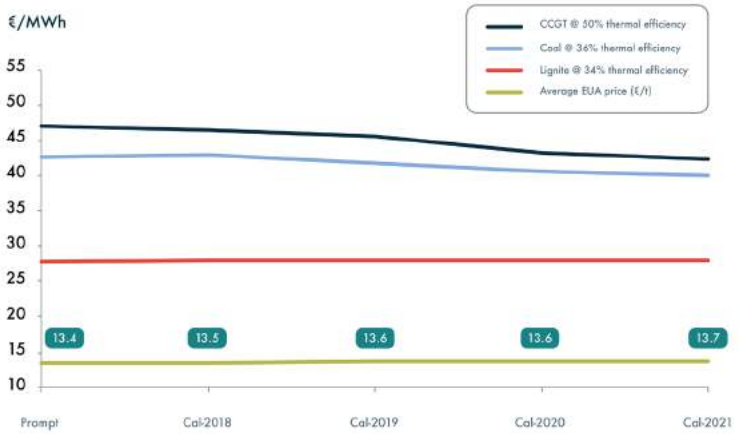
*Source: Bloomberg; *We add €10/t to the landed coal price for transportation costs.*

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

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

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 36%-efficient coal plant remains more competitive than our 50%-efficient CCGT on the basis of the current forward curves for coal, gas, and EUAs all the way out to 2020.

Figure 22: Stylized current German merit order for FF generators



Source: Bloomberg, CTI

In short, at current EUA prices – 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.

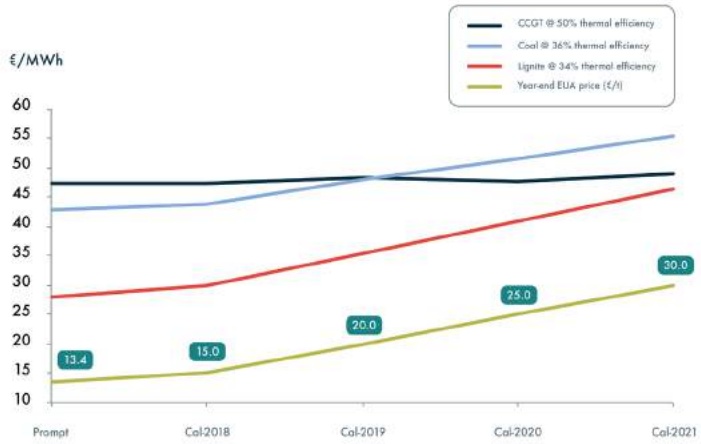
At what EUA price, then, would gas start to move ahead of coal and potentially even start to challenge lignite?

Pricing implications of the MSR squeeze: higher EUA prices needed to drive abatement

Figure 23 takes exactly the same inputs for the SRMC of lignite-, coal- and gas- fired generation as in Figure 22 above, except for the EUA price.

Instead of taking the current forward curve for EUAs, Figure 23 assume that prices rise more steeply in response to the tightening of supply caused by the start-up of the MSR, with prices hitting €15/t by year-end 2018, €20/t by y/e2019, €25/t by y/e 2025, and €30/t by y/e 2021.

Figure 23: Stylized German merit order for FF generators with EUAs rising to €30/t by y/e 2021



Source: Bloomberg, CTI

As can be seen, with this higher pricing schedule, our 50% thermally efficient gas plant would start to displace our 36%-efficient coal plant from the end of 2019 at an EUA price of €20/t, and would be running very comfortably ahead of coal at prices of €25-30/t.

Nonetheless, and as can also be seen, even at an EUA price of €30/t, our 50% efficient CCGT would still not quite be competitive with an old lignite plant with a thermal efficiency of only 34%, and it should also be remembered that the first wave of CCGT plant built across the EU in the 1990s had lower thermal efficiency rates of only 45%.

As such, it is also worth asking the following question: if the level of abatement required to clear the EU carbon market over 2019-23 were such that even with all 50%-efficient gas plant running ahead of all 36%-efficient coal right across the EU were insufficient to bring the carbon market into equilibrium, then what price level would be necessary to push a CCGT with a lower efficiency rate of 45% ahead of a 36%-efficient coal plant?

Figure 24 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 45% (while retaining 34% and 36% for our lignite and hard-coal plants respectively).

As can be seen, in this case the EUA price would have to rise to between €30/t and €35/t before the 45%-efficient CCGT could displace the 36%-efficient coal plant.

Figure 24: Stylized German merit order for FF generators with EUAs rising to €40/t by y/e 2021

Source: Bloomberg, CTI

Finally, with a view to showing at what price level the most efficient CCGT plants in the EU today would displace lignite, Figure 25 shows how the merit order would look for a 45%-, 50%, and also a 58% efficient CCGT on the same commodity-price assumptions as just shown above (i.e. taking the higher trajectory for EUA prices).

Figure 25: Stylized German merit order for FF generators with a range of CCGT efficiency rates, and with EUAs rising to €40/t by y/e 2021

Source: Bloomberg, CTI

As can be seen, on this higher EUA price trajectory, while the 45% efficient CCGT still has a higher SRMC than lignite even at a carbon price of €40/t, the 50%-efficient CCGT displaces lignite at a carbon price of €35/t, and the 58%-efficient plant at €30/t.

It is also interesting to note that the 58% efficient CCGT is already running ahead of a 36%-efficient coal plant at the current EUA price of €13.4/t.[59]

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.

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 CCGT and other 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, from today's vantage point we think that with significant levels of fuel switching likely required to plug the supply gap created by the impact of MSR from 2019 onwards, a range of €20-30/t seems to us a reasonable estimate of where EUA prices will have to go over 2019-21 to effect the abatement necessary to clear the EU carbon market over 2019-21.

As such, we think that fuel switching between CCGT plants with efficiency rates of 50% and above and coal plants with efficiency rates of 36% and below will likely be sufficient to clear the EU-ETS over 2019-21.

59 *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.*

As a result, we view our modelling to be consistent with EUA prices of €15/t at year-end 2018, €20/t at y/e 2019, and €25-30/t over 2020-21.

However, under a Paris-compliant cap for the EU-ETS over 2021-30 we think EUA prices would have to go very much higher owing to the much greater level of abatement implied under such a scenario.

With this in mind, it is to a more detailed consideration of the supply-demand dynamics in the EU-ETS under a Paris-compliant trajectory – and the pricing implications of such a trajectory – that we now turn.

4 Paris and the EU-ETS: Gauging the Post-MSR Gap

EU-ETS cap consistent with the Paris Agreement.[60] In this way we can answer two key questions: Introduction: **How far does the MSR get us towards a Paris-compliant EU-ETS?**

Last month the EU Council formally requested that the Commission draw up a plan for aligning the EU's long-term strategy with the Paris Agreement, as explained in the press release of the EU Council, 22 March 2018 (paragraph 6):

> *"The European Council invites the Commission to present by the first quarter of 2019 a proposal for a Strategy for long-term EU greenhouse-gas emissions reductions in accordance with the Paris Agreement, taking into account the national plans."*

In effect, this means that the EU Council has taken the first step towards establishing a Paris-compliant target for the EU-ETS by 2030. This is because the Commission must now come up with a proposal for a long-term EU-wide emissions-reduction trajectory consistent with Paris within 12 months. As part of this proposal, we expect the Commission to set out a Paris-compliant pathway for the EU-ETS for 2030 and beyond.

Accordingly, in this section we compare the impact that the MSR will have on the EU-ETS out to 2030 with the extra tightening that would be required under a 2030.

1 How far does the MSR reform already get us towards a Paris-compliant budget for the EU-ETS by 2030, and hence how much tighter would the EU-ETS cap need to be if the EU were to align its 2030 emissions target with the Paris Agreement?

Our analysis suggests that the MSR already gets the EU-ETS one quarter of the way towards a 2030 cap consistent with a Paris-compliant pathway compared with the over-supplied situation prevailing in

60 *As explained below, our modeling of a Paris-compliant carbon budget for the EU-ETS over 2013-30 is based on the IEA's Sustainable Development Scenario (SDS) as set out in the 2017 World Energy Outlook, and in particular on the extent to which the cap for the EU power sector is tightened under the SDS in order to deliver a Paris-compliant budget. As explained in greater detail below, cross-checking against a recent report from the Netherlands Environment Assessment Agency (NEAA) of the emissions reductions required by 2030 in order to put the EU on a trajectory consistent with the Paris Agreement, our analysis indicates that the carbon budget for the power sector over 2013-30 implied by the IEA's SDS would already tighten the EU-ETS overall by 2030 to the level required for it to meet its share of the EU-wide target consistent with Paris as set forth by the NEAA. This is because in the IEA's SDS the power sector takes a disproportionate share of the overall burden of tightening the EU-ETS under a Paris-compliant 2030 target.*

the EU-ETS before the recent reform. We reach this conclusion by breaking down the volume of supply that the MSR removes over (i) the end of Phase-3 (i.e. over 2019-20), and (ii) over Phase 4 (2021-30), and then comparing this breakdown with the extra emissions reductions that would be necessary over 2021-30 for the EU-ETS cap to be Paris-compliant.

As shown in our modelling in section 1 above, we project that the MSR will remove a total of 2,966m EUAs from the market over 2019-30, but the impact is very heavily front-loaded, with 2,417m taken out over 2019-20, and only 549m removed on a net basis over the whole of Phase 4.[61]

Meanwhile, on the basis of the IEA's modelling of a Paris-compliant EU-ETS cap for the EU power sector and our broader assessment of an EU-wide 2030 emissions target consistent with Paris, we calculate that for the EU-ETS as a whole incremental cumulative emissions reductions of 1,595Mt would be necessary over 2021-30 above and beyond what the MSR will deliver.

