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Review of the EU ETS Market Stability Reserve

Final report

Vivid Economics
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Executive Summary

This report reviews the performance of the Market Stability Reserve (MSR) and considers how the design of the MSR can be made fit for the future. It considers the historical performance of the MSR since it began operation in 2019, and how it is expected to perform given the rapid changes in the EU ETS market. It also identifies the key drivers, uncertainties and risks to future MSR operation, and what potential changes to the MSR design parameters would best address these risks.

The findings and recommendations outlined in this report are a result of independent work by Vivid Economics, and do not reflect the views of the European Commission. This review was commissioned as required under Decision 2015/1814 of the European Parliament and of the Council.[1] Vivid Economics carried out an independent assessment of the past performance of the MSR and its likely performance given scenarios for future policy and market developments to arrive at recommendations. These recommendations will be considered as part of a wider Green Deal package and should not be interpreted as indicators of future policy direction.

The MSR was legislated in 2015 and began operating in 2019 to help ensure the orderly functioning of the EU ETS market. The MSR operates according to pre-defined rules that intake allowances into the reserve in times of oversupply and release allowances from the reserve in times of undersupply, as measured by the total number of allowances in circulation (TNAC). The MSR was designed to address the historical build-up of emissions allowances and to make the EU ETS more resilient to economic shocks and other future events that could disrupt market stability.

This review is taking place against the backdrop of the 2030 Climate Target Plan announced in September 2020 and the planned larger revision of the European Union (EU) Emission Trading System (EU ETS) in 2021. The EU is increasing its climate ambition, with plans for a more stringent emissions reduction target as part of the European Green Deal. The EU's ambitious climate plan aims to cut GHG emissions by at least 55% by 2030 and reach net zero emissions by 2050. As it considers its broader climate policy mix, this may also involve other changes such as an expansion of the scope of the EU ETS and the potential introduction of a Carbon Border Adjustment Measure (CBAM). These changes will affect the functioning of the MSR and might in turn require changes to its design.

The operation of the MSR is inherently complex, influenced by a wide range of policy and behavioural drivers which require a broad analytical toolkit. Recognizing this complexity, the review has sought to draw on a wide range of quantitative and qualitative evidence in developing its conclusions. In addition to a series of modelling analyses performed specifically for this review, additional evidence was sought from the academic literature, market analysts (such as ICIS, BNEF, Refinitiv) and industry experts. The review also analysed wider opinion collected both from the European Commission's open public consultation and from a survey of compliance entities, which received over 900 responses.

The MSR has functioned well to date, however a changing market and policy environment brings uncertainty for the future. The changing environment means that new tests to market stability are on the horizon, particularly as we move into a period of increased scarcity of EU allowances. Further, uncertainty regarding key aspects of market functioning, including the allowance hedging needs of industrial participants, may require a revision to MSR parameters. Meanwhile, the current COVID-19 pandemic illustrates the need for the MSR to continue to deal with demand shocks more broadly. The changing policy environment and specific factors that could affect MSR functioning are laid out in Section 2.3.

[1] Article 3 of Decision (EU) 2015/1814 of the European Parliament and of the Council of 6 October 2015 concerning the establishment and operation of a market stability reserve for the Union greenhouse gas emission trading scheme and amending Directive 2003/87/EC ("the MSR Decision").

Box 1 provides an overview of the findings from this report, and the next sections delve into the historical performance and options for future design in more detail.

Box 1 Summary of findings

- **The MSR is delivering on its objective of reducing the historical surplus of allowances in the EU ETS market.** The placement of 'backloaded' allowances into the MSR holding account, alongside ongoing intakes from auctions to the MSR, has contributed to a 29% reduction in the TNAC from its high in 2013 to the 2019 level.

- **The MSR has contributed to the resilience of the EU ETS following the COVID-19 economic shock.** There is some agreement amongst market analysts, traders, and academia that the perceived likelihood of increased climate ambition was responsible for the price increase within the EU ETS in recent years. The MSR helped to reinforce this perception but was not the primary driver.

- **Existing evidence suggests the MSR has had minimal negative impacts on competitiveness.** Academic and policy studies to date have found the EU ETS has likely had minimal negative competitiveness impacts for industry. Analysis of the MSR's impact on prices and competitiveness conducted in this review found the MSR's impact on competitiveness is likely to be minor, with diffuse impacts between and within trade exposed sectors.

- **Changes are needed to ensure the MSR remains fit for purpose.** In the face of a changing policy and market environment, adjustments to the functioning of the MSR are necessary. Improvements have been identified across each aspect of MSR design, including the definition of the TNAC, threshold levels, intake and release mechanisms, invalidations, and the potential role of short term response measures.

- **Dynamic market environment in which the MSR operates means that regular reviews will be necessary.** Given this changing environment, reviews of MSR operation every three years, with subsequent reviews in 2024 and 2027, appear appropriate.

The performance of the MSR to date

The MSR is delivering on its objective of reducing the historical surplus of allowances in the EU ETS market. The MSR's first adjustments to auctioning volumes began in 2019, with two waves of intakes from January to August 2019 (265 million allowances) and from September 2019 to August 2020 (397 million). Another wave of intakes is currently taking place from September 2020 to August 2021 (308 million).[2] These adjustments build on the backloading of auction volumes in 2014, 2015 and 2016, of 400, 300 and 200 million allowances respectively, that were subsequently transferred to the MSR holding account. The combination of these measures, along with other market reforms, has meant that annual allowance supply has been less than verified emissions for every year of Phase 3, with the exception of 2013. This has reversed the growth of the allowance surplus, with the 2019 allowance surplus 29% lower than its 2013 peak.[3] Despite this reduction in surplus, the total number of allowances in circulation (TNAC) remains above the desired threshold level, with the MSR expected to continue reducing the persistent historical surplus of allowances in coming years.

In 2018, the price of EU allowances began to recover from the low levels reached in the earlier years of Phase 3 of the EU ETS. The MSR has been one of several drivers of price increases, with a range of market reforms between 2015 to 2018 restoring confidence in the EU ETS and underpinning a corresponding rise in allowance prices. This represents a marked change from the early years of Phase 3 of the EU ETS, when a

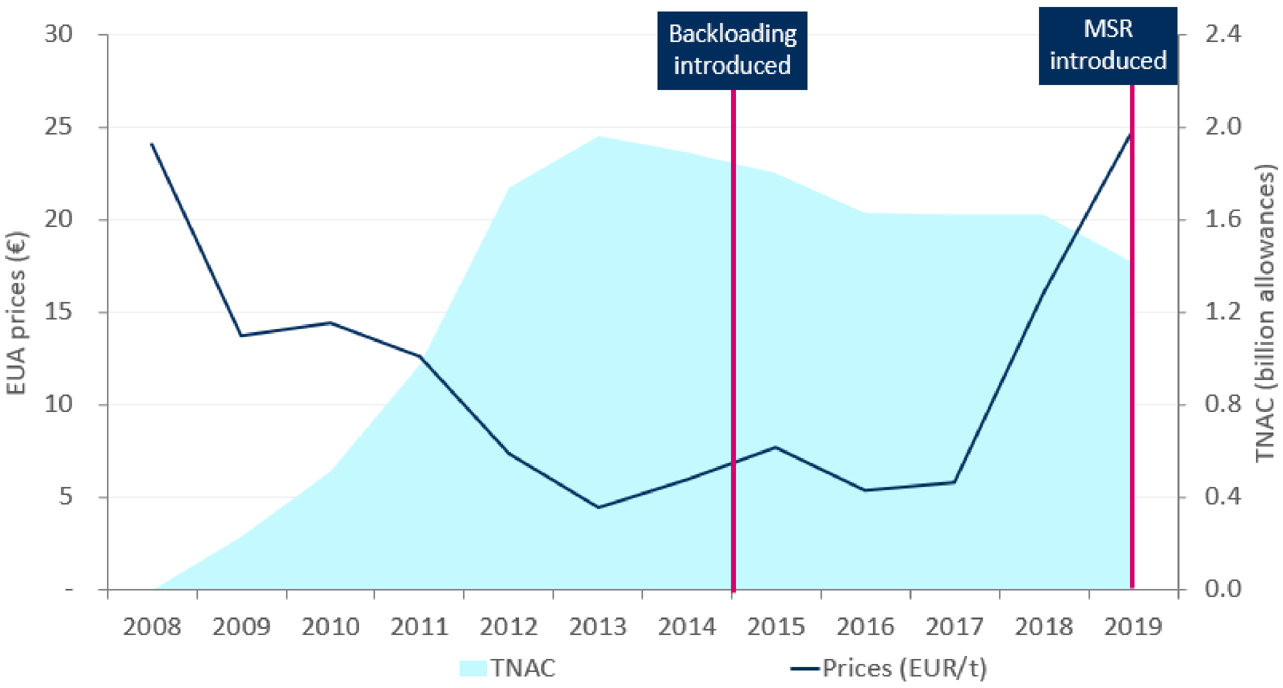
[2] Original published amount of 333 million (May 2020) adjusted to 307.7 million due to Brexit auction volume adjustment notice: see legal notice https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020XC1211(07)&from=EN

[3] https://ec.europa.eu/clima/sites/clima/files/ets/reform/docs/c_2020_2835_en.pdf

build-up of the allowance surplus shook market confidence and saw a significant fall in prices, declining to lows of under €5/tCO_2e in 2013 and persisting below €10/tCO_2e until 2018. This weak price signal undermined incentives to mitigate emissions and invest in low-carbon technologies.

While the MSR has played an important role in restoring market confidence by lowering short term allowance supply, it cannot be credited with the full price increase that began in 2018. The MSR has an impact on allowance price through its ability to adjust allowance supply through auction volumes, and hence medium-term allowance scarcity. However, other changes to the market including backloading, the addition of the MSR invalidation mechanism, the restrictions on international credits, and announced changes to the linear reduction factor all contributed to market confidence, the perception of scarcity, and corresponding price rises.[4] The MSR is one of a range of determinants of allowance prices, which respond to perceptions of scarcity both today and in the future.

Figure 1 Allowance Price Evolution Compared to the TNAC



Note: EU allowance Prices (€) (LHS); TNAC (billion allowances) (RHS)
Source: Vivid Economics based on European Union Transaction Log, ICAP/EEX

The demand shock caused by the COVID-19 pandemic represents the first major test to market stability since the MSR's introduction. The COVID-19 pandemic has seen GHG emissions fall alongside reduced energy consumption, industrial production, and travel. This is likely to translate to significantly reduced demand for allowances, putting upward pressure on the TNAC, and resulting in larger MSR intakes. As such, the MSR will continue to address the historical surplus while simultaneously responding to the impact of the demand shock stemming from the COVID-19 pandemic.

The COVID-19 demand shock is one example of how the MSR enhances the resilience of the EU ETS by adding flexibility to the market cap. The EU ETS cap is determined well in advance of the trading period and cannot be easily modified to respond to unexpected events and circumstances. The MSR adds flexibility to the allocation of allowances by automatically adjusting auction volumes when the number of allowances in

[4] https://www.pik-potsdam.de/en/institute/departments/transformation-pathways/research/climate-and-energy-policy/events/quemin

circulation is too high or too low, as can occur because of market shocks or other exogenous events. In this way, the MSR adjustments to allowance supply in response to a demand shock can better align supply with demand.

However, the MSR's initial reaction to market shocks is delayed and partial, with the MSR design necessitating several years of adjustments following a shock. The MSR is triggered by the TNAC calculation which is published in May the year following a given shock, with adjustments taking place from September to the end of August of the following year (the initial adjustment is not complete until at least one year and 8 months after the shock). The initial adjustment absorbs only a proportion (24% currently, 12% from 2024) of the shock's incremental impact on the TNAC.[5] With an intake rate of 24% (12%), it takes 3 (5) years for the MSR to absorb half of the initial shock, assuming ongoing intakes.

Nonetheless, by changing future supply expectations, the MSR cushions price impacts in the short term that could have resulted from the demand shock. Although the MSR's mechanistic effect on auctions occurs gradually over time, market participants anticipate this future reduction in the supply of allowances. Since the MSR's adjustment to auctioning volumes are transparent to market participants, they will be built into market expectations of future supply. The magnitude of this effect is dependent on the extent to which regulated entities, investors, and other market participants are forward looking and account for the impact of the MSR on future supply. For instance, over 32% of surveyed covered entities will increase their hedging volume if they expect an increase in future allowance prices. This type of forward looking response helps to cushion allowance prices from a given demand shock.[6]

The MSR's invalidation mechanism (introduced in the 2018 revision) made market adjustments permanent rather than temporary, which introduces uncertainty regarding the MSR's impact on overall policy ambition. The invalidation mechanism will apply from 2023 and will permanently invalidate allowances held in the MSR in excess of the previous year's auction volumes. This impacts the overall supply of allowances on the market by reducing the overall emissions budget available to EU ETS sectors.[7,8] Currently, MSR holdings continue to grow, and will stand at almost 1.6 billion allowances by 31 August 2021 with further intakes expected to occur through to 2023. In addition, unallocated allowances will also be transferred to the reserve.[9] There are range of estimates of the potential scale of invalidations with market analysts' expectations ranging from 1.7 billion to 2.4 billion allowances in 2023. [10,11] The ambiguity around the total number of invalidations is flagged as an area of regulatory uncertainty for market participants.

Existing literature is limited in its discussion of competitiveness or carbon leakage impacts related to the MSR, however impacts are expected to be minor. Existing literature has found little or no carbon leakage impacts from the EU ETS to date, with initial phases characterised by low EU allowance prices and high rates of free allocation. Analysis conducted for this review supports this outcome. Using a competition model, analysis in Section 3.2.3 finds that the MSR's impact on emissions-intensive and trade-exposed (EITE) industries' competitiveness through increasing EU allowance prices is likely to be minimal. The MSR has been only one of several factors that have contributed to allowance price rises in recent years and as such its impact on competitiveness is minimal. Moving forward, the MSR's impact on competitiveness, growth and jobs will be subsidiary to decisions on the stringency of the system (as defined through cap-rebasing and the LRF) and design options such as free allocation or a potential carbon border adjustment mechanism.

[5] The exception is when shocks occur when the TNAC is within the threshold levels, in which case the MSR will not respond.
[6] To be precise, the absolute number of forward looking market participants do not matter, as long as the ones that are forward looking have sufficient capital to trade in the market based on this conviction.
[7] https://ideas.repec.org/p/hhs/nlsseb/2020_004.html
[8] Perino, G. (2018). New EU ETS Phase 4 rules temporarily puncture waterbed. Nature Climate Change, 8(4), 262-264.
[9] This concerns allowances from Phase 3 that remained unused in the new entrants' reserve and allowances that were not handed out to installations because they stopped operations (closures) or reduced their production (partial cessations) https://ec.europa.eu/clima/policies/ets/reform_en
[10] Perino and Willner (2017)
[11] https://www.i4ce.org/wp-core/wp-content/uploads/2019/05/2019-State-of-the-EU-ETS-Report.pdf

Future risks to MSR functioning

The MSR has worked well until this point, but there are several limitations and risks to this performance going forward. These include:

- **The TNAC currently excludes some sources of allowance demand and supply, and as such is an incomplete measure of market balance.** Measured TNAC demand includes verified emissions from stationary installations and voluntary cancellations but excludes demand from the aviation sector and linked markets. Measured TNAC supply excludes EU aviation allowances and supply from linked markets. As such the TNAC is currently a partial measure of market balance, which will become of increasing importance if not rectified. Over time small annual differences will accumulate to represent large cumulative volumes. By 2019, the exclusion of aviation demand and supply from the TNAC calculation increased reported TNAC volumes by 150 million allowances. Further changes in the broader policy and economic environment may affect the extent to which the TNAC maps against actual market balance.

- **Changing patterns of allowance demand may mean that current thresholds no longer reflect an appropriate range needed to maintain market balance.** Since the MSR was established, demand for allowance banking has changed and will continue to evolve through Phase 4 of the EU ETS, driven by increasing EU allowance prices and decarbonisation trends. Estimates of hedging demand from utilities are projected to decline, while hedging demand from industrials and demand for holdings from non-compliance entities are much less certain. As a result, the current thresholds for MSR interventions may no longer reflect the range needed to maintain market balance.

- **Small changes in the TNAC can lead to significantly different MSR responses due to discontinuous thresholds ('threshold effect').** For instance, a TNAC of 830 million allowances in 2023 would not trigger intakes into the MSR, while a TNAC of 835 million allowances would lead to intakes of over 200 million allowances (at a 24% intake rate), which represents over 20 percent of expected auction volume in 2023. Similarly, for a TNAC just above the lower threshold, no allowances are released from the MSR, while a TNAC slightly below the lower threshold triggers releases of 100 million allowances. These variable dynamics can lead to fluctuations in auction supply and prices, introducing uncertainty and potentially reducing abatement activity. Additionally, because these threshold effects can lead to significant differences in MSR action (or inaction), small errors in TNAC calculations (for instance, using data that is subsequently corrected) could result in large changes in outcomes if the TNAC is incorrectly above or below the upper or lower threshold.

- **Invalidation quantities are indirectly affected by the intake and release mechanism.** The current invalidation mechanism invalidates all allowances held in the MSR above the previous year's auction volume. Under this design, invalidation depends on auction volumes, which can be altered by external policy decisions or the operation of the MSR itself. The invalidation quantity is affected by policy changes such as a phase out of free allocation, where an increase in auction volumes would lead to fewer invalidations. The invalidation quantity is also affected by fluctuations in auction volumes due to the intake and release mechanisms. As such, anything that impacts the MSR's intakes and releases (for instance, changes to emissions from economic events) would alter the number of allowances that are auctioned and subsequent invalidations. This interaction adds unnecessary complexity to the system.

- **In some circumstances, the MSR may lead to counterproductive interventions when the TNAC changes due to market participants' anticipation of future events.** The MSR does not distinguish between reasons for changes in the TNAC. The assumption implicit in the current MSR design is that a high TNAC reflects a market with a surplus of allowances, and a low TNAC reflects a market where the scarcity of allowances could undermine the efficient functioning of the market. However, there may be situations where changes in the TNAC reflect more complicated dynamics. For example, an anticipated reduction in future supply (for instance, due to an increased LRF) would likely lead to an increase in the TNAC, as firms look to bank more allowances and reduce emissions in anticipation of higher ambition. Conversely, if EU allowance demand is anticipated to fall due to complementary climate policies, firms may bank fewer allowances and emit more, reducing the TNAC. In these cases, the changes in TNAC are a result of forward looking behaviour of compliance entities. As a result, MSR intervention may be counterproductive, for instance removing supply from an already tight market when banking has increased in anticipation of future scarcity. This risk is contingent on market behaviour, including compliance entities choices regarding hedging and allowance banking, and financial participants decisions to hold allowances as long term investments.

- The MSR was primarily designed to reduce excessive market surplus in the long run. However the MSR indirectly mitigates various shocks to prices (such as supporting market confidence against a sudden drop in expected future demand during the COVID-19 pandemic), while its effect is often partial and depends on the size, duration, and direction of the shock.
- **A rapidly evolving policy, technology and market environment may interact with the MSR in complex and unexpected ways**. The operation of the MSR is influenced by a range of uncertain and inter-related factors including market sentiment, hedging strategies, technological development, abatement costs and the efficacy of overlapping policies. Additionally, new phenomena such as potential anticipatory banking or large scale holding from non-compliance entities would benefit from close monitoring in the medium term as it is difficult to predict how important these dynamics may be going forward.

The future design and operation of the MSR

An evolving policy and market environment will pose additional risks to MSR functioning, and necessitate changes to its design. The EU is increasing its climate ambition, with a more stringent emission reduction target as part of the European Green Deal. Potential policy changes that would impact the functioning of the MSR include the tightening of the EU ETS cap, the potential introduction a CBAM, and changes in the scope of the ETS. These changes will alter the size of the market, composition of market participants and subsequently the market balance. It is also likely that the composition of demand for EU allowances will change significantly over the next decade, due to the decarbonisation of the power sector, potentially more active engagement from industrial emitters, and growing interest in EU allowances as an investment asset from the financial sector. Similarly, aviation may become a more significant source of demand, depending on the scale and timing of the sector’s recovery from the economic impacts of COVID-19. This requires a consideration of the wide range of potential changes that could affect MSR operation.

This report identifies seven key recommendations to address the risks posed by the changing market environment. These issues are summarised in Figure 2, and discussed in turn below.

Figure 2 A summary of recommendations to address future risk to MSR functioning

Risks to MSR functioning	Recommendations
The TNAC is an incomplete measure of market balance	Update TNAC definition to cover all sources of supply and demand
Thresholds may not reflect supply needed to maintain market balance	Revise thresholds and implement a declining trajectory
Small changes in the TNAC can trigger a disproportionate response	Update intake mechanism to respond to marginal surplus (TNAC minus upper threshold)
Invalidations unnecessarily linked to auction volume and MSR actions	Link invalidation mechanism to lower threshold instead of auction volume
Counterproductive MSR interventions in some scenarios	Freeze intakes/releases given counterproductive interventions
The MSR is unable to respond to extreme prices	Consider strengthening short-term response measures
Unforeseen risks from changing policy and market environment	Implement more frequent MSR reviews

Source: Vivid Economics

The TNAC definition should be amended to consider all sources of supply and demand. Measured TNAC demand includes verified emissions from stationary installations and voluntary cancellations but excludes demand from the aviation sector and linked markets. Measured TNAC supply excludes EU aviation allowances and linked markets. If left uncorrected, the measured TNAC and the actual number of allowances available to the market may continue to diverge, particularly if the aviation sector continues to grow in size or the EU ETS links with more systems. As a result, this review recommends that the TNAC definition account for all current and future sources of allowance supply and demand.

Thresholds should be set at new levels which take changing hedging demand into account and decline with the cap to reflect declining market size. Hedging demand has fallen since the MSR was introduced and is likely to further decline over the course of Phase 4. A reduction in the upper threshold from 833 million allowances to 700 million allowances from 2024 is recommended to reflect this decline, while the lower threshold should remain at 400 million allowances. Both thresholds should decline in line with the cap after 2024, to capture the fact that the market is reducing in scale, and the appropriate threshold level is changing. Note that policy changes currently being considered by the Commission would affect the appropriate threshold level. Significant broadening of the ETS scope (for example by covering sectors such as transport or buildings) would considerably increase the size of the market and change hedging dynamics. The potential introduction of a CBAM is likely to increase the share of allowances auctioned compared to those allocated as free allowances, which could lead to a large increase in industrial hedging demand.

The intake mechanism should be updated so that the quantity of intakes is proportional to the amount by which the TNAC exceeds the upper threshold (the 'marginal surplus'). The current design results in threshold effects that could create price uncertainty. Adjusting the intake mechanism such that intakes gradually ramp up with the size of surplus would remove these effects. This review recommends changing the intake mechanism such that it removes 33-50% of the marginal surplus. This ensures that the size of the intake is small when the TNAC is just above the threshold and increases with larger surpluses, avoiding sharp jumps in MSR intakes when the TNAC is around the upper threshold.[12] This review recommends leaving the release mechanism unchanged until 2024, and from 2024 reducing the quantity of allowances release in line with the decline in the cap. Given the unlikely but severe implications of a liquidity shortage, retaining the ability to release a relatively large number of allowances was considered appropriate.

The invalidation rule should be simplified. The current invalidation rule introduces complex and unnecessary interactions between auction volumes, invalidations and MSR intakes. This review recommends replacing this with a simpler rule, that invalidates allowances held in excess of the lower threshold (equivalent to four years of releases from the MSR under proposed the recommendations on release mechanisms and lower thresholds). This would lead to a declining MSR stock given declining lower thresholds, while ensuring that at least four years of releases from the MSR remain available to assure liquidity.

The review also recommends a range of provisions that respond to the changing nature of the market. This includes provisions to stop counterproductive interventions, potential adjustments to safeguard against excessive prices and frequent reviews to account for changing market circumstances. The likely tightening of the EU ETS cap over Phase 4 is expected to fundamentally change the market from one with a persistent surplus to one of scarcity. In the medium term, this could lead market participants to bank a larger number of allowances in anticipation of future increased policy ambition. This could include higher levels of banking and emissions reductions from covered entities, as well as increased holdings from financial sector participants as long term investments, ultimately resulting in the concurrent increase in prices and the TNAC. This creates specific risks from the counterproductive functioning of the MSR.

Counterproductive MSR interventions should be stopped through a 'freeze' provision, which would pause ongoing MSR intakes (releases) given evidence of market scarcity (surplus), with price-levels used as an indicator of these states. A freeze could take effect once average auction prices are above €80 (below €35) for a month, with the freeze continued for two months after average auction prices have fallen below (risen above) this price level. The upper threshold of €80 has been identified to reflect a point beyond which short term abatement options are expected to tail off, meaning that EU allowance price increases are unlikely to incentivise additional abatement in the short term, except by reducing firms' production levels.[13] The lower threshold of €35 has been chosen to reflect the price level at which most fuel switching takes place.[14] Fuel switching is a relatively responsive form of abatement and the existence of unutilised opportunities for fuel switching would indicate that additional releases are not needed. Over time these price levels could be adjusted based on emerging evidence regarding this appropriate level.

It is important to note that a freeze provision does not target a certain price outcome, using price only as an indicator of when MSR interventions may be counterproductive. In situations where the TNAC is within the upper and lower thresholds, a freeze provision will have no impact regardless of the resulting price level. Similarly, should prices exceed (fall below) the upper price trigger while releases from (intakes to) the MSR are continuing, no action would be taken as the direction of the MSR intervention is consistent with the identified market scarcity (surfeit). As the freeze provision merely stops the MSR from intervening when it

[12] For example, suppose the TNAC crosses the upper threshold by 2 million allowances (i.e. the TNAC is 835 million allowances). Under the current design, the MSR will intake over 200 million allowances (24% of 835 million). Under the proposed marginal surplus approach, it would intake 1 million allowances at most (50% of the 2 million marginal surplus). If the TNAC crosses the upper threshold by 500 million allowances (i.e. the TNAC is 1,333 million allowances), the current mechanism would intake approximately 320 million allowances while the marginal surplus approach would intake a maximum of 250 million allowances. This dynamic is illustrated in Figure 23 on page 64.
[13] Based on industrial abatement cost estimates from ICIS and Refinitiv. In a list of 35 abatement technologies in industrial sectors which are technically feasible by 2025, 60% are cost-effective for a price of €80, up from 42% at a price of €60.
[14] Based on estimates for the range of EUA price for fuel-switching developed by ICIS and BNEF

may be harmful to market functioning and does not target specific prices, this may reduce risks of triggering the unanimity requirement.[15] Implementing a freeze provision is likely to require a change to provisions regarding the publishing of auction volumes, which are made available in advance of the auctions.[16]

Additional short term response measures could be considered to address excessively high or low prices. Article 29a of the EU ETS allows for intervention if prices reach an excessive level for a prolonged period. Specifically, it allows intervention if allowance prices exceed three times the average price of the past two years for six consecutive months. Given recent prices, this rule would require sustained high prices for an extended period, which could cause considerable undesirable impacts. As such changes that would reduce the threshold for Article 29a intervention and increase its responsiveness may be desirable, particularly if a freeze provision is not implemented. Similarly, the introduction of an auction reserve price could be considered to reduce the potential downside price risk facing covered entities investing in mitigation projects. However, given the increased ambition of the EU ETS, risks of market oversupply are likely less than in earlier Phases of the EU ETS.

Finally, while these recommendations will make the MSR operation more robust to a wide range of potential circumstances, more regular reviews may be required due to the rapidly evolving market landscape. The operation of the MSR is influenced by a range of uncertain and inter-related factors including market sentiment, hedging strategies, technological development, abatement costs and the efficacy of overlapping policies. Additionally, new phenomena such as potential anticipatory banking or large scale holding from non-compliance entities would benefit from close monitoring in the medium term as it is difficult to predict how important these dynamics may be going forward. The current review relies on a thorough analysis of information from a wide range of sources, but there is a need for regular monitoring to ensure its assumptions and theoretical frameworks are borne out in practice. Given the pace of market and policy evolution, more frequent reviews (every three years) are appropriate.