In other words, the total reduction in cumulative emissions required in the EU-ETS over 2021-30 relative to the current cap under the existing EU target for 2030 – which requires a 40% reduction in EU-wide emissions by 2030 relative to 1990 – is 2,143Mt, and on our numbers the MSR will deliver 549Mt or this, or 25%, leaving an extra 1,595Mt to be achieved via further tightening.

Looking at it another way, the MSR reform has the equivalent impact of raising the linear-reduction factor (LRF) to 2.65% from 2021 onwards (versus the 2.2% mandated under the current EU-wide 40% reduction target by 2030). In turn, this would imply a 2030 EU-ETS cap in 2030 of 1,233m (versus the 1,313m currently mandated).

This compares with the LRF of 4% that we calculate would be necessary from 2021 onwards to deliver a 2030 EU-ETS cap consistent with Paris of 943m. Again, this means that notwithstanding its very material impact in removing the surplus accumulated in the EU-ETS until now, the MSR only gets us one quarter of the way to where the EU-ETS needs to be under Paris, i.e. a reduction of 100m in the 2030 cap versus the 390m cut required against the existing cap in order to be Paris-compliant (100m/390m = 25%).

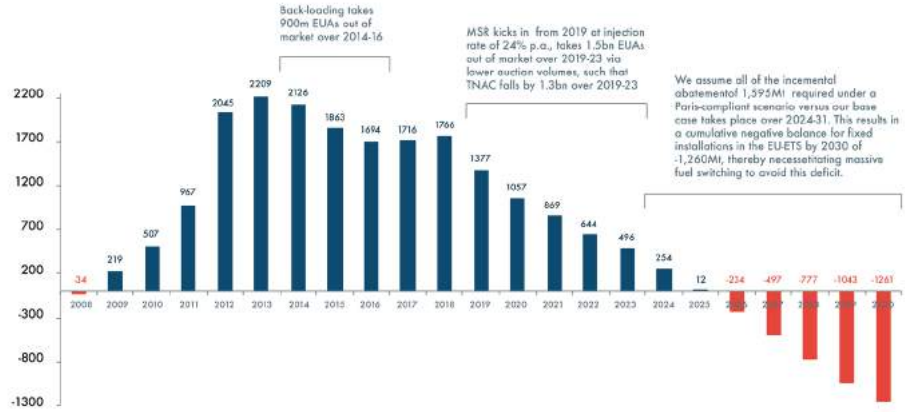
2 What would be the implications for EUA prices under a 2021-30 EU-ETS cap consistent with the Paris Agreement?

Figure 26 shows the profile of net cumulative balance in the EU-ETS over 2008-30 under our Paris-compliant scenario. As just explained, an EU-ETS cap consistent with the Paris Agreement would require 1.6Gt of extra emissions reductions from power generators alone in the EU-ETS over 2021-30, or an extra 160Mt of abatement per year on average over Phase 4 of the scheme.[62]

61 As explained below, this means that most of the MSR's impact is expended on reducing the surplus accumulated over the last decade, including that part of the surplus attributable to the allowed use of CDM/JI credits over 2008-20.

62 If the Commission presents its proposal for a long-term strategy to reduce EU emissions in line with the Paris Agreement by Q1 2019 as per the Council's request of 22 March, and even if any subsequent legislation process were to go as smoothly as possible – highly unlikely, in our view, given the very contentious negotiation between EU member

Figure 26: CTI scenario analysis of Paris-compliant EU-ETS total system cumulative balance, 2008-30, EUAs/EUAAs (m)



Source: European Commission, EU Council, CTI research estimates

For our modelling purposes, however, we assume that the full 1,595m supply reduction required under a Paris-compliant Phase-4 cap would be weighted over 2024-30. This is because the MSR is already still removing allowances from auctioning volumes until 2023.

As can be seen by comparing the evolution of the EU-ETS balance under our Paris-compliant scenario in Figure 26 with that of our base case as shown in Figure 20 above, on our estimates would imply a net cumulative negative balance of -1,260m[63], compared with a net cumulative surplus of 334m by the end of Phase 4 under our base-case scenario.[64]

The impact of such a material increase in the physical abatement required in the EU-ETS on EUA prices would be very significant, suggesting on our estimates a sustained average pricing range of €45-55/t over 2021-30 as all fuel-switching options in the power sector would likely be needed.

The structure of our analysis in this section Against this introductory backdrop, our analysis below is structured in five main sub-sections.

states that any proposal to tighten emissions targets to a level consistent with Paris would inevitably be – the reality is that the earliest this could become EU Law would be 2021.

63 As already explained in section 2 above, as EU-ETS rules prohibit the borrowing of allowances from the next or any other trading period into the current one, it is impossible to accumulate a deficit over a given trading period. Again, this means that the profile of the cumulative EU-ETS balance shown in Figure 26 could not in reality happen, and hence that substantial extra physical emissions reductions would be required over Phase 4 under a Paris-compliant cap.

64 Note also that Figure 26 shows our projections for a Paris-compliant EU-ETS over 2013-30 for fixed installations only, i.e. not including the aviation sector. Given that the aviation has a cumulative deficit of -600m by 2030 even under our base-case scenario (see Figure 18), and that it, too, would be required to make extra emissions reductions under a Paris-compliant cap, the incremental abatement required on a total-system basis would be greater than the 1,595Mt we have modelled here.

First, we give a contextual overview of how the EU's current 2030 emissions target of -40% versus 1990 breaks down between the EU-ETS and non-ETS sectors of the economy.

Second we estimate how much extra effort would be required by each of these sectors under a 2030 target consistent with Paris. This then enables us to lay out the rationale behind the numbers we have derived for a Paris-compliant EU-ETS cap out to 2030.

Third, we explain the methodology we have used to derive our projected tightening of the cap for the EU power sector, which is based on the IEA's SDS scenario as set out in the 2017 WEO. The IEA itself bases its analysis on the work of the Intergovernmental Panel on Climate Change (IPCC), and in particular the IPCC's Assessment Report 5 (AR5).

Fourth, we then look in more detail at the numbers behind a Paris-compliant carbon budget for the EU power sector out to 2030. Compared with the cap currently mandated out to 2030 under the EU's 40% emissions-reduction target, we estimate that a Paris-compliant budget would require a reduction in emissions from the EU power sector of 2.4Gt over the entire 2013-30 period,[65] all of which would essentially have to come from reduced coal-fired generation. Indeed, our analysis of the IEA numbers leads us to estimate that nearly all of the reduction in FF-fired generation required under a Paris-compliant EU-ETS cap would have to be coal-based: out of 2,800TWh of the reduction in FF-fired production that we estimate would be required under the SDS relative to the IEA's base case, 2,700TWh would have to come from coal- and lignite-fired output.

Finally, we consider the potential pricing impact of a Paris-compliant EU-ETS cap. Given the very material increase in the abatement required over Phase 4 versus our base-case scenario, we think that a Paris-compliant EU-ETS cap would require higher-cost abatement options as all fuel-switching options in the power sector – including not only gas displacing hard coal, but also both gas and hard coal displacing lignite at least some of the time – would in our view likely have to come into play.

On our calculations based on the current forward curves for coal and gas, and the generation costs for lignite plants of varying efficiency, this would suggest sustained average EUA prices of €45-55/t over 2021-30 under a Paris-compliant scenario.

The Paris Agreement and the EU-wide target: gauging the gap

The current EU-wide climate target for 2030 is to reduce emissions by 40% versus 1990 levels, with the EU-ETS having to take a disproportionate share of this burden. However, the burden for achieving the 2030 target is allocated not on the basis of 1990 emissions, but rather of 2005 emissions. In order to hit the overall target of -40% versus 1990, EU-ETS emissions have to fall by 43% versus 2005 levels, and

65 *As explained below, this is the entire reduction required between over 2013-30, and the impact of our base-case modeling of the MSR's impact shown in Section 1 already accounts for about one third of this, leaving 1.6Gt that would have to be achieved over Phase 4 under a Paris-compliant cap.*

non-EU-ETS emissions by 30% versus 2005 levels.[66]

Figure 27 shows what this means in hard numbers. Total EU-wide emissions of 5,215Mt in 2005 broke down as 2,339Mt for the EU-ETS, and 2,876Mt for the non-ETS sector. This means that the EU-ETS cap under the current EU-wide target is 1,333Mt (-43% versus 2005), and for the non-ETS sector 2,013Mt (-30% versus 2005). Under the current -40% 2030 target, the cap declines at a rate of 1.74% per year fixed against the 2010 level[67] until 2020, and thereafter at 2.2%. As the annual reduction is fixed in absolute terms against 2010 – it declines at 38Mt per year until 2020 (1.74% of the 2010 level), and 48Mt per year from 2021 onwards (2.2% of the 2010 level) – it is known as the Linear Reduction Factor (LRF).

However, before the recent EU-ETS reform and the introduction of the MSR, the 2030 EU-ETS was not a hard cap but rather a soft one. In other words, it was not necessary to hold emissions to a level equivalent to the volume of EUAs issued under the cap. This is because in addition to the EUAs issued under the EU-ETS cap, 1,644m CDM/JI credits were allowed into the EU-ETS on a one-for-one equivalence basis for compliance purposes.