Table 1 summarises the recommended changes to MSR design and their rationale.

Table 1 Recommendations for the design of the MSR

Design option	Current design	Recommended design	Rationale
TNAC definition	TNAC currently does not capture all sources of allowance demand and supply, including from aviation and linked markets	Revise the TNAC definition to capture all sources of allowance demand and supply in the EU ETS and linked markets, including aviation and the Swiss ETS	Capturing all sources of demand and supply ensures MSR operations reflect true market surplus
Upper threshold	833 million allowances	Reduce the upper threshold to 700 million in 2024, after which it declines in line with the overall emissions cap	The reduction to 700 million reflects a reduction in estimated hedging demand, and a declining path captures ongoing reductions in expected hedging demand
Lower threshold	400 million allowances	Maintain the lower threshold at 400 million	400 million remains below current estimates of hedging

[15] Art 192(2) TFEU stipulates that all fiscal measures require unanimous approval from the Council of the European Union. However, as a purely environmental policy, the EU ETS (including the MSR and Article 29a provisions) have not triggered this requirement. The freeze provision is not intended to control prices, but instead to aide market functioning and reduce unnecessary intervention.

[16] To provide transparency and avoid delays to the implementation of the freeze, the auction calendar could be amended to publish contingent volumes – one under normal operation, and another in the case that the freeze is triggered. This would likely require legislative and regulatory changes, which could be implemented as part of the wider legal and design changes required as part of the Green Deal update.

Design option	Current design	Recommended design	Rationale
		allowances to 2024, after which it declines in line with the overall emissions cap	demand, which is gradually reduced to reflect the declining ETS market
Intake mechanism	12% of TNAC, doubled to 24% until 2023	Set intakes at between 33-50% of the difference between the TNAC and the upper threshold value (the 'marginal surplus')	Removing threshold effects reduces the risks of volatility; a higher intake rate increases the responsiveness of a given MSR design to shocks
Release mechanism	100 million allowances, doubled to 200 million until 2023	100 million in 2024, after which it declines in line with the overall emissions cap	Maintaining a discrete release mechanism limits the risk of supply shortages; reducing releases in line with the ETS cap ensures they are proportional to overall allowance supply
Invalidation mechanism	From 2023, invalidate allowances above the previous year's auction volume	From 2023, invalidate allowances above the lower threshold (equivalent to four years of releases from the MSR under the recommendations in this report)	This rule will lead to a steadily declining MSR stock, while ensuring that at least four years of releases from the MSR remain to provide liquidity if triggered.
Freeze mechanism for intakes and releases	None currently included	When average auction prices exceed €80 (fall below €35) for a month, intakes to the MSR (releases from the MSR) are stopped until prices return below (above) the threshold for two months	When prices are above €80, intakes to the MSR are unlikely to drive substantive amounts of additional abatement, and increase total compliance costs. Conversely, prices below €35 imply releases are unlikely to be needed for liquidity.
Short term response measures	Article 29a of the EU ETS allows for intervention if prices exceed three times the average price of the past two years for six consecutive months. This may in turn trigger the release of 100 million allowances from the MSR.	Consider lowering the threshold and timeframe of potential interventions to provide more flexibility in responding to short term price shocks; consider complementing with an auction reserve price	A faster potential short term response to price spikes can help maintain market stability
Review period	Every five years	Every three years, specifically reviews in 2024 and 2027	Ensuring MSR policy parameters, particularly the thresholds, are appropriate given rapidly evolving market environment.

Source: Vivid Economics

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1 Introduction

This report reviews the performance of the Market Stability Reserve (MSR) as required under Decision 2015/1814 of the European Parliament and of the Council, and considers how the design of the MSR can be made fit for the future. [17] This review looks at the historical performance of the MSR since it began operation in 2019, and how it is expected to perform in relation to market dynamics under its current design. It also identifies the key drivers, uncertainties, and risks to future MSR operation, and what potential changes to the MSR design parameters would best address these risks. This review is taking place against the backdrop of the 2030 Climate Target Plan announced in September 2020 and the planned larger revision of the European Union (EU) Emission Trading System (EU ETS) in 2021.

The MSR was legislated in 2015 and began operating in 2019 to help ensure the orderly functioning of the EU ETS market. The MSR operates entirely according to pre-defined rules that intake allowances into the reserve in times of oversupply and release allowances from the reserve in times of undersupply, as measured by the total number of allowances in circulation (TNAC). The MSR was designed to address the historical build-up of emissions allowances and to render the EU ETS more resilient to future events that could disrupt market stability. This latter objective is interpreted to entail ensuring that the market functions efficiently, is resilient to shocks, and delivers emissions and price outcomes consistent with a long run efficient trajectory to achieving the EU's climate mitigation objectives.

The European Parliament and the Council emphasises that the MSR should address the historical allowance surplus while also building resilience to future events that create supply-demand imbalances.[18] This includes an overall objective of improving the functioning of the European carbon market, increasing the system's resilience to major shocks while avoiding negative impacts on competitiveness, growth, and jobs.

> *"In order to address that problem [historical build-up of allowances] and to make the EU ETS more resilient in relation to supply-demand imbalances, so as to enable the EU ETS to function in an orderly market, a market stability reserve [will be introduced]"* DECISION (EU) 2015/1814

This report is aligned to the legislated requirement to review the MSR by the end of 2021, and every five years thereafter. The MSR decision, promotes two themes of analysis that are addressed in this report:

- **Design**: This focuses on specific design parameters, such as MSR intake and release rules, the value of trigger thresholds and the MSR's invalidation mechanism. The review considers how changes in the broader policy and market environment may require changes to these parameters, for example, how changes in hedging behaviour by regulated entities could necessitate changes to the trigger thresholds.

- **Wider economic impacts**: This focuses on the MSR's impact on growth, jobs, industrial competitiveness, carbon leakage risk, auction revenues and other social impacts. This includes an assessment of the MSR's role in shaping allowance prices and constraining price volatility.

The review draws on a wide range of qualitative and quantitative analysis to inform its findings. This includes economic modelling, expert interviews, a survey of covered entities, consultations with market participants, and review of the broader literature regarding MSR functioning.

The findings and recommendations outlined in this report are a result of independent work by Vivid Economics, and do not reflect the views of the European Commission. Vivid Economics carried out an independent assessment of the past performance of the MSR and the likely policy environment to arrive at

[17] Article 3 of Decision (EU) 2015/1814 of the European Parliament and of the Council of 6 October 2015 concerning the establishment and operation of a market stability reserve for the Union greenhouse gas emission trading scheme and amending Directive 2003/87/EC ("the MSR Decision").
[18] https://ec.europa.eu/clima/sites/clima/files/ets/revision/docs/impact_assessment_en.pdf

recommendations. These recommendations will be considered as part of a wider Green Deal package and should not be interpreted as indicators of future policy direction.

1.1 Approach to assessing the MSR

This review draws on a wide range of evidence to obtain a balanced assessment of the MSR's historical performance and develop recommendations for its future design. The MSR operates in an uncertain environment that is shaped by many policy choices (both within the EU ETS and in broader climate and energy policies) and market behaviour. In part due to the complexity of the MSR, there are diverse opinions on how it has performed to date and how it should be improved in the future. To perform a robust assessment, all analytical findings from this review are based on multiple sources of evidence.

The review begins with a clear framework to guide the analysis. This includes the definition of market balance and resilience and evaluation criteria for the performance of the MSR (Section 2.4). The qualitative framework further identifies the impact channels through which changes in the market and policy environment may affect the market balance, MSR response and resulting market outcomes.

The quantitative assessment draws heavily on a leading model from the academic literature to study MSR performance under a range of scenarios. A key part of this review to estimate the TNAC, auction volumes, emissions, and prices trajectories under different MSR policy settings. This review uses the Vivid EU ETS model, adapted from Quemin and Trotignon (2019), to perform this quantitative assessment. The model was chosen because it is able to capture some important aspects of market behaviour, such as imperfect foresight and a limited planning horizon. The technical details of this model are described in the annex for modelling (Section 6). To accommodate for a range of possible market and policy environments, the model also runs through a large number of scenarios and sensitivity tests. The main modelling results are described in Section 5.

Competitiveness impacts of the MSR are quantified in a separate model. This review uses Vivid's Full Industrial Market Model (FIMM+), a competition model, to estimate the MSR's competitiveness impacts. The model depicts changes to production, prices, and profits within industrial sectors at a high resolution. Details of this approach is set out in the annex on competitiveness (Section 9).

The review compiled further evidence from a wide range of stakeholders, including:

- **Market participants:** the review received survey responses from over 900 covered entities within the EU ETS on their views on the MSR and 6 additional targeted interviews with traders to understand market behaviour in detail;
- **Academia:** the review performed an extensive literature review and convened a panel of academics to provide input on the modelling methodology;
- **Market analysts:** the review engaged several market analysts, including Bloomberg NEF, ICIS and Refinitiv, to discuss their researching findings and forecasts. This took place both in the form of expert workshops and in-depth interviews; and
- **Public consultation:** the review analysed responses from the European Commission's open public consultation (OPC), which collected diverse opinion from stakeholders such as national governments, businesses, and advocacy groups.

The review synthesises the various sources of evidence to develop its final recommendations. Qualitative evidence plays a larger role where quantitative estimates fall short of providing a clear answer. Sources of uncertainty are identified and evaluated where relevant.

A detailed overview of the different sources of evidence is provided in the Annexes to the report.

1.2 Structure of the report

This remainder of the report is structured as follows:

- **Section 2: Context for the review.** This section will discuss the context of the MSR review, including the design of the EU ETS, the MSR and expected changes in the policy and market environment. It also identifies key indicators for success including the efficacy of response, timeliness of response, impact on allowance price and price volatility, and complexity of policy.

- **Section 3: Operation of the MSR to date** – This section will introduce the historical performance of the MSR and key lessons learnt. It will assess whether the MSR tackled historical supply-demand imbalances and improved resilience of the EU ETS. The analysis will also consider impacts of the MSR on price levels and volatility, competitiveness, employment and innovation.

- **Section 4: Future risks to MSR functioning –** This section will summarise the main problems with the current MSR design that might pose a risk to its functioning. These issues include the TNAC definition, threshold levels, threshold effects, policy complexity, short term price volatility, and counterproductive responses to wider policy changes.

- **Section 5: MSR design options and recommendations**– This section will examine the design options considered and their performance under different circumstances. It will outline potential variations in MSR design options such as the TNAC definition, thresholds, intake and release mechanism, invalidation and price-based mechanisms, as compared to the current design. It will also highlight the impacts of these design options in terms of various market stability indicators such as allowances, price levels and volatility, as compared to the baseline. This section also presents the main recommendations, including an update of parameters, strengthening price response measures and implementing regular reviews.

The to the report outlines the detailed modelling methodology, survey findings, hedging and speculation analysis and competitiveness. It also presents the literature review and key findings from the survey.

2 Context for the Review

This section outlines the structure of the EU ETS in relation to the MSR and introduces the MSR's key design features. This includes introducing the EU ETS and how the MSR works in relation to the market cap. MSR design parameters such as intake rates, thresholds for interventions, and the invalidation mechanism are defined and explained.

The section also outlines the types of changes in external events, the policy landscape, and market participants behaviour that can affect the stability of the EU ETS and therefore test the functioning of the MSR. Exogenous events such as economic shocks, breakthroughs in low-carbon technologies, and changes in relative fuel prices will alter GHG emissions and hence the demand for EU allowances. Likewise, policy changes such as increased ambition will alter the expectations of market participants about the future market environment, and hence their behaviour today. Market participants' behaviour is also changing as a result of the progress and evolution of abatement opportunities and obligations that is described here. Each of these events may impact the stability of the market and tests whether the MSR is able to successfully respond.

2.1 The EU ETS

The EU ETS has been the flagship climate change policy for the EU's efforts to reduce greenhouse gas (GHG) emissions since 2005. The EU ETS aims to reduce emissions from large industrial emitters and utilities (electricity and heat production) across the EU's 27 member states alongside the European Economic Area (EEA) countries of Iceland, Norway, and Liechtenstein. In January 2020, the EU ETS was linked to Switzerland's ETS, and since 2012 has included aviation emissions from flights operating within the EEA. In 2018, the EU ETS covered 10,744 installations and over 500 aircraft operators, or about 40% of the EU's total GHG emissions.[19]

The EU ETS operates by restricting the amount of GHG emissions that can be emitted to a pre-defined level or cap. European Union allowances (EU allowances) are allocated in accordance with this cap, and regulated entities must surrender an allowance for each tonne of carbon dioxide equivalent (tCO_2e) that they emit. Allowances are distributed for free or auctioned, and market participants can trade without restriction. The cap falls over time which creates scarcity, while the trading of allowances generates a market price that incentivizes firms to reduce GHG emissions if doing so is cheaper than buying allowances.

The cap is determined in advance, to align with the EU's long term mitigation objectives. The cap itself is therefore not adjusted if market outcomes differ from expectations (for instance if emissions fall faster than expected). For Phase 3 of the EU ETS (2013 to 2020) a common EU-wide cap was used, replacing the previous system of national caps.[20] The cap was set at 2.084 billion allowances in 2013 and decreased each year by a linear reduction factor (LRF) of 1.74% amounting to 38.26 million allowances (1.74% of the average total quantity of allowances issued annually in 2008-2012).[21] In 2020, the cap was set at 21% below 2005 emissions levels to be aligned to the EU's international target of reducing economy-wide emissions by 20% from 1990 levels by 2020.[22] For Phase 4 of the EU ETS, the LRF was increased to 2.2% to increase the pace of emissions cuts. In December 2020, the EU adopted a target to cut its GHG emissions by 55% compared to 1990 levels by 2030, which will require a more rapid reduction in the EU ETS cap over the course of Phase 4.