And even though CERs/ERUs cannot be used beyond 2020, the fact that they are valid for EU-ETS compliance on a one-for-one basis before that date means that for every CER or ERU submitted before 2020, one EUA can be banked for use into a subsequent year or a subsequent trading period.

Figure 27: EU 2030 emissions targets for ETS and non-ETS sectors (Mt)

Source : European Commissions, CTI research estimates

66 *For the full background on the EU's current 2030 emissions targets see the DG Climate website's section on the 2030 Climate and energy Framework.*

67 *The 2010 cap used is a notional level of 2,199m that takes account of the expansion in scope of the scheme from Phase 3.*

However, before the recent EU-ETS reform and the introduction of the MSR, the 2030 EU-ETS was not a hard cap but rather a soft one. In other words, it was not necessary to hold emissions to a level equivalent to the volume of EUAs issued under the cap. This is because in addition to the EUAs issued under the EU-ETS cap, 1,644m CDM/JI credits were allowed into the EU-ETS on a one-for-one equivalence basis for compliance purposes.

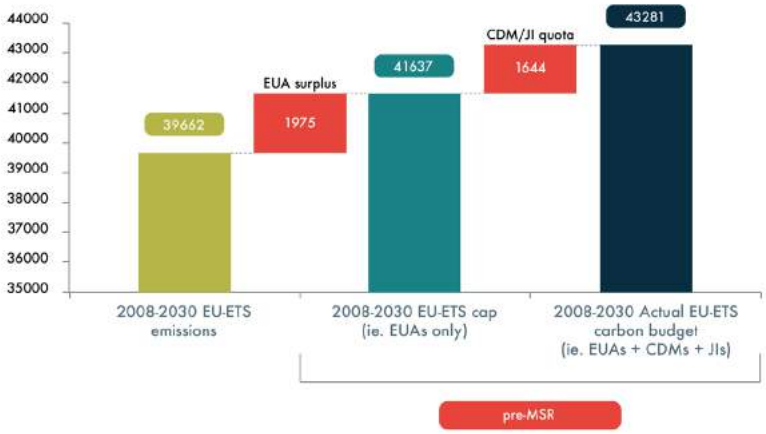
And even though CERs/ERUs cannot be used beyond 2020, the fact that they are valid for EU-ETS compliance on a one-for-one basis before that date means that for every CER or ERU submitted before 2020, one EUA can be banked for use into a subsequent year or a subsequent trading period.

As a result, before the recent EU-ETS reform and the introduction of the MSR, up to 1.644Gt of emissions above the EU-ETS cap over 2008-30 could be offset via the use of Kyoto credits.[68]

Figure 28 shows what this means in terms of the total supply of carbon credits – i.e. EUAs plus CERs and ERUs – over 2008-30 prior to the recent EU-ETS reform, and compares these supply volumes with the total emissions we are now projecting over 2008-30 as per our modelling in section 1 above.

As can be seen, while the EU-ETS cap itself (i.e. EUAs only) consistent with the current -40% target by 2030 comes to 41.6Gt over 2008-30, once the maximum allowed use of CDM/JI credits is added on top we get to 43.3Gt. Meanwhile, the aggregate emissions we are now projecting over 2008-30 comes to only 39.7Gt.

Figure 28: CTI estimates of total EU-ETS emissions and credits available, pre MSR (Mt)



Source : European Commissions, CTI research estimates

68 *As set out in Section 1, in our base-case scenario we assume that out of a total allowed quota over 2008-20 of 1,644m CERs/ERUs, 1,515m are actually used.*

This means that assuming all of the EUAs issued under the cap and all of the CERs/ERUs allowed into the EU-ETS before 2020 were used, then prior to the recent EU-ETS reform and the start-up of the MSR from 2019 we would have been projecting an EUA surplus of 1,975m over and above aggregate emissions over 2008-30, and a total surplus of 3,619m after adding back the 1,644m CER/ERU quota.

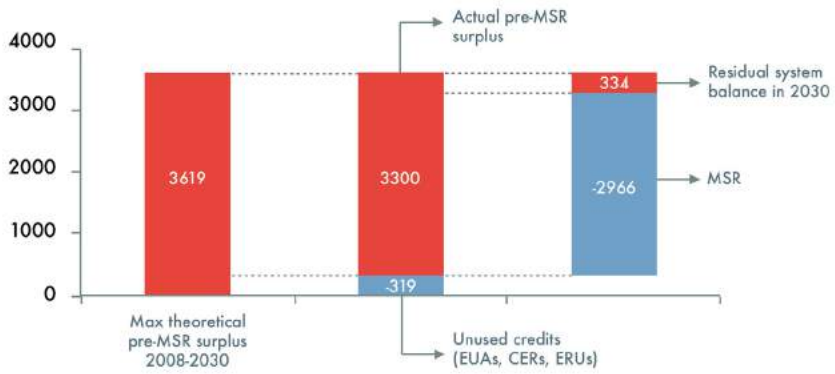
That said, in our base-case modelling of supply dynamics (Figure 29 below) we estimate that a total of 190m EUAs from the Phase-2 and Phase-3 caps are retired without being used for compliance,[69] and assume that 129m CERs/ERUs end up going unused owing to smaller installations' not using their full quotas.

This means that the pre-MSR surplus we would have been modelling in the absence of the recent EU-ETS reform would have been 3,300m prior to the impact of the MSR. With the MSR then taking out a total of 2,966m EUAs on a net basis over 2019-30 as per our base-case modelling set out in Section 1 above, this leaves a surplus of 334m by the end of 2030 (again, as per our base case).

However, the overwhelming majority of the excess supply removed by the MSR is taken out already at the end of Phase 3 over 2019-20.

As shown in Figure 30, a net total of 2,417m EUAs is removed from the Phase-3 cap over 2019-20, while the net outflow from the Phase-4 cap over 2021-30 is only 549m (the 683m of inflows from withheld auction volumes over 2021-23 minus the 133m auctioned back over 2029-30 after the TNAC falls below 400m). Together, the net removals from the Phase-3 and Phase-4 caps of -2,417m and -549m respectively give us our net MSR impact on the market balance over 2019-30 of -2,966m.

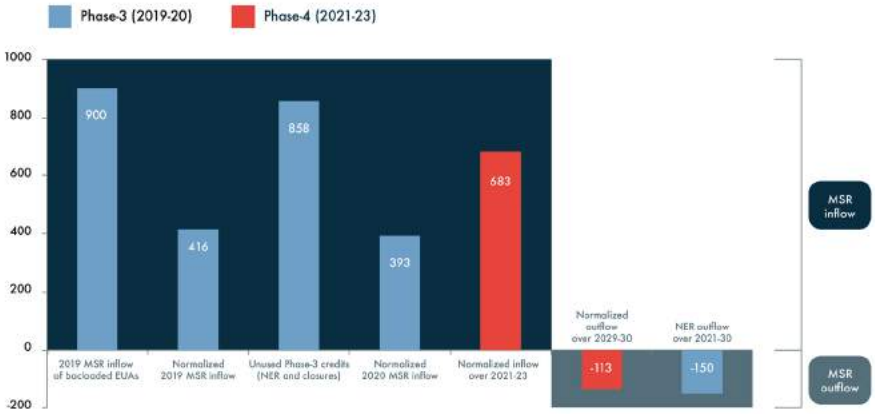
Figure 29: CTI base-case estimate of total MSR impact on EU-ETS system balance (EUA m)



Source : European Commissions, CTI research estimates

69 *These are mainly EUAs left over in the Phase-2 NER.*

Figure 30: Breakdown of CTI base-case MSR impact by element, 2019-20 & 2021-30 (EUA m)



Source : European Commissions, CTI research estimates

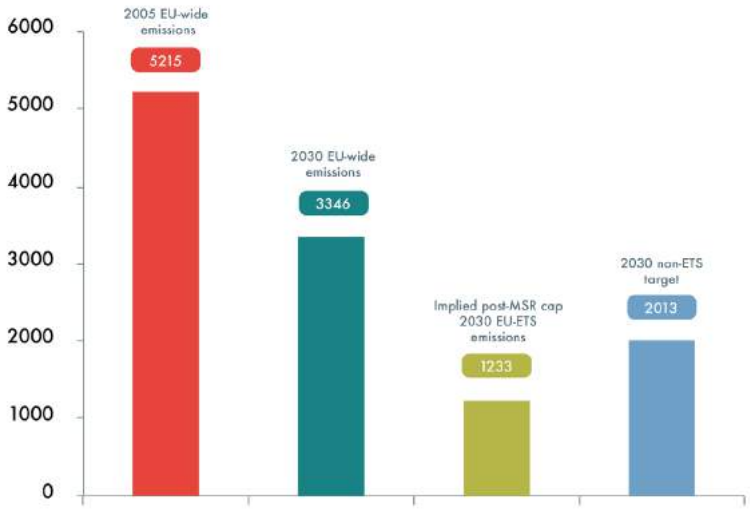
In turn, this means that most of the work done by the MSR is to help remove the surplus accumulated over 2008-20, and that as a result, and despite taking a total of 2,967m EUAs out of the market, it only tightens the Phase-4 cap[70] by 549m (to 14,955m from 15,504m).

Another way to think about this is by translating the 549m reduction in the Phase-4 cap into an equivalent LRF. In other words, at what level would the LRF have to be set from 2021 onwards in order to reduce the cap by 549m over 2021-30, and what cap would this imply for 2030 compared with the 1,333m mandated by the current -40% EU-wide target?

As already explained, the current LRF consistent with the -40% target is 2.2% from 2021 (giving an annual absolute reduction in the cap over Phase 4 of 48Mt), and in order to reduce the Phase-4 cap by 549m the LRF would need to be set at 2.65% which would give an annual absolute reduction of 58.5Mt.

70 *Note that even though it is distributed over 2021-30, the NER outflow of 150m does not come out of the Phase-4 cap, but rather out of the Phase-3 cap. This is why we say that the net amount taken out of the Phase-3 cap is 2,417m, i.e. the sum of 900m plus 416m plus 858m plus 393m and then minus the 150m that flows out of the MSR over 2021-30.*

Figure 31: Implied 2030 EU-ETS cap in CTI base-case modelling of EU-ETS post-MSR impact (Mt)



Source: European Commission, CTI research estimates

On this basis, we calculate that the implied 2030 cap consistent with our base-case modelling of the MSR's impact on EU-ETS dynamics is 1,233Mt (Figure 31), 100m below the currently mandated cap of 1,333Mt under the existing -40% target (Figure 27).

We say 'implied' because in reality the cap itself has not changed. As already explained in section 1 above, the MSR reduces EUA volumes via the withholding of EUAs from auctions, not via a simple reduction in the cap itself. Nonetheless, on our numbers the impact of the MSR over 2021-30 is equivalent to what the impact of raising the LRF to 2.65% from 2.2% from 2021 would be. The impact of the MSR also means that on our numbers the EU-ETS will reduce its emissions by 48% by 2030 relative to 2005, rather than by 43% as mandated under the current EU-wide -40% target.

And crucially, the start-up of the MSR from 2019 will now ensure that the cap over 2021-30 is a hard cap rather than a soft one. This is because the MSR will entirely eradicate the inflation of the EU-ETS cap caused by the allowed use of CDM/JI credits over 2008-20 (while also reducing significantly the size of the accumulated EUA surplus as well).[71]

The next question is, how much lower would a Paris-compliant cap over 2021-30 need to be, and how much higher would the LRF need to be from 2021 in order to deliver a Paris-compliant 2030 cap?

71 *Note that this is true even though there is still a surplus of 334m EUAs by 2030 under our base case as set out in Section 1 above. This is because what matters here is that the effect of the MSR is to eradicate the ability of EU-ETS operators to offset excess emissions above the EU-ETS cap (i.e. the EUA cap) via the use of carbon credits sourced from outside the EU (i.e. CDM/JI credits). Post-MSR, therefore, the EU-ETS has a hard cap.*

The Paris Agreement and the EU-ETS: gauging the gap to 2030

The ultimate objective of the Paris Agreement, as set out in Article 2, Paragraph 1 (a), is as follows:

> *This Agreement, in enhancing the implementation of the Convention, including its objective, aims to strengthen the global response to the threat of climate change, in the context of sustainable development and efforts to eradicate poverty, including by:* ***Holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels,*** *recognizing that this would significantly reduce the risks and impacts of climate change." (Our emphasis).*

Accordingly, the key question for the European Commission when it comes to producing the *"proposal for a Strategy for long-term EU greenhouse-gas emissions reductions in accordance with the Paris Agreement"* that the Council has requested it publish by Q1 2019 is what such a proposal would mean in terms of the EU's emissions target for 2030: by how much would the EU's total emissions have to fall by 2030 relative to 19990 to put the EU onto a Paris-compliant pathway, and what would this mean for the EU-ETS?

The first and most important thing to say in answer to this question is that the science of emissions budgets consistent with different average warming levels is probabilistic. In other words, for a given level of cumulative emissions over a given period of time it can only ever give temperature ranges associated with those emissions levels, and the probability of remaining within those ranges.

Moreover, the Paris text itself does not give a precise temperature target per se. Rather it states that the goal is to hold the increase to well below 2°C, and to pursue efforts to limit the increase to 1.5°C. This means there is scope for differing political interpretations of exactly what "well below 2°C" means: for some it will mean 1.5°C, but for others it might mean as much as 1.8°C or even 1.9°C.

For these reasons, a precise answer to the question of where the 2030 EU target would need to be set in order to put the EU onto a Paris-compliant pathway is by its nature both scientifically and politically problematic.

Nonetheless, in a detailed study of the implications of the Paris Agreement for both its own future climate policy and that of the EU as a whole, the NEAA[72] recently

72 *See The Implications of the Paris Climate Agreement for the Dutch Climate Objectives, October 2017, authored by Detlef P. van Vuuren, Pieter A. Boot, Jan Ros, Andries F. Hof, and Michel G.J. den Elzen, and published by the Netherlands Environment Assessment Agency. Specifically, the NEAA study states (see p.18) that a 2030 EU target of -55% in CO_2 emissions (as opposed to GHG emissions as a whole) versus 1990 levels would be consistent with a probability >66% of restricting the average global temperature increase to 2°C, and that as such a -55% target could be said to meet the "well below 2°C" wording of the Paris Agreement. The European NGO coalition on climate and energy CANE (Climate Action Network Europe) also sees a -55% target versus 1990 as a minimum Paris compliance (although CANE refers to GHG emissions as a whole, not just CO_2 emissions), stating on its website under Climate and energy Targets: "The EU's 2030 Climate and Energy Targets are not compatible with the objective of the Paris Agreement to keep temperature rise to 1.5°C.In fact, CAN Europe and many other stakeholders have been calling for much stronger*

concluded that an EU-wide emissions target of -55% by 2030 versus 1990 would be consistent with a Paris-compliant pathway.

This also helps explain why in a major speech in front of other EU leaders in Berlin recently,[73] the Netherlands' Prime Minister, Mark Rutte, urged the EU to raise its 2030 target to -55% already this year to show it is taking Paris seriously:

> *We need to raise the bar... This will show that we're serious about the commitments we made in Paris. By adopting this target, the EU will be doing its share to get closer to the global ambition of keeping warming to 1.5°C. So let's not delay. The current Commission could start making preparations. I'd like to see the June European Council approve this."*

And although Prime Minister Rutte's exhortation to action will not be acted upon as soon as he hopes – in our view, there is no prospect of the EU Council in June voting to raise the 2030 emissions target – we do now have a timetable for a process to raise it following the Council's request to the Commission, two weeks after Mr. Rutte's speech, to come up with a strategy for Paris compliance by Q1 of next year.

In short, and notwithstanding the scientific and political complications of setting a cap consistent with Paris, for our purposes here we take a reduction of the EU's GHG emissions of 55% by 2030 versus 1990 to be consistent with the EU's commitment under the Paris Agreement.

The key question, then, is this: at what level would the EU-ETS cap have to be set over 2021-30 in order to be consistent with Paris after taking into account the contribution that the EU-ETS would likely be required to make towards achieving such an EU-wide target relative to the non-ETS sector of the economy?

Our approach to answering this question is to look at the IEA's carbon budget for the EU power sector over 2013-30 under its SDS, and work back from there to see what it implies for both (i) the EU-ETS overall, and (ii) the non-ETS sector of the economy.

We set out our methodology and detailed calculations for the power sector's Paris-compliant budget in the next two sub-sections below, but our conclusion upfront is this: on the assumption that an EU-wide 2030 emissions target of -55% would require the EU-ETS and non-ETS sectors of the economy to make the same proportional effort as they do under the current -40% target, then the carbon budget for the EU power sector under the IEA's SDS out to 2030 implies that generators would

2030 targets: at least 55% greenhouse-gas emission reductions." As explained below, our own analysis of a Paris-compliant EU-ETS target out to 2030 (as based on the IEA's SDS for the EU power sector) implies a 60% reduction in CO_2 emissions for the EU-ETS overall versus 2005 levels (compared with 43% under the current EU-wide -40% 2030 target for total EU GHG emissions versus 1990 levels), and a 54.4% reduction in total EU-wide GHG emissions versus 1990 levels. As such, our estimate of what a Paris-complaint EU-ETS cap over 2021-30 would need to look like is very closely aligned with what both the NEAA deems to be Paris compliant, and what CANE is calling for in terms of a Paris-compliant 2030 EU target.

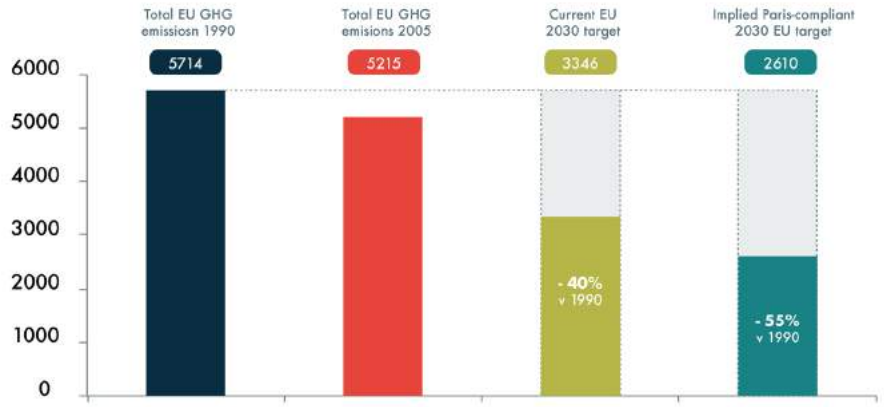
73 See the story on Climate Home News, Dutch PM Calls for More Ambitious 2030 EU Climate Target, 5 March 2018.

carry the entire burden for achieving the incremental emissions reductions required within the EU-ETS under a -55% target for the EU as a whole.