[19] Calculation includes UK emissions and facilities https://ec.europa.eu/transparency/regdoc/rep/1/2019/EN/COM-2019-557-F2-EN-MAIN-PART-1.PDF
[20] According to ICAP: the cap for Phase 2 was 2,049 to 2,096 million tonnes annual data which is reflected in the charts below.
[21] EU Commission Decision 2010/384/EU, see: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32010D0634, this equates to an annual average decrease of 1.95%.
[22] https://ec.europa.eu/clima/policies/strategies/2020_en

Over Phase 2 and 3 of the EU ETS a limited number of credits from international projects could also be used by compliance entities. Certified Emission Reductions (CERs) from the Clean Development Mechanism (CDM) and Emission Reduction Units (ERUs) from Joint Implementation (JI) that are issued under the Kyoto Protocol could be used for compliance up to a predefined limit calculated at the facility level. These credits entitlements were in addition to the issuance of allowances under the cap. In Phase 2, these could be used directly for compliance, whereas in Phase 3 these credits had to be exchanged for EU allowances.[23] These allowances cannot be used for compliance under Phase 4 (2021 to 2030) of the EU ETS as per the EU's 2030 GHG framework outlined in 2014.[24][25]

2.2 The MSR

The MSR was developed as a rules-based approach to adjusting allowance supply given the inflexibility of the cap to respond to economic, policy and behavioural changes. The MSR was introduced in 2015, amended in 2018 and became operational in 2019.[26] The MSR's objectives included to restore market balance and, in so doing, help the EU ETS deliver a meaningful investment signal to reduce emissions in a cost-efficient manner.[27] The MSR is designed to automatically adjust the quantity of allowances auctioned when demand is lower than anticipated, due to policy changes, economic drivers, changes in relative energy prices, or changes to market participants abatement or other behaviour.

The MSR responds to a quantity-based trigger, the total number of allowances in circulation (TNAC). Key determinants of the MSR response are the definition of the TNAC, TNAC 'thresholds', rules for the volume of MSR allowance intakes and releases, the invalidation mechanism, and the potential trigger of releases in the event of excessive price fluctuations. The definition of the TNAC explains how the TNAC is calculated through underlying supply and demand components. TNAC thresholds depict the level of the TNAC that will trigger automatic adjustments to allowance auctioning volumes, at which point rules define the extent that auctioning volumes are adjusted which are currently based on a percentage of the TNAC. The invalidation mechanism has the ability to permanently invalidate allowances, while there is also a measure under Article 29a to support discretionary intervention in the case of allowance price spikes. Each of these are described in more detail below.

Table 2 Summary of current MSR design parameters

MSR design parameters	Current MSR design
TNAC definition	Cumulative Allowance Supply – (Cumulative Allowance Demand + MSR holdings)
Upper threshold (for intakes)	833 million allowances
Lower threshold (for releases)	400 million allowances
MSR intakes	12% of TNAC (24% over 2019-23)
MSR releases	100 million allowances (200 million allowances over 2019-23)
Invalidation mechanism	Permanently invalidate excess allowances in MSR holding account above prior year auction volume (2023 onwards)

[23] Paragraph 27 of DIRECTIVE (EU) 2018/410
[24] https://ec.europa.eu/commission/presscorner/detail/en/MEMO_14_40
[25] COM(2014) 15 specifies GHG reductions have to occur via "domestic measures" alone (i.e. no use of international credits)
[26] Decision (EU) 2015/1814 of the European Parliament and of the Council of 6 October 2015 concerning the establishment and operation of a market stability reserve for the Union greenhouse gas emission trading scheme and amending Directive 2003/87/EC, OJ L 264, 9.10.2015, p. 1. See: https://eur-lex.europa.eu/legal-content/EN/TXT/?toc=OJ:L:2015:264:TOC&uri=uriserv:OJ.L_.2015.264.01.0001.01.ENG
[27] https://doi.org/http://eurlex.europa.eu/pri/en/oj/dat/2003/l_285/l_28520031101en00330037.pdf

MSR design parameters	Current MSR design
Releases in the event of excessive price fluctuations	100 million allowances may be released if measures are adopted under Article 29a of the EU ETS Directive, and if the TNAC exceeds the lower threshold. These measures may be adopted if for more than six consecutive months, the allowance price is more than three times the average price from the previous two years.

Source: Vivid Economics based on DG CLIMA

2.2.1 The TNAC

The number of allowances available to market participants in a given year is a function of the allowances created under the EU ETS cap and allowances banked from previous years compared to cumulative emissions and cancellations. Allowances are allocated or auctioned in accordance with the cap, and these can be bought and sold be compliance and non-compliance market participants. Participants may choose to bank allowances between years and trading periods without constraint such that allowances accumulate over time when they are not used for compliance.

The TNAC estimates the cumulative amount of banking by market participants. It captures the total supply of allowances that have not been used for compliance, voluntarily cancelled, or otherwise made unavailable to market participants. The TNAC has been calculated and published annually since 2017. It is calculated as the cumulative supply of allowances less the cumulative demand for allowances since the beginning of Phase 3 and includes the carryover of allowances from Phase 2 (see Box 2). Specifically, the TNAC is defined as:

> *'the cumulative number of allowances issued in the period since 1 January 2008, including the number issued pursuant to Article 13(2) of Directive 2003/87/EC in that period and entitlements to use international credits exercised by installations under the EU ETS in respect of emissions up to 31 December of that given year, minus the cumulative tonnes of verified emissions from installations under the EU ETS between 1 January 2008 and 31 December of that same given year, any allowances invalidated in accordance with Article 12(4) of Directive 2003/87/EC and the number of allowances in the reserve' (European Commission, 2015a, p. 3).*

The TNAC is an important indicator of the level of allowance supply in the market, with consequences for market balance and allowance prices. The TNAC can be used to assess the current level of allowance scarcity in the market but does not provide information about future scarcity. A large or growing TNAC means that the available supply of allowances is exceeding demand in the current period, a situation that if often linked to lower prices. Likewise, a low TNAC is an indicator that there may not be enough allowances available to provide sufficient supply for necessary risk management (hedging) and to optimise low-carbon investment strategies across time.

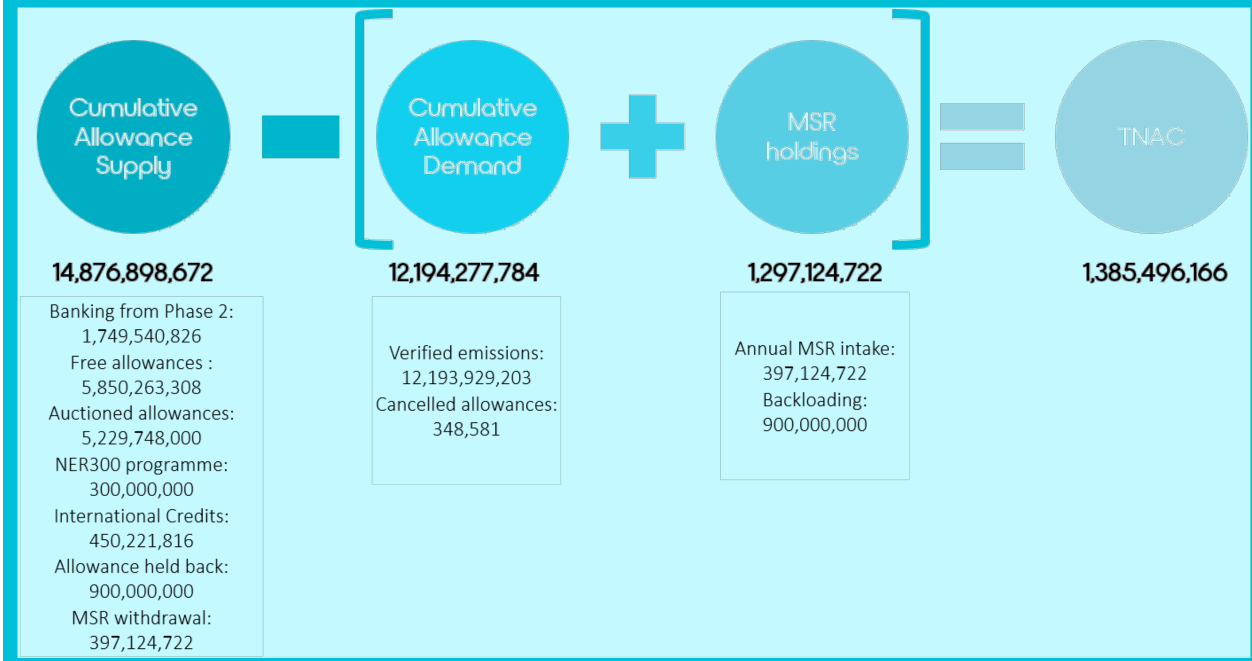
The level of the TNAC determines MSR adjustments to auction volumes. As such the definition of the TNAC is central to determining the functioning of the MSR as well as to providing a measure of its MSR success.

Box 2 Calculating the total number of allowances in circulation (TNAC)

The TNAC is calculated by subtracting the cumulative demand for allowances from cumulative supply. Supply includes the volume of allowances that have been issued for free or auctioned since the beginning of Phase 3 (2013). It also includes allowances auctioned under the NER300 programme and international credits. Finally, supply includes the 1.7 billion allowances that were carried over from Phase 2. Demand includes verified emissions (reflect the surrender of an allowance for each tonne of verified emissions) and allowances cancelled in accordance with Article 12(4) of Directive 2003/87/EC.[28]

To depict the MSR holdings account, the TNAC calculation also includes backloaded allowances and MSR-related allowance withdrawals from auctioning volumes. MSR holdings are included on both sides of the TNAC equation to ensure all sources of supply and demand are transparent. This means including the 900 million allowances that were removed from auctioning volumes between 2014 and 2016 under the backloading legislation, as well as the cumulative MSR withdrawals from auctioning volumes, as potential supply being held in the MSR holding account. Figure 3 depicts an example of the 2019 TNAC, published in May 2020.

Figure 3 2019 TNAC Calculations



The TNAC is calculated on an annual basis with the inclusion of data from the previous calendar year. Each May, the TNAC from the previous calendar year is calculated and published by the EU Commission. The TNAC publications include data on underlying supply and demand components as recorded by 30 April.

The annual publications also include updated data from previous years that have been corrected or adjusted over time. Data on verified emissions and free allocation are updated continuously for all years from 2013 to the most current year and may change significantly from previous year's estimates. The published cumulative demand and supply figures capture these updates to historical data.

2.2.2 MSR-related thresholds for the TNAC

Adjustments to auction supply are made when the TNAC is above or below predetermined thresholds. Auction supply is reduced, and allowances moved into the MSR's holding account if the TNAC exceeds 833 million allowances. Allowances are released from the MSR's holding account and added to future auction supply, if the TNAC falls below 400 million allowances.

[28] Member states can cancel allowances at any time at the request of the holder. They may also cancel allowances from auctioning volumes that correspond to the 5-year average emissions of electricity generating plants that have closed.

The band implied by the upper and lower thresholds of the MSR is considered to represent the required TNAC 'space' for current emitters to hedge future emissions liabilities. A certain number of banked allowances is needed for regulated entities to optimise investment decisions and minimise mitigation costs over time. The band provides short term flexibility to enable efficient intertemporal optimisation by market participants while ensuring enough allowance scarcity to spur low-carbon investment.[29]

The appropriate threshold level will be subject to change with market developments, policy design and participants' hedging needs. The current thresholds were based on estimates of the available allowances required in the market to allow regulated entities to hedge their obligations over time. However, demand for hedging can vary based on the characteristics of entities with liabilities under the EU ETS as they respond to a changing policy landscape. As such, the appropriate level for these thresholds will change over time.

2.2.3 Rules for MSR intakes and releases

Allowance supply adjustments are made through intakes to, or releases from the MSR, with matching adjustments to auction volumes. When the TNAC is above the upper threshold of 833 million, allowances are added to the MSR holdings account from future auction volumes at a rate of 24% of the previous year's TNAC. When the TNAC is below the lower threshold of 400 million allowances, 200 million allowances are released from the reserve and auctioned. These intake and release rates apply only to the 2019-23 period, as a result of a decision to temporarily double rates as part of the 2018 MSR amendments. From 2024, the intake rate will reduce to 12% of the previous year's TNAC, and the release rate will reduce to 100 million allowances.

The MSR withdrawal and injection rates determine the scale of intervention of the MSR, and its ability to respond to market imbalances in a timely fashion. The specification and size of intakes and releases into the MSR determine the speed at which it will address the historical allowance surplus and its ability to respond to market demand shocks in a timely fashion. If interventions are too small this could mean that the MSR is ineffective in responding to market imbalance, while if interventions are too large this could lead the MSR to "overcorrect" imbalances potentially risking policy driven price volatility.

2.2.4 Invalidation mechanism

The MSR's invalidation mechanism alters the long run allowance supply in the EU ETS by permanently invalidating allowances held in the MSR's holding account in excess of the previous year's auction volume. From 2023 onwards, if the volume of allowances held in the MSR's holding account exceeds the total volume of allowances auctioned in the previous year any excess allowances will be invalidated. While there is some divergence in estimates, analysts expect a significant quantity of allowances to be invalidated from the reserve, with estimates ranging from 1.7 billion to 2.4 billion allowances in 2023. [30][31]

The invalidation mechanism acts to limit aggregate banking of allowances into future periods by permanently removing them from circulation, thus strengthening the overall ambition of the ETS. By permanently invalidating allowances in the MSR holdings account above the previous year's auctioning volumes, it ensures that these allowances will never be returned to the market. The invalidation mechanism will affect the overall emissions budget available to ETS sectors, and therefore the total level of mitigation ambition within the EU ETS.

2.2.5 Releases in the event of excessive price fluctuations

Releases from the MSR may also occur in the event of excessive price fluctuations. Specifically, 100 million allowances are released from the MSR when measures are adopted under Article 29a of the ETS Directive, if

29 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52014SC0018&from=EN

[30] Perino and Willner (2017)

[31] https://www.i4ce.org/wp-core/wp-content/uploads/2019/05/2019-State-of-the-EU-ETS-Report.pdf

the TNAC exceeds the lower threshold**.** This Article has not been invoked in the operation of the EU ETS to date and its operation is not a subject of this Review.

Article 29a allows for measures to be adopted to increase supply in the event of excessive price fluctuations. It requires that the European Commission hold a committee meeting to discuss the possibility of increasing the supply of allowances if, for more than six consecutive months, the EU allowance price is more than three times the average price from the previous two years. In the event that the committee determines that the price evolution does not correspond to changing market fundamentals, measures may be adopted to bring forward allowances from future auctions, or auction up to 25% of remaining allowances in the New Entrants Reserve (NER).

2.3 Resilience in a changing market

A key objective of the MSR is to ensure the resilience of the EU ETS, which requires that the market functions effectively in the presence of shocks and changes to the policy and market environment. A resilient market will efficiently deliver on long run decarbonisation objectives, while providing short term flexibility to account for underlying economic conditions including by smoothing costs over time. This includes enabling efficient intertemporal optimisation by market participants – such as through short term hedging or long term holdings – while providing incentives for low-carbon investment.[32]

A market is resilient when it can function well under a range of plausible circumstances, including returning the market to balance within a reasonable timeframe following a shock. Shocks are changes to the environment in which the ETS operates, without changes to the ETS design or market characteristics themselves. For instance, the financial crisis of 2009 significantly lowered demand for allowances and led to the build-up of a surplus of allowances, with prices falling to a level at which it was unable to incentivise low-carbon investment or abatement.

In addition to shocks, market-related events can affect market operation, including changes to market design and in market participants' behaviour. Changes to market design include changes to the LRF, linking to other ETS systems, and new legislated sources of allowance demand. Changes in market participants behaviour include changes in hedging demand or speculative holdings, or changes in behaviour related to the voluntary cancellations of allowances.

A summary of the potential sources of shocks and market related events that can affect the resilience of the EU ETS are discussed in Figure 4.

32 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52014SC0018&from=EN

Figure 4 Events and shocks that Impact the EU ETS

	Exogenous Events					Market-Related Events	
	Economic shock	Relative changes in fuel prices	Breakthrough in low-carbon technologies	Anticipated overlapping policy change	Unanticipated overlapping policy change	Changes to EU ETS market design	Changes in ETS participants' behaviour
Description	Economic activity slows or accelerates beyond ex-ante expectations. This could include relatively short-term shocks (e.g., COVID-19) or longer lasting shocks (e.g., 2008/9 financial crisis)	Significant change in relative energy prices (e.g., oil price drops; natural gas price rises)	Innovation or other breakthrough decreases costs of low-carbon alternative technologies (e.g., renewable energy, negative emissions technology)	Changes to future mitigation ambitions (e.g., mandated closure of coal plants; electrification of transport) and other expected policy (e.g., nuclear closure)	Sudden changes in ambition (e.g., release of allowances from NER for a new program) and unexpected policy (e.g., a new generation of solar panels turns out to be less effective)	Policy changes (e.g., changes to the LRF) and market design changes (e.g., linking to other ETS; new sources of demand)	Changes to hedging demand, changes to speculative or long-term holding demand, changes to voluntary cancellation
Impact on Market Supply-Demand Balance	Demand and hence output, energy, and aviation travel falls (rises). GHG emissions are lower (higher) than ex-ante expectations, leading to a temporary or lasting supply/demand imbalance	Demand for fossil fuels increases (decreases) when prices fall (rise), with corresponding impact on GHG emissions. TNAC falls (increases)	GHG abatement increases, emissions fall; TNAC rises since there is less demand for allowances. Anticipation of lower future demand.	Increased (decreased) mitigation and banking now due to future expectations of scarcity (TNAC rises). The effect depends on expectation of future allowance supply and demand.	Reduces/Increases demand for allowances	Changes to the LRF will alter allowance supply and demand; Linking ETS systems will add both allowance supply and demand; New sources of demand will impact market balance	Voluntary cancellations will alter available supply of allowances; Increases to hedging demand or other sources of demand will not impact TNAC but have other impacts on market stability.

Source: Vivid Economics

The following sections consider the changing nature of the EU ETS considering potential policy change and changes to the market environment.

2.3.1 Shocks

A wide range of unforeseen external events can have implications for MSR and ETS functioning. This could include unexpected changes in economic activity, fuel or low-carbon technology costs or the ambition of overlapping climate policies. To the extent these shocks change EU allowance demand, they can lead to changes in the TNAC and additional intakes or releases.

Shocks which lead to an unanticipated reduction in EU allowance demand increase the TNAC, which can lead to additional intakes to the MSR. These shocks include negative economic shock and a relative increase in fossil fuel prices. By leading to lower emissions, these shocks will lead to a higher level of TNAC than otherwise expected, as fewer allowances are demanded for emissions verification. This may lead to additional intake into the MSR if TNAC is above the upper threshold following the shock. In the case that these shocks imply a permanent reduction in EU allowance demand, additional intakes into the MSR can ensure that the cumulative allowance supply also falls, leading to a permanent reduction in covered sector emissions. An unanticipated increase in emissions would lead to a reduction in TNAC, potentially leading to fewer intakes to the MSR or additional releases.

Shocks which lead to an anticipated reduction in EU allowance demand can reduce the TNAC, potentially reducing the quantity of intakes to the MSR or leading to releases from the MSR. An anticipated reduction in EU allowance demand could arise due to breakthroughs in low-carbon technology. If EU allowance demand is projected to fall due to the new availability of low-cost abatement, price expectations will also fall. This will lead to a reduction in current prices, and subsequently a reduction in abatement activity, reducing the TNAC. If the TNAC is above the upper threshold, this will lead to a reduction in intakes, and if TNAC falls below the lower thresholds this will lead to a release of allowances from the MSR. By increasing the cumulative auction supply, the MSR may effectively counteract some of the environmental benefits associated with the breakthrough in low-carbon technologies. An anticipated increase in EU allowance demand would

2.3.2 Changes in overlapping policies

The EU, as well as its member states, continue to develop additional climate and energy policies to help reach these targets. For example, the EU renewable energy financing mechanism supports greater uptake of renewable energy sources across the EU and has obligation schemes for energy companies to achieve yearly energy savings of 1.5% of annual sales to final consumers. [33] [34] Similarly, at the member state level, Germany plans to phase-out power generated by coal by 2038, while in France building renovations will be mandatory by 2025 for the least efficient dwellings (specific consumption over 330 kWh/m^2).[35][36] These overlapping policies will interact with the EU ETS in complex ways. The overall price and mitigation effect of overlapping policies will differ depending on the timing of overlapping policies, the level to which they are anticipated by market participants, the type and magnitude of abatement options targeted, and how close the TNAC is to the upper or lower intake thresholds.

A key challenge for ETS is the "waterbed effect", whereby the fixed number of allowances under the cap, any reductions in emissions in one jurisdiction will result in emissions rising in another jurisdiction. For example, a national carbon price floor for electricity generation in the Netherlands would see emissions fall more quickly in the Dutch electric utilities sector (and potentially in electricity end-use categories in the area). However, this creates space for more emissions under the EU ETS cap and simply lowers demand for EU allowances. This in turn lowers the EU allowance price, and therefore lowers abatement in other EU jurisdictions. This is referred to as intra-EU carbon leakage.[37] The MSR invalidation mechanism 'punctures' the waterbed effect as the total allowances supply is no longer fixed. Climate and energy policies that lead to additional emission reductions will lower the demand for allowances and therefore increase the TNAC. This will result in the MSR intaking a higher level of allowances from auctioning volumes. Perino (2018) argues that, given the large historical surplus in the market, when the invalidation mechanism begins in 2023, the MSR's holding account will contain sufficient allowances that any additional allowances placed in the MSR will be permanently invalidated. [38] Since invalidating allowances effectively lowers the overall emissions budget over time, the MSR therefore substantially reduces the waterbed effect.

When overlapping policies are anticipated, market participants bank less allowances for the future. Rosendahl (2019) argue that claims of the punctured waterbed effect are incomplete because most policy changes are anticipated, and therefore shape market dynamics both today as well as in the future when the policy is implemented. If market participants expect the demand for allowances to be lower in the future (due to additional emission reductions stemming from other policies), this could lead to less banking, and hence a lower TNAC. Lower levels of banking decrease the TNAC and therefore the MSR withdraws a smaller number of allowances from auctioning volumes. Anticipated policy changes can lower allowance prices, and emissions rise. This means more allowances are needed for compliance and banking falls. In this situation, the TNAC ends up lower as a result of the anticipated policy, and therefore the MSR will make smaller adjustments to auctioning volumes. In the end, lower adjustments mean less allowances in the MSR holdings account and fewer invalidations. It is possible that overall GHG emissions could increase as a result of overlapping policies. [39] Gerlagh et al (2019) argue that the MSR creates a 'new green paradox', as the volume of invalidations, and hence overall abatement, decreases as a result of overlapping policies. If overlapping policies result in lower MSR adjustments and therefore less allowances are invalidated, the overall emissions budget ends up higher than it would have been in the absence of the overlapping policy.

[33] https://ec.europa.eu/energy/topics/renewable-energy/eu-renewable-energy-financing-mechanism_en
[34] https://ec.europa.eu/energy/topics/energy-efficiency/targets-directive-and-rules/energy-efficiency-directive_en
[35] https://www.odyssee-mure.eu/publications/efficiency-trends-policies-profiles/france.html#:~:text=The%20Energy%20Transition%20Act%20of,over%20330%20kWh%2Fm2).
[36] https://www.bmwi.de/Redaktion/EN/Pressemitteilungen/2020/20200703-final-decision-to-launch-the-coal-phase-out.html#:~:text=Germany%20is%20one%20of%20a,the%20regions%20affected%20by%20this.
[37] https://cepr.org/active/publications/discussion_papers/dp.php?dpno=13569
[38] Perino, G. (2018). New EU ETS Phase 4 rules temporarily puncture waterbed. Nature Climate Change, 8(4), 262-264.
[39] https://www.cree.uio.no/publications/CREE_working_papers/pdf_2019/gerlagh_heijmans_rosendahl_paradox_cree_wp_08_2019.pdf

The interaction of the MSR with overlapping policies depends on the timing, scope and magnitude of overlapping policies. If an overlapping policy takes effect at a time when the MSR is not taking intakes of EU allowances, the drop in demand may not be sufficient to raise the TNAC above the upper threshold. This would mean no related MSR adjustments or invalidations, and hence a return of the waterbed effect. This therefore leads to higher emissions in the long run. The impact of overlapping policies on overall emissions in the EU ETS varies depending on the timing of implementation, type of abatement options targeted and the magnitude of impact the overlapping policy has on emissions.[40] A recent analysis of the German coal phase-out suggests that the MSR cannot cancel enough allowances to fully alleviate the induced waterbed effect and is prone to a green paradox.[41] That is, market participants anticipation of lower demand for allowances due to the phase-out can lower near-term intakes to the MSR, leading to lower invalidations in 2023, and could therefore lead to higher cumulative emissions.[42]

Voluntary cancellations can be used to counteract the potential for a waterbed effect. Usually cancellations allow allowance supply to be adjusted to account for the additional abatement caused by the overlapping policy negating the possibility of the emissions being taken up elsewhere in the economy. However, estimating the magnitude of the abatement impact of an overlapping policy is not straightforward and can only be estimated using modelling.

The timing of voluntary cancellations interacts with the MSR and its invalidation mechanism. In response to the complications caused by overlapping policies, a delay to voluntary cancellations could increase the invalidations made by the MSR and hence overall abatement. Banked allowances count towards the TNAC during the delay, and therefore would create higher MSR adjustments and greater invalidations. In contrast, when allowances are voluntarily cancelled, those allowances then form part of demand in the TNAC calculation and therefore lower MSR intakes and subsequent invalidations. As such, a strategy where allowances are held instead of cancelled would lead to the greatest GHG abatement. Voluntary cancellations are discretionary for each member state, meaning cancellations would occur at any point with uncertainties on the number of allowances cancelled. So far, voluntary cancellations have been insignificant but there is potential for them to increase considerably in the future. The uncertainty on cancellations could translate into price volatility if voluntary cancellations are large or if market actors look to anticipate potential cancellations.

2.3.3 Policy changes in the EU ETS

An evolving policy landscape including increased environmental ambition will affect the operation of the MSR. The EU is increasing its climate ambition, with plans for a more stringent emission reduction target as part of the European Green Deal. Potential policy changes that would impact the functioning of the MSR include the tightening of the EU ETS cap, introduction of carbon border adjustment measures (CBAMs), and changes in the scope of the ETS. Many of these policy changes will be finalised simultaneously, including the tightening of the cap to meet increased ambition, and a change in EU ETS scope. Moreover, the introduction of CBAMs is currently under review.

In coming years, changes to the EU ETS as part of the European Green Deal will alter the market environment in which the MSR operates. The EU's ambitious climate plan aims to cut GHG emissions by at least 55% by 2030 from 1990 levels and reach net zero emissions by 2050. The 2030 Climate Target Plan outlines plans to achieve the 55% reduction target including initiatives spanning numerous policy areas. A revamped Innovation Fund and Modernisation Fund will support a low-carbon transition in energy-intensive industrial sectors and energy systems in member states which are reliant on older, inefficient, fossil fuel generation.[43]

[40] See studies from Bruninx et al. (2019b), Gerlagh et al. (2020a), Schmidt (2020) and Perino et al. (2020)
[41] https://www.pik-potsdam.de/members/pahle/pahle-edenhofer-et-al-risiken-kohleausstieg.pdf
[42] https://www.sciencedirect.com/science/article/pii/S0140988320300694?casa_token=JdD41nEetx0AAAAA:tzpaekQLZLXaOpPylr_BZOYjhrInhp5a9wZb2DDf2rQ1RozYWv7L8fnXgKM1S8x7_idvo8ez
[43] European Commission, 2017a

The Commission will review and propose to revise where necessary all relevant climate-related policy instruments by June 2021. These changes will affect the functioning of the MSR and have a bearing on the appropriate parameters for future design.