Let us now go through our reasoning to show how we reach this conclusion.

Figure 32 shows total EU GHG emissions in 1990[74] and 2005,[75] together with the current 2030 EU-wide target (-40%) and the target we are here assuming would be consistent with Paris (-55%).[76]

Figure 32: CTI estimate of EU-wide 2030 emissions target under a Paris-compliant pathway (Mt)



Source: European Commission, CTI research estimates

74 We would note that the 1990 number for EU GHG emissions shown here of 5,714Mt is the latest available figure as published by the European Environment Agency in its EEA GHG data viewer. However, as these historical numbers are subject to periodic (albeit usually very small) revisions, it is actually slightly higher than the number that was used as the basis for the current 2030 target. This is why the current EU target – which we estimate at 3,346Mt – actually represents a 41% reduction against the 1990 level shown here.

75 The 2005 number shown here is not the latest one available (5,345Mt per the EEA's GHG data viewer), but rather the one that was used for allocating the burden for achieving the overall emissions reductions required under the current 2030 target between the EU-ETS and the non-ETS sectors (again, the slight difference reflects a small revision to the original number). As such, we also use this number as the basis for apportioning the incremental abatement required under a Paris -compliant EU-wide target between the EU-ETS and non-ETS sectors.

76 Our implied EU-wide Paris compliant target of -55% actually represents a 54.3% reduction against the 1990 levels shown here, rather than 55%. This reflects the fact that our -55% target is in fact imputed from the 2005 EU-wide emissions level shown in Figure 27 (5,215Mt), as this was the number used to apportion the current EU-ETS target to 2030 and as such is therefore the best number to take for consistency of comparison between the current -40% EU-wide target and a -55% EU-wide target.

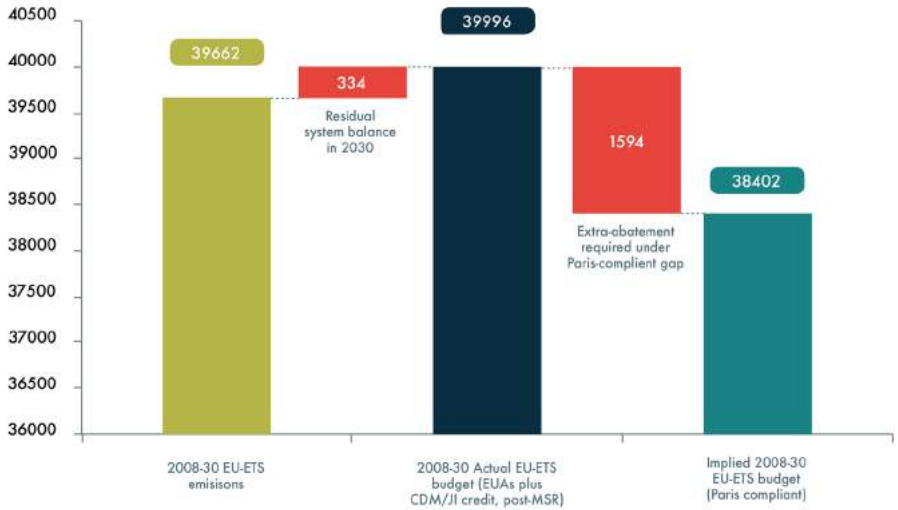
The next question is how our 2030 EU-wide -55% target should be allocated between the EU-ETS and non-ETS sectors. As already explained, under the current -40% target, the EU-ETS has to reduce its emissions by 43% against 2005 levels, and the non-ETS sector by 30% (Figure 27 above).

This means that the EU-ETS has to reduce its emissions by 1.43x more than the non-ETS sector (i.e.43%/30%), so it would seem reasonable to assume that in attributing the incremental emissions reduction required under a -55% target the EU would look to apportion it in a similar ratio between the two sectors.

Bearing this ratio in mind, we then move from a top-down approach to the bottom-up approach we have used in our analysis of a Paris-compliant carbon budget for the EU power sector under its SDS. In this way, we will be able to cross-check the implied reduction in the 2030 EU-ETS cap under a Paris-compliant trajectory thus derived with the top-down numbers we have just set out above to see if they reconcile with each other.

Figure 33 shows our projected aggregate EU-ETS emissions and aggregate post-MSR EU-ETS cap over 2008-30, both per our base-case analysis as set out in Section 1 above.

Figure 33: CTI base-case estimates of 2008-30 EU-ETS emissions and carbon budget post-MSR versus CTI estimate of Paris-compliant carbon budget for the EU-ETS (Mt)



Source: European Commission, CTI research estimates

As we know, the difference between the two is 334m, which represents the residual EU-ETS surplus we are projecting by 2030 in our base case.[77]

At the same time, Figure 33 also shows our estimate of the Paris-compliant EU-ETS cap over 2008-30 based on the extra abatement required by the EU power sector under the IEA's SDS. As can be seen, the difference between the aggregate 2008-30 EU-ETS budget we are projecting in our base case (39,996Mt) and what we see as the Paris-compliant EU-ETS budget derived from the IEA's modelling of the carbon budget for power generators under its SDS (38,402Mt) is 1,595Mt.

From all of this it follows that if we are right in our view that the aggregate EU-ETS budget we have derived from the IEA's modelling of the EU power sector in its SDS is indeed consistent with a Paris-compliant pathway for the EU-ETS to 2030, then the 1,595Mt of extra abatement we have imputed to be necessary over 2021-30 versus our base-case scenario should be able to meet two key criteria:

1. A cumulative reduction in EU-ETS emissions of 1,595Mt over 2021-30 should bring the 2030 EU-ETS cap down to the level required to be consistent with a 55% reduction in EU emissions overall versus 1990;

2. A cumulative reduction in EU-ETS emissions of 1,595Mt over 2021-30 should be equivalent to 1.43x the level of extra emissions reductions required from the non-ETS sector over this period for the EU-wide -55% target to be met.

So, is this is in fact the case? Would a 1,595m reduction in the EU-ETS cap over 2021-30 be enough to deliver a 2030 cap consistent with a 55% EU-wide reduction while at the same time respecting the same relative burden for delivering this target between the EU-ETS and non-ETS sectors?

Again, the best way to answer this is by translating the 1,595m reduction in the Phase-4 cap into an equivalent LRF. In other words, at what level would the LRF have to be set from 2021 onwards in order to reduce the cap by a further 1,595m over 2021-30 relative to our effective post-MSR 2030 cap of 1,233m shown in Figure 31?

Figure 34 shows the answer. In order to reduce the cumulative volume of allowances by an extra 1,595m over 2021-30 versus our base-case analysis, the LRF would have to be set at 4% from 2021 onwards instead of the 2.65% implied under our base case, and the 2.2% at which it is actually still formally set.

Setting the LRF at 4% from 2021 would reduce the cap by 87Mt per year over 2021-30, compared with the annual reduction of 58.5Mt implied under our base case as a result of the MSR's impact, and the 48Mt still formally prescribed in the current legislation.

77 *It should be remembered that this residual surplus of 334m in 2030 relates only to the balance for fixed installations in the EU-ETS; As explained in section 2 of this report above, when the aviation sector is taken into account the residual cumulative balance for the EU-ETS on our numbers is negative in 2030 (-266m), which means there has to be abatement.*

This would result in a 2030 EU-ETS cap of 943Mt, which is 60% below the 2005 reference level of 2,339m (Figure 27).

Given that we are solving for an EU-wide 2030 target of 2,610Mt (i.e. -55% versus 1990), this gives an implied non-ETS cap of 1,668Mt. This means that under a -55% target, the non-ETS sector would have to reduce its emissions by 42% versus its 2005 reference level of 2,876m.

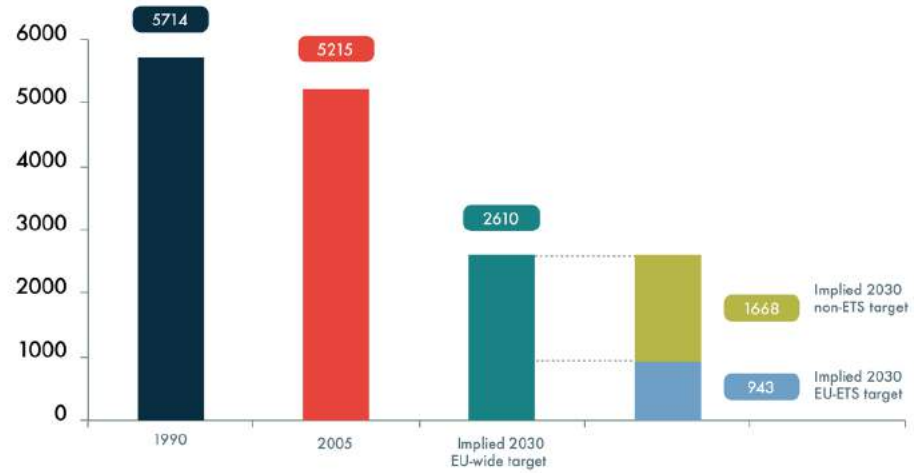
In turn, this means that the same ratio for apportioning the relative burden of reduction required under a -55% EU-wide target between the EU-ETS and non-ETS sectors is respected as under the current -40% target.

of reduction by 2030 against 2005 under the current -40% target is 1.43x (i.e. 43%/30%), and under a -55% target in our analysis above the ratio is also 1.43x (60%/42%).