A key aspect of the changing policy environment is the EU's ramped-up ambition for emissions reductions, targeting 55% reduction in GHG emissions by 2030. This increase ambition can be achieved through a mix of different policies, including the EU ETS. For example, in order to meet the 55% overall reduction target, the sectors covered by the ETS may have to reduce emissions by 65% in 2030 from 2005 levels.[44] In Phase 4, climate ambition has been enhanced by an increase in the LRF from 1.74% (reducing the cap by about 38 $MtCO_2e$ per year) to 2.2% (reducing the cap by about 48 $MtCO_2e$ per year). To meet the more stringent targets adopted the LRF will need to further increase, and a rebase of the cap is also being considered.

Discussions have started on introducing a CBAM for selected sectors as an alternative to free allocations to reduce the risk of carbon leakage. A legislative proposal is planned for mid-2021. The CBAM would address carbon leakage risk by introducing fees on imported goods based on their carbon content. The design of a CBAM is still being finalised but could result in a graduated phase out of free allocations in a subset of sectors. Any changes to free allocation imposed by the introduction of a CBAM would alter the number of auctioned allowances, and subsequently effect MSR design elements such as the invalidation mechanism thresholds. Additionally, this could cause change market behaviour, such as an increase demand for hedging from industrial emitters, which may necessitate changes to thresholds.

The inclusion of new sectors in the EU ETS would increase the total emissions covered by the ETS, potentially necessitating changes to MSR thresholds. These implications arise through three main channels: an increase in the size of emissions covered by the ETS, a change in hedging behaviour as new entities fall under ETS regulation, and a change in abatement costs. These factors can have complex and interrelated effects on the aggregate system. Potential changes in scope range from minor, such as the coverage of inter-EEA maritime emissions, to major, such as the coverage of emissions from buildings and road transport. Minor changes in scope would be unlikely to have a major effect on the operation of the MSR, however major changes would have significant implications for MSR design.[45] A coverage expansion would necessitate an upwards revision of the cap and would likely require an adjustment to MSR thresholds to support market balance under the new scope.

2.3.4 Changes in the market environment

The behaviour of market participants has implications on the demand for allowances and hence market balance, TNAC calculations, and MSR functioning. Allowances are held by market participants for various reasons, which have changed over time as the market has developed. Allowances are primarily held by "utilities" (primarily power and heating) or "industrials" (emissions intensive firms operating in industries such as cement or steel). These companies must surrender allowances to meet their obligations under the EU ETS. Utilities are the most active of these buyers, holding an estimated three quarters of outstanding allowances.[46] Some industrial installations are eligible for free allowances each year but most purchase allowances via auctions or on the secondary market. Historically many industrials were able to meet most of their obligations using free or banked allowances. As such, active trading tends to be limited to large industrial firms, while smaller firms often limit purchases to that needed to fulfil their obligations. However, as free allocations have declined it has become more common for industrials to trade in secondary markets.

Hedging allows companies to lock-in prices for future compliance obligations, thus reducing their cost volatility. Because of long term power contracts in liberalised utilities markets, hedging is more common in these markets, and utilities are more likely to hedge over a longer tenor covering more of their exposure

[44] European Commission (2020) https://ec.europa.eu/clima/sites/clima/files/eu-climate-action/docs/impact_en.pdf
[45] Current emissions from these sectors stands at a total of 1190 Mt in 2020, which would constitute more than 73% of the 2020 ETS cap. The largest share comes from transport (690 Mt), followed by buildings (430 Mt), and finally international maritime navigation (70 Mt). PRIMES reference scenario, adjusted for COVID, retrieved in January 2021
[46] Carbon Pulse (2020)

compared to more regulated markets. Some larger industrials, especially in the oil and gas industry, also hedge but it is less common than for utilities. Demand for hedging can vary based on the characteristics of entities with liabilities under the EU ETS. Entities may have different propensities to hedge based on factors including the sector they operate in, their sophistication, the absolute scale of their liabilities, their relative short/long position after considering free allocations and the price level prevailing in their market.

Market participants' demand for allowances goes beyond immediate regulatory compliance and includes hedging by compliance entities, and speculative trading from non-compliance actors. These sources of demand are not included in TNAC calculations as allowances remain available on the secondary market. Participants may also engage in speculative trading, before 2017 this trade was limited, however in recent years changes to the EU ETS had improved confidence in the market's stability, liquidity and upward price potential.[47] This led to an increased amount of short term speculation, as well as participation from longer term investors and voluntary buyers.

The key sources of demand in allowance markets are expected to change over the coming decade. Hedging demand from utilities is expected to decline while hedging demand from industrials increases. Likewise, while non-compliant holdings are not expected to increase significantly, this is an area of uncertainty given increased interest in carbon markets as an asset class. Given these fundamental changes to participants behaviour, future MSR threshold levels should account for both reasonable levels of forward hedging and potentially some degree of holding by long term investors. Given these dynamics it may be appropriate for thresholds to be changed in absolute levels, or for their calculation to be altered to allow flexibility over time.

(1) Utility hedging

Utilities large holdings of allowances are primarily due to their hedging of future liabilities. A large proportion of the production of heating and power plants are sold in advance. As such many utilities will seek to hedge their future liabilities at the same time, to lock in their costs and overall margin. As a result, most of these companies undertake a structured hedging process which results in their buying a proportion of future expected liabilities. For example, a utility may purchase 70% of required allowances for their current year emissions but will also purchase 20% of next year's expected requirements and 10% of the year after that. Many large utilities companies have increased their hedging timeframes in recent years due to concern over rising carbon prices, such as RWE, who have hedged some proportion of their liabilities as far out as 2030.[48]

Hedging demand from the electricity sectors is likely to reduce, as renewable generation increases and emissions fall. Recent increases in prices and the coal phase-out means that hedging demand from utilities is likely to fall alongside emissions. Increased investment in abatement reduces the volume of hedging demand given reduced future compliance requirements. However recent experience also suggests that hedging behaviour in the market may be changing, with some generation utilities hedging more than 5 years in advance. Over the period from 2018 to 2020, the hedging position of electricity generators is estimated to have reduced from 835 million allowances to 790 million allowances, while emissions from the sector are estimated to have reduced from 879 $MtCO_2e$ to 657 $MtCO_2e$.[49]

(2) Industrial banking and hedging

Industrials have historically not undertaken significant hedging given the large number of allowances they hold. Banking refers to allowances that industrials have kept in reserve on balance sheets rather than selling into the secondary market. Industrial companies received significant amounts of excess free allowances over Phase 2 and much of Phase 3 to reduce the risk of carbon leakage. In recent years free allowances allocations have reduced enough such that industrials now surrender more allowances than they receive each year. Nonetheless, many industrials hold significant numbers of free allowances which provides a

[47] Short term speculative EU allowance trading is the buying and selling of EU allowances in order to profit from short term price changes related to market events, policy announcements or momentum behaviour (rather than underlying structural trends).
[48] https://carbon-pulse.com/94238/
[49] ICIS, 2021

natural hedge for these entities. As such, structured hedging programs are not common among industrial participants.

Over the next decade, industrial emitters are likely to become an increasingly large share of hedging demand in the market, but this is subject to significant uncertainty. Many small industrials have no active allowance exposure management. However, an increasing number of industrials have begun to undertake hedging over multi-year timeframes. Most small to mid-size industrials trade via intermediaries such as banks, traders, or other financial institutions rather than using in-house trading teams. As free allowances decrease, banked allowances are used, and prices increase, industrials are expected to increase hedging.

Potential policy changes could have a large impact on industrials' hedging demand. The key drivers of changes in demand are a potential expansion of sectoral scope and the introduction of a CBAM to replace free allocations. An expansion of ETS scope would imply additional hedging demand from newly covered sectors, such as maritime, buildings and transport. Larger maritime entities currently take part in hedging activity for bunker fuels, as such it is likely they would also take part in hedge allowances. Upstream providers in the buildings and transport sectors are also expected to hedge allowances if covered. The implementation of a CBAM and reduction of free allocations would reduce the natural hedge provided by free allocations, likely resulting in some industrial facilities implementing hedging programmes. This could increase total hedging demand by 50-100 million allowances in 2030.[50]

(3) Speculative demand

Speculative trading has increased significantly in recent years following a significant period with very little speculative activity. Prior to 2014, a significant number of participants traded speculatively, with a focus on short term trades (less than 1 year holding periods). However, oversupply in the allowance market and depressed prices reduced the number of short term speculators in the market, with those remaining predominately participating in the carry trade.[51] By the end of 2017, the implementation of the MSR and other policy announcements contributed to increased market confidence. Short term speculation increased in volume over 2018 and 2019, driven by increased price expectations. Short term trading volumes fell over 2020 due to increased market volatility, with increasing speculation from long term investors.

As the EU's climate ambition strengthened volume shifted to long term investors and hedge funds seeking to generate returns from price increases over several years. In February 2021, there was a market rally following media reports on investor expectations about EU allowance prices. Prices reached all-time highs, breaching €40 and bringing carbon to the attention of investors worldwide as an asset class. The impact of the market rally on the potential size of the speculative market is still unknown.

Like hedging, an increase in long term speculative holdings can have a direct effect on the TNAC and remove allowances from circulation. The size of long term speculative holdings in the market is currently estimated to range between 50 to 100 million allowances.[52] This includes over-hedging by utility firms and the long term positions held by investors. A significant increase in total speculative holdings could drive up prices, leading to increased levels of abatement and an increased TNAC. This scenario has been deemed unlikely by market participants. However, understanding the nature of speculative behaviour will be important in the future, especially as carbon comes to the attention of investors worldwide.

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[50] Assuming the full phase out of allocations in the steel and cement sectors

[51] The carry trade seeks to exploit differences in the relative prices of spot and future EU allowance contracts relative to other risk-free assets. Simultaneously buying spot EU allowance contracts vs selling EU allowance futures contracts creates a risk flat position, which held over time can generate a risk-free return. Over Phase 3 this rate of return was around 4-5%. This is sometimes referred to as "optimising cost of cash" or a "contango trade" and does not reflect an outright investment or holding in the underlying EU allowance instrument.

[52] For more information, see Annex 2 for an evaluation of hedging and speculation behaviour in the ETS.

2.4 Indicators for success

Changes in relation to external events, the policy environment, and market behaviour may impact the stability of the market and will test whether the MSR is able to successfully respond. When these factors cause changes to market balance, they trigger a response from the MSR. Central to the MSR's success is ensuring market resilience. The MSR's response is designed to impact the TNAC but will also have indirect effects on the other indicators of market stability such as the price level. To this end, a framework for assessing resilience against indicators of market stability is defined below (Table 3).

Table 3 Indicators for success of the MSR

Variable	Theoretical indicator of Stability	Ideal MSR Response
Supply-Demand balance	The cumulative supply of allowances does not significantly exceed the cumulative demand for allowances over market participants' planning horizon	The MSR withdraws allowances from auctioning volumes when cumulative supply greatly exceeds cumulative demand as measured through the TNAC
Price level	The allowance price is consistent with efficient price pathways (i.e., sufficient price to drive required emissions reductions without undue burden on covered entities)	The MSR's reduction of auctioning volumes returns the allowance price towards levels consistent with an efficient long term decarbonisation trajectory
Price volatility	The allowance price is stable with price predictability to support long term investment decisions	The MSR reduces, or does not increase price volatility
Market liquidity	Allowances can be easily bought and sold at a price reflecting their true value	The MSR adjustments support robust market liquidity considering hedging and speculative demand and market responses to shocks
Strategic behaviour	Market manipulation and gaming is minimised	The MSR limits, or does not increase, opportunities for market manipulation and gaming
Predictability, complexity and transparency	Market rules and functioning are transparent and not overly complex, and the price responds in predictable ways to exogenous stimulus such as shocks. Market participants have complete and accurate information to understand and manage risks as well as to support investment decisions.	The MSR responds in a predictable manner to a given set of market outcomes, and does not unduly add to market complexity or uncertainty
Market sentiment	Market participants have trust in the functioning of the market (important for rational behaviour and long term investments)	The MSR increases, or does not reduce, overall trust in the efficacy and credibility of the EU ETS

Source: Vivid Economics

3 Operation of the MSR to date

In its short period of operation to date, the MSR has removed a significant number of allowances from circulation and has likely contributed to the resilience of the EU ETS. The MSR continues to deliver significant annual reductions in allowance supply since it began operation in 2019. These adjustments, coupled with other interventions such as allowance backloading, mean that the 2019 TNAC is 28% lower than its high in 2013. Meanwhile, EU allowance prices have recovered and grown following their historical lows.

The historical evolution of the TNAC is described in this section, along with a description of how the market imbalance was addressed through policy interventions and the introduction of the MSR. The following section analyses the evolution of underlying allowance supply and demand dynamics which led to the build-up of banking over time. Market interventions and reforms are then described including the roll that the introduction of the MSR played in those reforms. Finally, the MSR's ability to help shape market prices is explained along with a description of EU allowance price recovery.

The MSR will continue to address the persistent historical allowance surplus going forward, but will also respond to other market shocks, such as the COVID-19 induced demand shock, to ensure ongoing resilience. The MSR will continue to address the historical surplus, with the TNAC currently estimated at 1.4 billion allowances in 2019, while also tackling the negative market demand shock from the COVID-19 pandemic. The assessment of the impact of the MSR on system resilience requires consideration of its likely functioning in a changing policy and market environment which is set out in chapter 5].