Figure 35 then summarizes the actual and implied LRFs over 2021-30 under our three scenarios above. The actual 2020 cap of 1,816Mt provides the starting point for all three, but thereafter they diverge.

First, we have the 2.2% LRF under the existing 2030 EU-wide target of -40% This gets us to a 2030 EU-ETS cap of 1,333Mt.

Figure 34: CTI estimate of 2030 EU-ETS cap under a Paris-compliant EU-wide target (Mt)



Source: European Commission, CTI research estimates

As explained above, the ratio in the rate

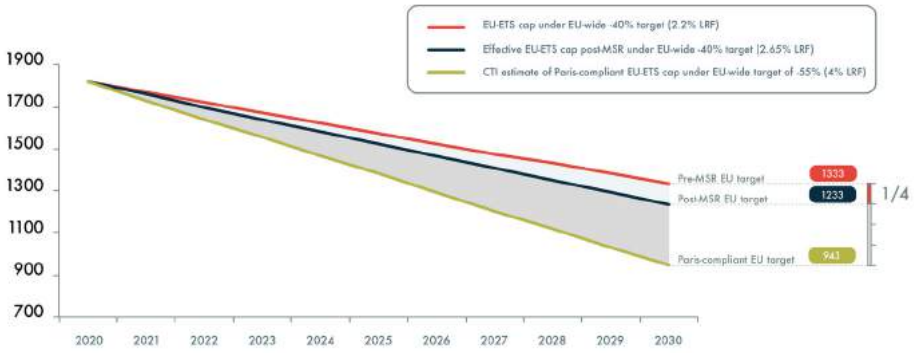
Second we have the 2.65% LRF implied by the impact of the MSR in our modelling of EU-ETS supply-demand dynamics over 2021-30.[78] This gives us an implied 2030 EU-ETS cap under our current base case of 1,233Mt.

Finally, we have the 4% LRF implied by our analysis of a Paris-compliant scenario for the EU-ETS under an EU-wide 2030 target of -55%. This gives us an implied 2030 EU-ETS cap of 943Mt.[79]

To summarize: our analysis of a Paris-compliant trajectory for the EU-ETS by 2030 based on the IEA's modelling of a Paris-compliant emissions trajectory for the EU power sector indicates that the recent EU-ETS reform – while removing nearly all of the surplus for fixed installations by 2030 that has accumulated since 2009 – is still far short of what would be required under a Paris-compliant scenario for the EU-ETS. Indeed, our analysis indicates that the MSR only gets us one quarter of the way towards where the EU-ETS cap would need to be set over 2021-30 under a Paris-compliant trajectory.

With all of this in mind, we now turn to a more detailed examination of our analysis and interpretation of the IEA's modelling of the EU power sector in its SDS.

Figure 35: LRF in EU-ETS under current legislation, together with CTI estimate of effective LRF on a post-MSR basis, and CTI estimate of a Paris-compliant pathway (2021-30)



Source: European Commission, CTI research estimates

78 *We say 'implied' because, as already explained, in reality the cap itself has not formally changed under the recent EU-ETS reform given that the MSR reduces EUA volumes via the withholding of EUAs from auctions, not via a simple reduction in the cap itself. Nonetheless, the impact of the MSR over 2021-30 is equivalent to what the impact of raising the LRF to 2.65% from 2.2% from 2021 would be.*

79 *We would note that an LRF of 4% from 2021 would see the EU-ETS cap drop to zero by 2041 compared with 2058 under the currently mandated LRF of 2.2% .*

Methodology: the IEA's Sustainable Development Scenario and the Paris Agreement

In its *World Energy Outlook 2017*, the IEA introduced for the first time the Sustainable Development Scenario,[80] and stated the following regarding the emissions trajectory it projects (WEO 2017: 134):

> *"By 2040, CO_2 emissions are in the Sustainable Development Scenario are at the lower end of a range of estimates drawn from the most recently publicly available emissions scenarios, all of which project a mean global temperature scenario by 2100 of between 1.7C and about 1.8C."*

The IEA's approach is to derive a CO_2 budget for the global energy industry from the IPCC's budget and allocate this between different regions and sectors to derive a Paris-compliant trajectory for global energy emissions.

Accordingly, the WEO 2017 sets out a Paris-compliant pathway for the EU power sector in the SDS over 2013-30 by attributing a budget of CO_2 emissions to EU generators that is materially lower over this period than the base-case carbon budget it attributes to the EU power sector under its base-case scenario (known as the New Policies Scenario, or NPS).

The WEO 2017 does not give numbers for every year over 2013-30, but from the numbers shown in Figure 36 below we can estimate the cumulative carbon budget for the EU power sector under the two different scenarios.

Figure 36: Imputed carbon budget for EU power sector in EU-ETS over 2013-30, IEA NPS & SDS (Mt)

	2013	2015	2016	2017	2025	2030	Imputed cumulative carbon budget, 2013-30
NPS	1,216	1,124	1,072	1,046	857	739	17,077
SDS	1,216	1,124	1,072	1,032	619	447	14,066

Source: IEA, WEO 2017. Also based on CTI research estimates

80 The SDS offers for the first time a holistic approach to three major energy issues, namely climate change, air pollution, and energy access for all. As such it is slightly different from the climate-focused scenario that the IEA had developed in previous editions of the WEO, known as the 450-scenario. That said, the 2017 WEO (page 131) makes clear that the 450-scenario remains the basis for its modelling of a Paris-compliant emissions trajectory under the SDS: "In terms of climate change, the point of departure is the WEO's established 450-scenario." In turn, this means that underlying the SDS modelling of a Paris-compliant emissions trajectory for the global energy industry is the carbon budget as calculated by the Inter-governmental Panel on Climate Change (IPCC) in its Fifth Assessment Report.

To calculate the cumulative carbon budget under each scenario, we simply interpolate values between the years for which the IEA discloses a number, assuming a linear trend between them. Using this linear-interpolation method we derive a carbon budget for the EU power sector under the NPS of 17,077Mt, and under the SDS of 14,660Mt. This means the delta between the IEA's base-case budget for the EU power sector over 2013-30 and its Paris-compliant scenario is 2.4Gt.

As it transpires, the carbon budget that we derive for the EU power sector in this way under the IEA's NPS is almost exactly the same as the volume of EUAs that we calculate as being earmarked for the power sector under the EU-ETS over the period 2013-30 under the current 2030 EU-wide -40% target (17,077Mt and 17,093Mt respectively).

However, and as already set out in our base-case modelling of EU-ETS dynamics over 2013-30 in section 1 above, this original EUA budget of 17,093m that constitutes our estimate of the carbon budget allocated to EU generators in the EU-ETS over 2013-30 then has to adjusted for two other factors that are not taken into account in the IEA's NPS: (i) the quota of CDM/JI credits allowed to the power sector over this period; and (ii) the impact of the MSR.

This gives us an adjusted carbon budget for EU power generators over 2013-30 of 16,225Mt, which is the number we have in our model as set out in our detailed analysis in Section 1 above. This means that comparing this number with our SDS-derived carbon budget for the EU power sector – i.e. 16,255Mt versus 14,660Mt – gives us the gap that would still need to be bridged by the EU power sector between now and 2030 under a Paris compliant pathway.

Accordingly, it is to a more detailed examination of this gap that we now turn.

Paris and the EU power sector: closing the gap

Figure 37 shows our calculations for the carbon budget for EU generators over 2013-30 on a pre- and post-MSR basis as derived from our EU-ETS model set out in Section 1 above.

For our purposes here, we define the carbon budget for the power sector as the amount of allowances earmarked for generators in the aggregate EU-ETS cap over 2013-30, i.e. the cap on emission for the EU power sector under the current EU-wide target to reduce emissions by 40% by 2030 versus 1990 levels.

In principle, this carbon budget for generators should be close to the number for total auctionable allowances in the EU-ETS over 2013-30, as in theory the power sector has to purchase all of its allowances via auctions over 2013-30, while many operators in the other industrial sectors covered by the scheme continue to receive a large proportion of their allowances for free all the way out to 2030.

In practice, however, it is difficult to derive a completely accurate number for the implied carbon budget for generators on this basis as the fit is not an absolutely perfect one.

Nonetheless, we think the pool of auctionable allowances available for purchase in the market over 2013-30 is close enough to serve as a good proxy for the initial budget of EUAs allocated to the power sector, and as shown in Figure 37, this gives an initial carbon budget for the EU power sector over 2013-30 of 17,093Mt, or 17.1Gt.

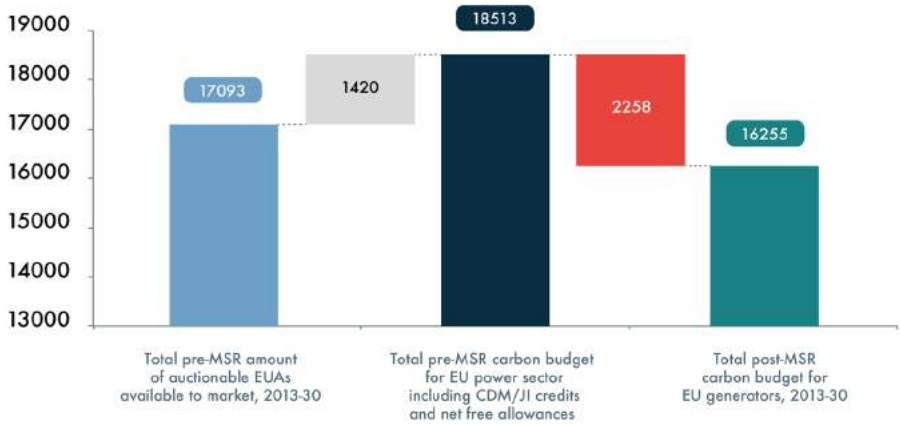
We then need to adjust this number to allow for the CDM/JI credits that the EU power sector is able to purchase and use for compliance purposes in the EU-ETS over 2013-30, which on our estimates comes to 920m. We also need to adjust for the net number of free allowances the power sector will still receive over 2013 as some eastern European generators continue to get free allocations even over Phase 4. We estimate this number at 500m.[81]

After making these adjustments, we derive a total pre-MSR carbon budget for EU generators over 2013-30 of 18.5Gt.