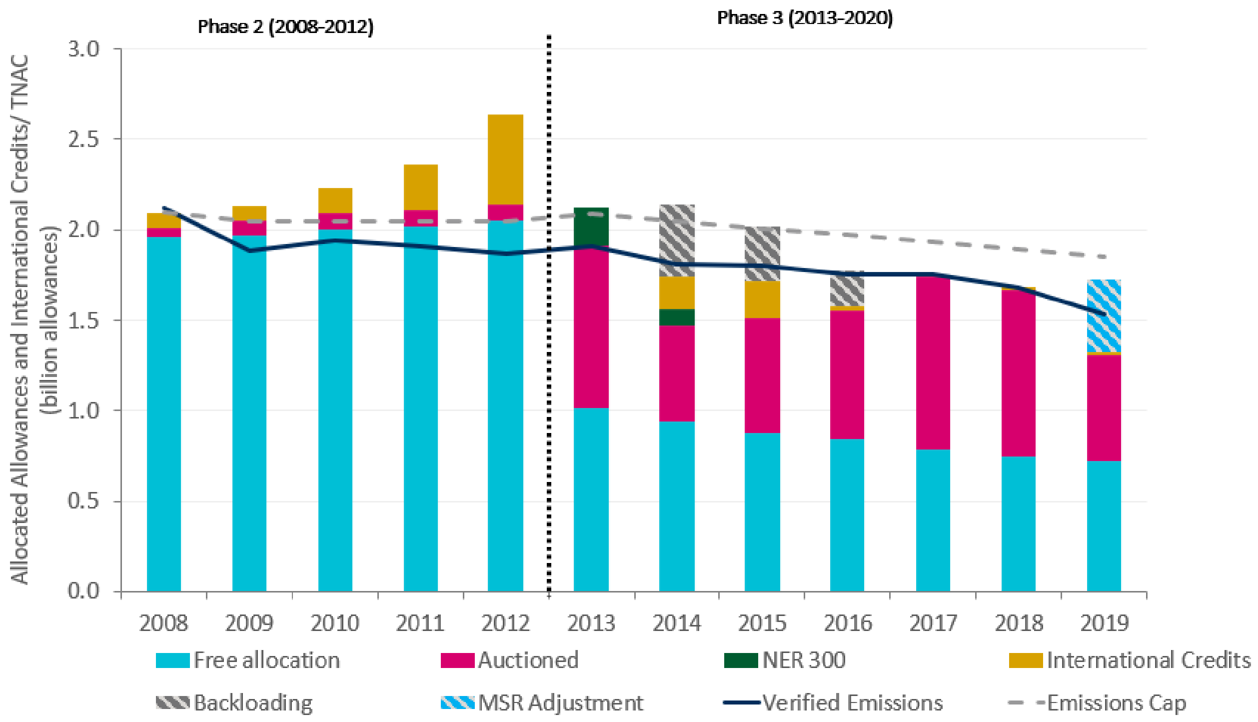
3.1 The historical evolution of the TNAC

The build-up of the TNAC over Phase 2 and the early years of Phase 3 motivated market reforms and the introduction of the MSR. With the supply of allowances surpassing demand, there was a historical build-up of banked allowances and very low allowance prices over most of Phase 2 and the early years of Phase 3 of the EU ETS, motivating the introduction of measures to address this imbalance, including the MSR.

In Phase 2 of the EU ETS (2008 to 2012) the number of allowances that were put into circulation greatly exceeded demand, leading the TNAC to expand to reach 1.75 billion allowances. Total supply of allowances exceeded demand in every year except 2008, with the volume of allowances allocated for free or auctioned exceeding verified GHG emissions each year post 2008. The surplus of allowances was exacerbated by a cumulative volume of 1.47 billion international credits. These international credits could be used for compliance by covered entities up to a pre-determined entitlement level.[53] This additional supply added significantly to the build-up of the TNAC over Phase 2. In Phase 3, falling allowance demand would have resulted in the continued growth of the TNAC in the absence of market intervention. However, backloading of allowances, and the introduction of the MSR helped to reduce TNAC levels over the period to 2019, as shown in Figure 5 below.

[53] In Phase 3, international credits were required to be traded for EU allowances and are no longer direct compliance mechanisms. It should be noted that these credits represent almost 1.5 billion tonnes of GHG emissions abated through corresponding JI and CDM projects in other jurisdictions.

Figure 5 TNAC composition Phase 2 and 3



Source: Vivid Economics based on European Union Transaction Log

A major driver of the increase in TNAC over Phase 2, was the lower-than-expected demand due in large part to the economic crisis. Emissions fell in 2009 driven by reduced output in energy-intensive sectors and lower electricity consumption due to the financial crisis and economic slowdown.[54] GDP growth of the EU over the period of Phase 2 was persistently lower than anticipated in the modelling exercises that informed the design of the phase.[55] Demand was dampened further through the success of overlapping policies such as renewable energy and energy efficiency targets.[56] In 2010, the energy intensity of EU industry was 149 tonnes of oil equivalent (toe) per million euro, down from 174 in 2000 and 167 in 2005, falling more rapidly than expectations.[57] By 2013, total renewables deployment was slightly higher than anticipated for the EU in 2011.[58] The combination of these effects coupled with the economic slowdown, meant that allowance demand was significantly suppressed, putting an upward pressure on the TNAC.

The growing TNAC reduced scarcity of allowances on the secondary market, leading to very low allowances prices. The allowance price fell to lows of €4.46/t in 2013, weakening the signal to mitigate emissions and invest in low-carbon technologies.[59] Perceived policy uncertainty, related to the credibility of climate policy and future emissions targets, has also been cited as a factor for allowance price and demand deterioration.[60] This lowered demand further for hedging and from non-compliance actors who lost confidence that allowance prices would continue to rise.

In total, 1.75 billion unused allowances were available to be carried over from Phase 2 to Phase 3. The Phase 2 TNAC grew from zero in 2008 to over half a billion allowances by the end of 2010. By the end of Phase 2, the

[54] https://www.nber.org/system/files/working_papers/w17569/w17569.pdf
[55] https://ec.europa.eu/energy/sites/ener/files/documents/trends_to_2030_update_2007.pdf
[56] https://www.pnas.org/content/117/16/8804
[57] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52013DC0169&from=EN
[58] https://www.mcc-berlin.net/fileadmin/data/pdf/Publikationen/Grosjean_et_al_2014_Is_Delegation_the_Key_to_EU_ETS_Reform_May2014.pdf
[59] EU allowance prices obtained from Quandl
[60] https://ec.europa.eu/energy/sites/ener/files/documents/trends_to_2030_update_2007.pdf

TNAC had grown to 1.75 billion allowances. Market participants were able to carryover these unused allowances into Phase 3, adding supply equivalent to 11% of the cumulative cap over Phase 3.

In Phase 3, GHG emissions were again lower than anticipated. Modelling from 2013 projected EU-28 emissions to be 4,626 $MtCO_2e$ in 2015, with 2,091 $MtCO_2e$ from ETS covered sectors.[61] In reality, emissions from covered sectors stood at 1,802 $MtCO_2e$ in 2015, 289 $MtCO_2e$ lower than anticipated.[62] While the cap declined in this period from 2.1 billion tonnes in 2013 to 1.9 million tonnes in 2019 at an average annual declining rate of 1.95%, verified emissions have been significantly under the cap every year, declining at the faster rate of 3.57% on an average annual basis. This fall in demand was largely driven by climate and energy policies that led to a decrease in emissions from electricity and heat production; while emissions from industry also decreased slightly.[63]

The allowance surplus was exacerbated by delivery of allowances under the NER300 program and continued use of international credits. This NER300 program was introduced to raise financing for carbon capture and storage and innovative renewable energy, monetising 300 million allowances over 2011 and 2012 from the New Entrants Reserve. These allowances were sold by forward contracts and became available to market participants in 2013 (210 million) and 2014 (89 million) adding 300 million allowances to available supply. In addition, over 450 million international credits had been used in Phase 3 by the end of 2019.

The growing TNAC at the beginning of Phase 3 was a cause for concern for policy makers and a growing recognition of the need to rebalance the market. The price of EU allowances fell to lows of €4.46/t and €6.00/t in 2013 and 2014 respectively.[64] These low prices provided very little incentive to regulated entities to reduce emissions or invest in low-carbon technologies. Given these structural market imbalances could not be dealt with by the market itself within a reasonable timeframe, the European Commission approved the backloading of allowances and subsequently the introduction of the MSR as a long term solution.[65]

'Backloading' of allowances was the primary tool for reducing the TNAC prior to the introduction of the MSR. Backloading, introduced under an amendment to the EU ETS Auctioning Regulation in 2014,reduced auction volumes in 2014, 2015 and 2016, by 400, 300 and 200 million allowances, respectively. [66][67] Originally, backloaded allowances would not reduce the surplus, as the 'backloaded' allowances were expected to be returned onto the market towards the end of the decade. However, in 2015, as part of the introduction of the MSR, it was decided that backloaded allowances would be placed in the MSR holding account (Article 1 (2) of Decision 2015/1814) where they could potentially face invalidation in 2023 (paragraph 23 of the 2018 amendment). [68][69] Without backloading, the TNAC would have been 53% higher at the end of 2016. Instead, when the MSR began operating in 2019, as per the EC's 2015 decision, the TNAC was reduced by 17% compared to its peak 2013 volume (Figure 6). [70]

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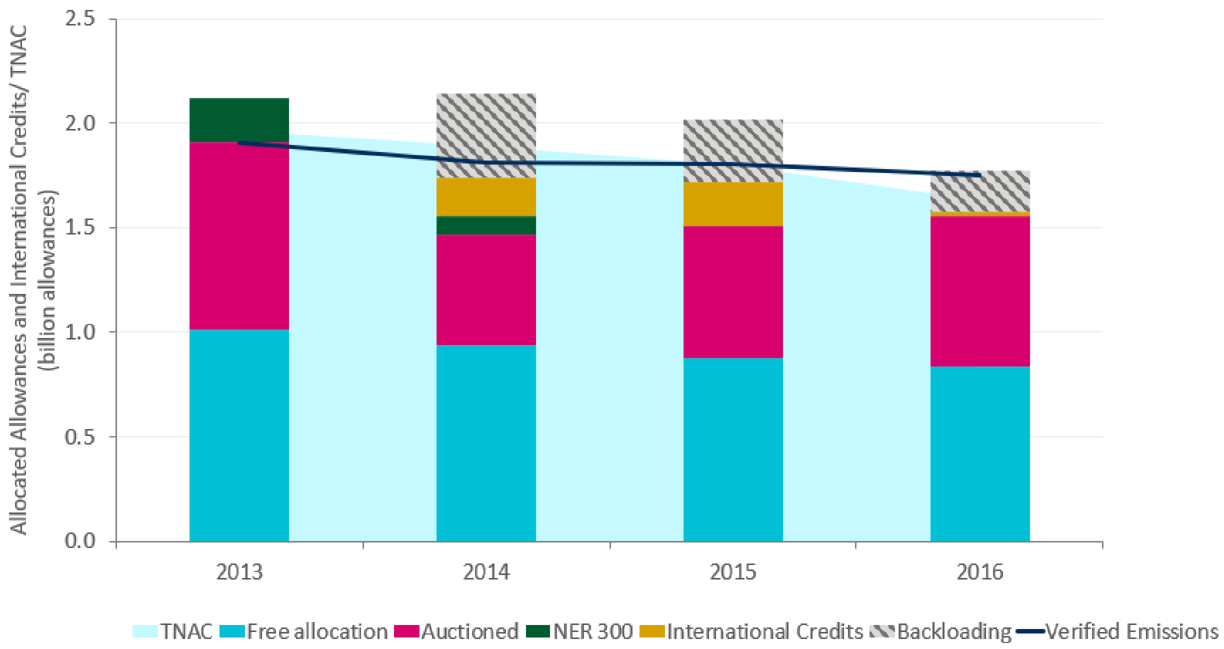
[61] https://ec.europa.eu/transport/sites/transport/files/media/publications/doc/trends-to-2050-update-2013.pdf%5d
[62] https://www.eea.europa.eu/data-and-maps/dashboards/emissions-trading-viewer-1
[63] https://ec.europa.eu/transparency/regdoc/rep/1/2019/EN/COM-2019-557-F2-EN-MAIN-PART-1.PDF
[64] https://ember-climate.org/data/carbon-price-viewer/
[65] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52014SC0018&from=EN
[66] Commission Regulation (EU) No 176/2014
[67] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014R0176&from=EN
[68] Decision 2015/1814
[69] DIRECTIVE (EU) 2018/410
[70] Decision 2015/1814

Figure 6 The impacts of backloading on the TNAC



Source: Vivid Economics based on European Union Transaction Log, EEX, ICE

A range of other policy changes also contributed to the reduction of the TNAC over Phase 3. These included the removal of unallocated allowances from the New Entrants Reserve and allowance adjustments from installations that had closed or reduced their production levels or capacity (compared to the level used to calculate initial Phase 3 allowance distributions). Estimates put these unallocated allowances at 550 to 700 million allowances through 2020.[71] Restrictions on international credit entitlements also significantly constrained allowance supply. The TNAC was further reduced by a small number of voluntarily cancelled allowances, totalling about 0.35 million allowances from 2013 to 2019.

3.1.1 Overestimation of the TNAC

The TNAC definition excludes certain sources of demand, leading to an overestimate of the number of allowances available to the market. When calculating the TNAC, allowance demand is currently calculated as verified emissions and allowances cancelled in accordance with Article 12(4) of Directive 2003/87/EC.[72] This fails to consider demand from aviation operators, linked systems, and other sources where allowances can be used for regulatory compliance.