Finally, we need to adjust for the impact of the MSR, which, as set out in our detailed analysis shown in Section 1 above, removes 2,258m EUAs from the pool of auctionable allowances over the end of Phase 3 and the course of Phase 4: (i) the 900m EUAs back-loaded over 2014-16; (ii) the 1.51bn removed from auctioning volumes over 2019-23; and (iii) the 133m added back in 2029-30.

This gives us a total post-MSR carbon budget for the EU power sector over 2013-30 of 16,255Mt. Accordingly this is the number we have in our supply-side modelling of EU-ETS dynamics out to 2030 as per our analysis in Section 1 above.

Figure 37: CTI base-case total carbon credits available in EU-ETS on a pre- and post MSR basis (m)



Source: European Commission, CTI research estimates

81 *In other words, this represents our estimate of the net extra number of EUAs the EU power sector receives over 2013-30 beyond the pool of auctionable allowances. As such it is the difference between the free allowances still received by the power sector over 2013-30 on the one hand, and the allowances earmarked for other sectors from the auctionable pool on the other.*

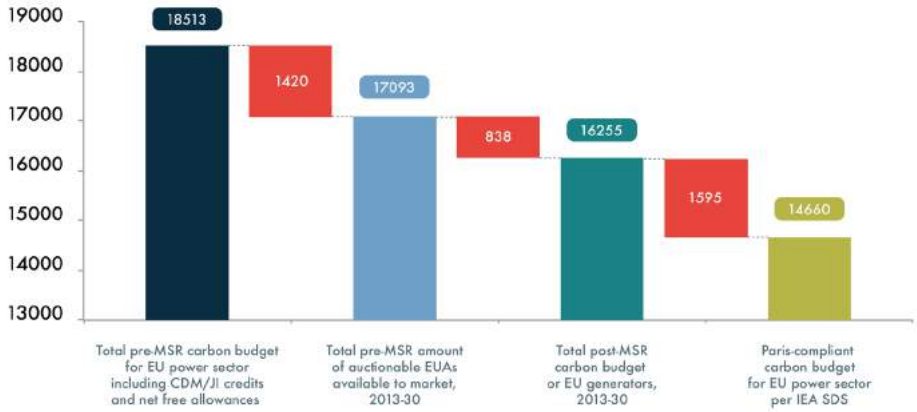
This is because there are exceptions in both directions: some power generators (especially in certain eastern European countries) will benefit from free EUAs over both Phase 3 and Phase 4, while many industrial operators in other sectors will have to bid for an increasing share of their allowances in auctions going forward.

So, how much tighter than this would a carbon budget for the EU power sector have to be in order to align with the Paris Agreement? Figure 38 shows our pre- and post-MSR carbon budgets for EU generators over 2013-30 under the existing EU 2030 emissions target, together with the carbon budget for the EU power sector that we estimate would be consistent with the Paris Agreement. To derive the latter – which comes to 14,660Mt – we take the IEA's SDS as published in its WEO 2017, as just explained above.[82]

The gap between the pre-MSR budget and the Paris-compliant carbon budget for the EU power sector over 2013-30 is 2.4Gt (i.e. 17.1Gt minus 14.7Gt). In turn, this means that the current carbon budget for the EU power sector out to 2030 even after taking the MSR into account is still 1,595Mt higher than it needs to be under a Paris-compliant pathway.

An EU-ETS cap consistent with the Paris Agreement would therefore require 1.6Gt of extra emissions reductions from power generators alone in the EU-ETS over 2021-30, or an extra 160Mt of abatement per year on average over Phase 4 of the scheme.[83]

Figure 38: CTI base-case total carbon credits available in EU-ETS on a pre- and post MSR basis, together with implied carbon budget for EU power sector under IEA's SDS (m)



Source: European Commission, CTI research estimates

82 *See the previous sub-section, Methodology: the IEA's Sustainable Development Scenario and the Paris Agreement.*

83 *As already explained above, if the Commission presents its proposal for a long-term strategy to reduce EU emissions in line with the Paris Agreement by Q1 2019 as per the Council's request of 22 March, the reality is that the earliest this could become EU Law would be 2021.*

This incremental abatement for the EU power sector over 2021-30 of 1,595Mt tallies exactly with the analysis we did on the EU-ETS as a whole above.[84] There we showed that in order for the 2030 EU-ETS cap to fall to a level consistent with an EU-wide target of -55% by 2030, incremental cumulative emissions reductions of 1,595Mt would be necessary versus our base-case analysis of EU-ETS dynamics out to 2030, which in turn would imply an LRF of 4% from 2021 onwards.

It is for this reason we conclude that the carbon budget for the EU power sector to 2030 under the IEA's SDS is consistent with a Paris-compliant cap for the EU-ETS as a whole over 2021-30.

And the SDS indicates that coal-fired generation would fall significantly over 2021-30 under a Paris-compliant EU-ETS cap.

A Paris-compliant carbon budget means much lower coal output in the EU

Below we look at the delta between the IEA's base-case scenario (i.e. the NPS) for the EU power sector's carbon budget over 2021-30 and the carbon budget for generators implied under its SDS, as well as the different generation profiles for coal and gas under these two scenarios.

As already mentioned above, the carbon budget for the EU power sector that we derive for 2013-30 under the IEA's NPS (17,077Mt) is almost exactly the same number as the volume of EUAs we ourselves estimate was originally allocated for generators under the EU-ETS cap over 2013-30. [85]

As such, the delta between the IEA's two scenarios shown below is almost exactly the same as the delta between our own estimate of (i) the original EUA-cap for the power sector over 2013-30 before adjusting for the allowed use of Kyoto credits and the MSR, and (ii) the IEA's Paris-compliant cap.

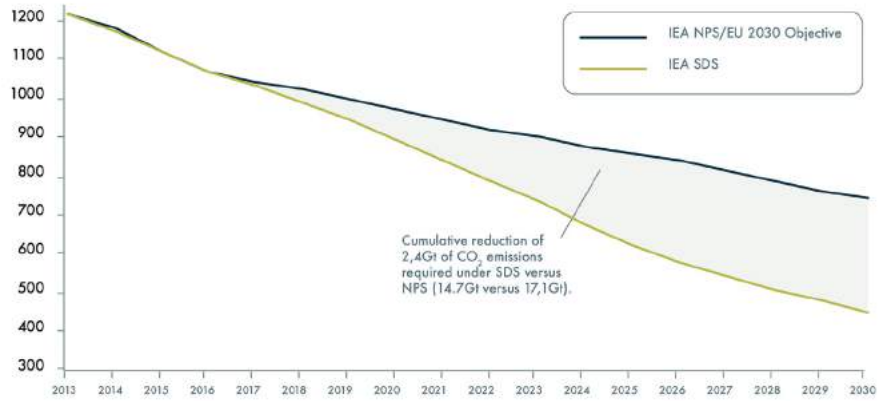
With all this in mind, Figure 39 shows our estimate of the total CO_2 emissions from the EU power sector over 2013-30 implied under the IEA's NPS and SDS.[86]

84 *See the earlier sub-section The Paris Agreement and the EU-ETS: gauging the gap to 2030*

85 *The difference between our own base-case modelling of the total supply of EUAs available to generators over 2013-30 (as set out in section 1 above) and the supply available under the IEA's NPS is that we have adjusted for two factors that the IEA does not take into account: (i) the allowed use of CDM/JI credits, and (ii) the impact of the MSR. This is why our current base-case carbon budget for the EU power sector over 2013-30 on a post-MSR basis is 16,255Mt, and not the 17,093Mt that we estimate was originally earmarked for the power sector to 2030.*

86 *The differences between the two IEA scenarios shown in Figures 39-42 here (in power-sector emissions, total FF output, coal-fired output, and gas-fired output) are all based on our linear-interpolation method explained above.*

Figure 39: Delta in EU power-sector carbon budgets between EA's NPS and SDS, 2013-30 (Mt)

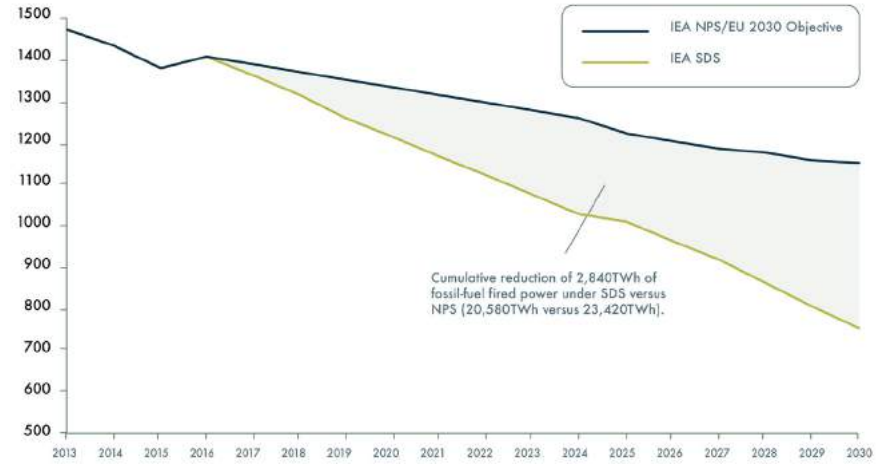


Source: Based on IEA data from the World Energy Outlook © OECD/IEA 2017, IEA Publishing. Licence: www.iea.org/t&c/termsandconditions. Also based on CTI estimates.

Figure 40 then shows total FF-fired generation under the IEA's two scenarios over the same period.

As can be seen, cumulative power-sector emissions over 2013-30 are lower by 2.4Gt under the SDS compared with the NPS, and total FF-fired power generation is lower 2,840TWh over the same period; also worth noting is that the overwhelming majority of the lower fossil-fired power generation and CO_2 emissions under the SDS happens after 2020, i.e. over Phase 4 of the EU-ETS.

Figure 40: Delta in EU power-sector's FF-fired output between IEA's NPS and SDS, 2013-30 (TWh)



Source: Based on IEA data from the World Energy Outlook © OECD/IEA 2017, IEA Publishing. Licence: www.iea.org/t&c/termsandconditions. Also based on CTI estimates.

Taking a closer look at the reduction in overall fossil-fired generation under the SDS, Figures 41 and 42 show the delta in coal- and gas-fired generation respectively under the two scenarios.

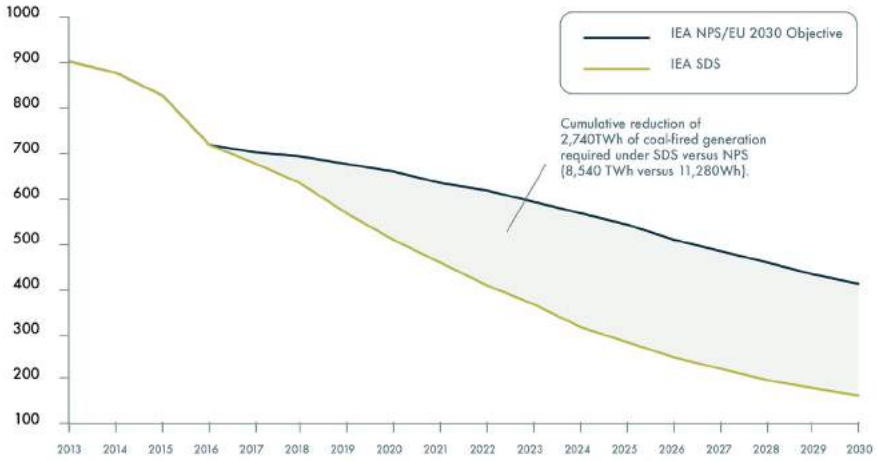
What is most striking is that whereas coal-fired output is materially lower under the SDS, total gas-fired output over the period is unchanged, although the distribution is slightly different under the SDS. Overall, our imputed numbers indicate that coal-fired output is lower by 2,740TWh under the SDS versus the NPS (8,540TWh and 11,280TWh respectively), while cumulative gas-fired production is 11,400TWh under both scenarios.

This means that all of the emissions reductions projected in the SDS against the NPS come from lower coal-fired power generation.

The final point we need to consider in all of this concerns the pricing implications of a Paris-compliant EU-ETS cap over 2021-30.

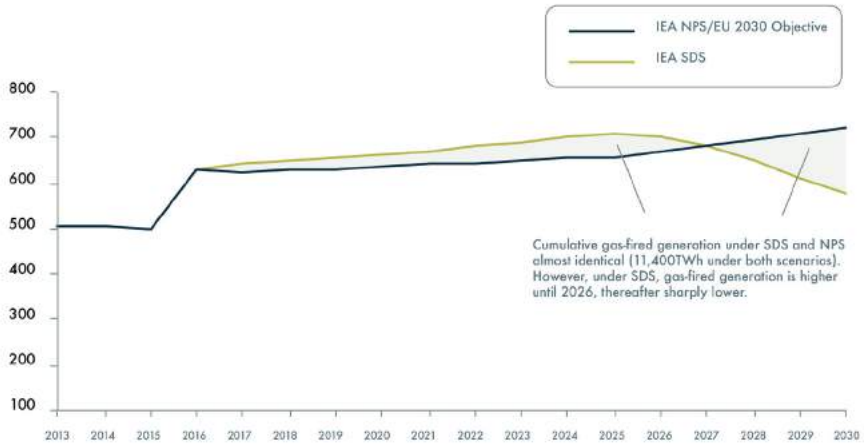
Given the very significant increase in abatement required in the EU-ETS over 2021-30 under a Paris-compliant cap (1,595Mt of extra reductions versus our base-case scenario), what would this imply for EUA prices over Phase-4 of the scheme if the EU were ultimately to align its 2030 target with Paris?

Figure 41: Delta in EU coal-fired power generation between IEA's NPS and SDS, 2013-30 (TWh)



Source: Based on IEA data from the World Energy Outlook © OECD/IEA 2017, IEA Publishing. Licence: www.iea.org/t&c/termsandconditions. Also based on CTI estimates.

Figure 42: Delta in EU gas-fired power generation between IEA's NPS and SDS, 2013-30 (TWh)



Source: Based on IEA data from the World Energy Outlook © OECD/IEA 2017, IEA Publishing. Licence: www.iea.org/t&c/termsandconditions. Also based on CTI estimates.

EUA-pricing implications under a Paris-compliant EU-ETS cap to 2030

We estimate that the impact of such a material increase in the physical abatement required in the EU-ETS on EUA prices would be very significant. Again, reiterating all the caveats already entered in Section 3 above around the difficulties of deriving firm projections for carbon prices given the number and nature of variables involved,[87] our modelling suggests to us an implied sustained average pricing range of €45-55/t over the whole of 2021-30 under a Paris-compliant cap as all fuel-switching options in the power sector would likely be needed.

Figure 43 represents our stylized representation of how the German FF merit order would look over 2024-28 for the range of lignite, coal, and CCGT plants we looked at in Section 3 above, with one crucial difference: as there is no forward curve to speak of for European coal and gas beyond 2021, we here assume fixed prices for coal and gas all the way over 2024-28, taking the values for coal and gas currently shown for 2021 on the forward curve that we gave in Figure 21 above ($74.3/t for coal, and €16.6/MWh for gas). We also assume that EUA prices rise from €40/t to €60/t over the period.

87 *Indeed, all the more so here given the extra uncertainties created by the significantly higher levels of required abatement that we project would be needed under a Paris-compliant cap.*

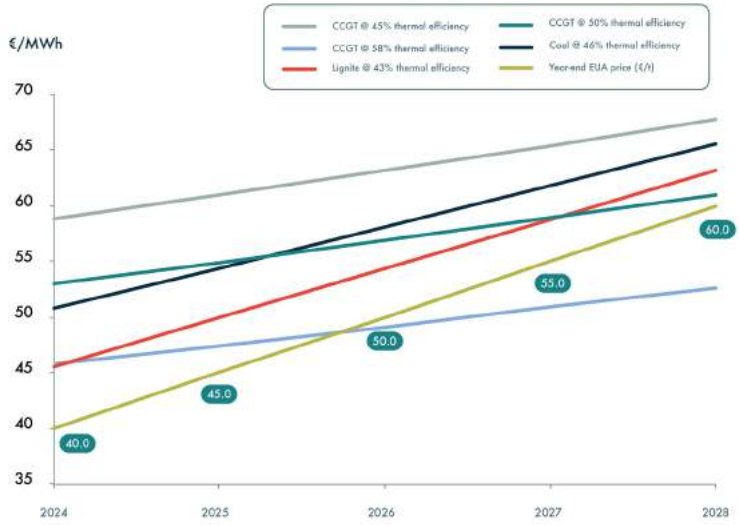
Given that under this scenario a 50%-efficient gas plant would almost certainly have to displace even the very limited number of 46%-highest-efficiency coal plants, and also the 43%-highest-efficiency lignite plants, we estimate that EUA prices would likely have to average €45-55/t under a Paris-compliant scenario.

As can be seen, the 58%-efficient CCGT is already running ahead of a 43%-efficient lignite plant from a carbon price of €40/t, while by contrast the 45%-efficient CCGT is still uncompetitive against both 43% -lignite and 46% coal even at a price of €60/t.[88]

Meanwhile, the average-efficiency 50% CCGT displaces 46%-efficient coal between €45-50/t, and then displaces 43%-efficient lignite at €55/t.

Assuming that fuel switching between CCGT plants with efficiency rates of 50% or more and all coal and lignite plants – i.e. even the most efficient coal and lignite plants with efficiency rates of 46% and 43% respectively – would be needed, we derive an implied indicative average pricing range for EUAs over 2021-30 under our Paris-compliant cap of €45-55/t.

Figure 43: Stylized German merit order for FF generators over 2024-28 with a range of CCGT efficiency rates, and with EUAs rising to €60/t by year-end 2021



Source: Bloomberg, CTI research estimates

88 *From which it follows that if abatement from 45%-efficient CCGT plant displacing 46% coal or 43%-lignite were needed under a Paris-compliant cap, the EUA price would have to go even higher than €60/t (on our estimates to €68-70/t).*

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