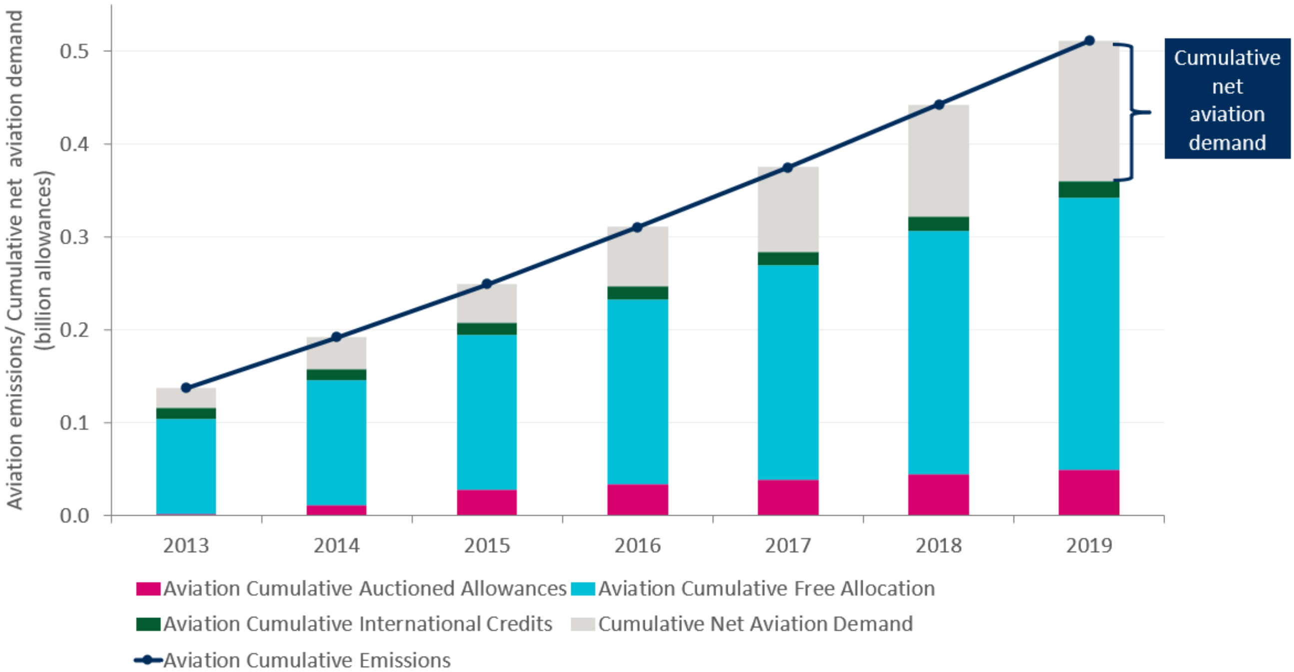
Aviation has been in the scope of the EU ETS since 2012, with all airlines operating flights within the European Economic Area (EEA) required to monitor, report, and verify emissions reductions.[73] The aviation sector's annual cap for allowances is determined and allocated separately from stationary emissions sources. EU aviation allowances (EUAA) are distributed as 82% free allocations, 15% auctioning, and 3% to a separate reserve for distribution to fast-growing aircraft operators and new entrants.[74] Participating aircraft operators

[71] https://ec.europa.eu/clima/policies/ets/reform_en
[72] Member states can cancel allowances at any time at the request of the holder. They may also cancel allowances from auction volumes that correspond to the 5-year average emissions of electricity generating plants that have closed.
[73] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52019DC0557R(01)&from=EN All international flights operating to or from EU countries were initially intended to be covered. However, a scope was limited in 2013 in recognition of the International Civil Aviation Organization (ICAO) developing global aviation standards and implementing a Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA).
[74] https://ec.europa.eu/clima/policies/ets/allowances/aviation_en

can surrender EU allowances or EUAAs to meet their liabilities. In contrast, stationary installation operations are ineligible to use EUAAs for compliance.

The TNAC would have been smaller in every year of Phase 3, with smaller MSR adjustments, if net demand from aviation was included in the definition. Domestic aviation accounts for 3% of the EU's GHG emissions, however the rapid increase in demand for aviation over the last decade means that it has consistently been a source of demand for allowances. [75] Net demand for allowances can be calculated by subtracting the sum of free and auctioned EUAAs from aviation emissions. International credits entitlements for aircraft operators should also be included. This net demand for EU allowances from the aviation sector has increased consistently over 2013-19, with cumulative net demand reaching over 151 $MtCO_2e$ in 2019 (Figure 7).

Figure 7 Net aviation emissions 2013 – 2019



Source: Vivid Economics based on European Union Transaction Log

The inclusion of aviation would have reduced the TNAC in each year of Phase 3, impacting MSR adjustments. When included in calculations, net aviation demand reduces the TNAC, resulting in lower total allowances in circulation than recorded at present. Thus far, this impact has been limited with the largest difference occurring in 2019 when net aviation demand was the highest at approximately 151 million cumulative allowances. In 2019, accounting for this net demand would have reduced the MSR's intake from 397 to 359 million allowances, a 9.4% lower intake than under the current definition. From September 2020-August 2021, accounting for this net demand would have reduced the MSR's intake from 308 to 303 million allowances, a 1.4% lower intake than under the current definition. [76] Aviation emissions in 2020 are expected to be significantly lower due to COVID-19, which may limit aviation's demand for EU allowances, but demand is projected to grow thereafter. [77]

[75] https://ec.europa.eu/clima/policies/transport/aviation_en
[76] Original published amount of 333 million (May 2020) adjusted to 307.7 million due to Brexit auction volume adjustment notice: see legal notice https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020XC1211(07)&from=EN. The original MSR intake in 2020 was calculated to be 375 million allowances (from Sep 2019 – Aug 2020, 2/3 * 397million allowance and from Sep 2020 – Aug 2021, 1/3 * 333 million allowances). Following the revision of the Sep 2020 – Aug 2021 intake, the intake between Sep 2019 – Aug 2021 is 367 million allowances.
[77] https://www.eurocontrol.int/sites/default/files/2020-04/eurocontrol-aviation-recovery-factsheet-27042020.pdf

The ETS link with Switzerland represents sources of supply and demand for allowances. The Swiss ETS linked with the EU ETS on January 1st, 2020 after a 10-year process of negotiations. The Swiss ETS covered about 10% of the country's total GHG emissions in 2019, or 4.72 $MtCO_2e$ (2017 data).[78] EU and Swiss operators can surrender allowances from either system to meet their emissions liabilities.[79] Since allowances are fully fungible between the two systems, if Swiss demand and supply of allowances are not included in the TNAC calculation this could lead the TNAC to misrepresent the overall market balance. As a relatively small source of demand and supply this alteration is of less importance to the MSR's functioning. The Swiss demand and supply was not taken into consideration for the TNAC publication in May 2020 as it reflected the TNAC from 2019 when the EU ETS was not yet linked to the Swiss ETS.[80]

Over time, other sources of supply and demand may become relevant to the TNAC calculation and should then be included in the definition. This includes any new sources of demand and supply from new ETS links with other jurisdictions, such as the potential link with the United Kingdom. Further, the surrender of EU allowances under the Effort Sharing Regulation over Phase 4 should be considered as a source of demand.[81] Under the current legislation, EU member states have binding mitigation targets for sectors that fall outside the scope of the EU ETS, including transport, buildings, and agriculture. The Effort Sharing Regulation allows nine member states the choice to use ETS allowances for offsetting emissions in these sectors. As such, this would form another regulated source of demand for EU allowances and should be included as demand components in TNAC publications.

3.2 The impact of the MSR

The MSR was introduced in 2015, amended in 2018 and began operating in 2019 as the primary mechanism to manage allowance surpluses and deficits in the EU ETS.[82] The MSR provides supply flexibility that enables supply to respond to shocks to allowance demand. The EU ETS cap is determined well in advance of the trading period and is therefore unable to unexpected events and circumstances, such as the 2009 recession or impact of the COVID-19 Pandemic. The MSR offers a solution to this inherent inflexibility by adjusting the number of allowances available when the TNAC is too high or too low.

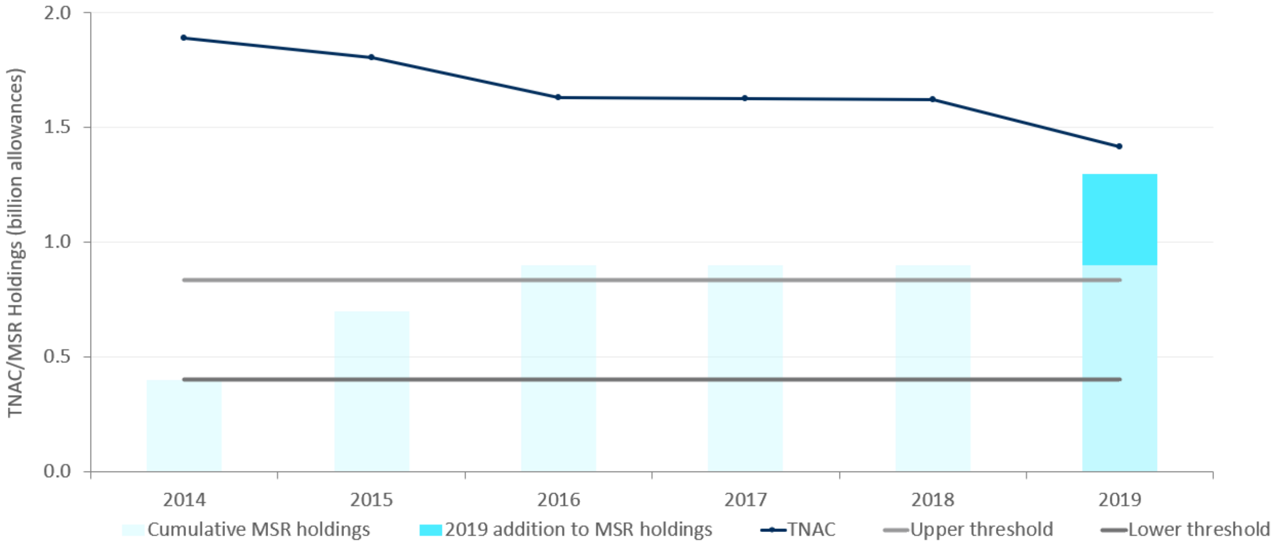
While the MSR clearly reduced the market surplus, it is more difficult to quantify its impact on allowance prices, mitigation decisions, and the competitiveness of market participants. The impact of the MSR through these channels is considered in the sections below.

3.2.1 Historical allowance surplus

The MSR's first adjustments to auctioning volumes began in 2019, where an additional 397 million allowances were added to the MSR holding account. The accumulation of allowances in the MSR holding account since 2014 corresponds to the declining TNAC over that period. Figure 8 demonstrates how the TNAC has changed over the period 2014-2020, and how backloading and MSR adjustments have led to a build-up in cumulative MSR holdings.

[78] https://icapcarbonaction.com/en/?option=com_etsmap&task=export&format=pdf&layout=list&systems%5B%5D=64
[79] https://ec.europa.eu/clima/sites/clima/files/ets/markets/docs/faq_linking_agreement_part2_en.pdf
[80] https://ec.europa.eu/clima/sites/clima/files/ets/markets/docs/faq_linking_agreement_part2_en.pdf
[81] https://ec.europa.eu/clima/policies/effort/regulation_en
[82] Decision (EU) 2015/1814 of the European Parliament and of the Council of 6 October 2015 concerning the establishment and operation of a market stability reserve for the Union greenhouse gas emission trading scheme and amending Directive 2003/87/EC, OJ L 264, 9.10.2015, p. 1. See: https://eur-lex.europa.eu/legal-content/EN/TXT/?toc=OJ:L:2015:264:TOC&uri=uriserv:OJ.L_.2015.264.01.0001.01.ENG

Figure 8 Recent evolution of the TNAC

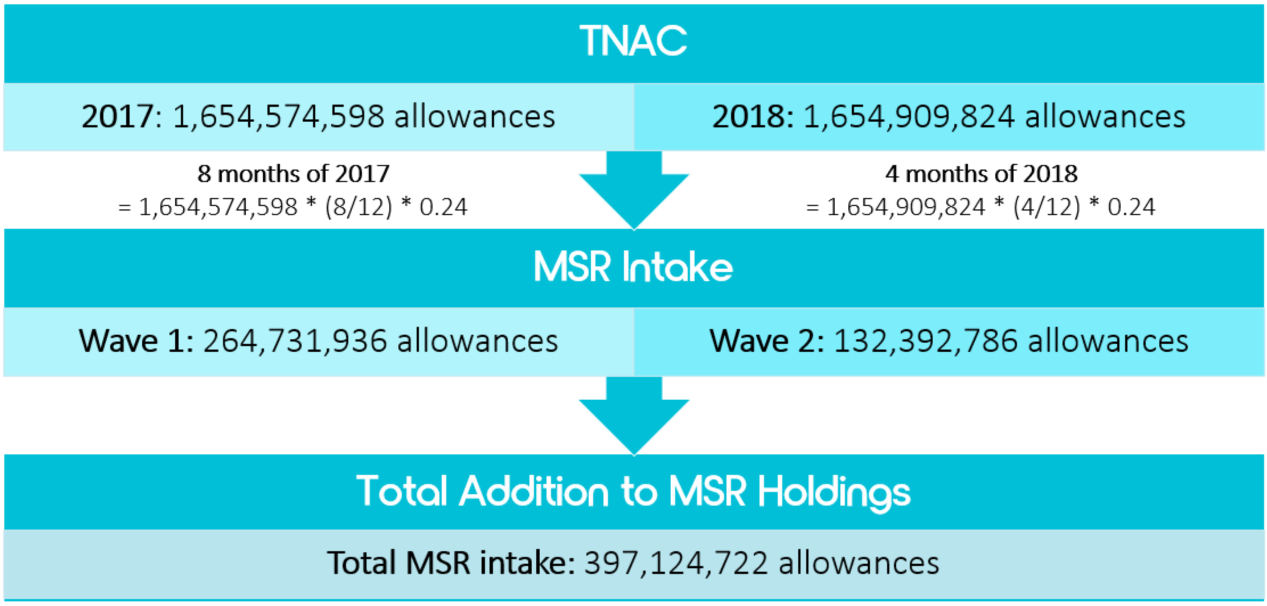


Source: Vivid Economics based on European Union Transaction Log

The MSR has begun to address historical imbalances in the EU ETS market. This includes an adjustment of 397 million allowances withdrawn from auction volumes over 2019, and 308 million allowances withdrawn from auction volumes over 2020-21, representing 24% of the previous year's published TNAC in each case, after accounting for Brexit.[83] The MSR's first intakes occurred over January to August 2019 and September to January 2019, while the second tranche of intakes continue to occur from September 2020 to August 2021. These intakes were triggered by the TNAC levels in 2017 and 2018, which were both in the range of 1.65 billion allowances, well in excess of the upper threshold of 833 million allowances. In total, 397 million allowances were withdrawn from auction volumes from 1 January 2019 to 31 December 2019 (Figure 9). Likewise, the 2019 TNAC triggered an MSR intake of 308 million allowances to be carried out from 1 September 2020 to 31 August 2021.[84] These adjustments alongside others such as backloading reduced the 2019 TNAC to 29% below its high in 2013.

[83] Following the departure of the UK from the EU ETS, the total amount of allowances that will be placed in the Market Stability Reserve from 1 September 2020 to 31 August 2021 was revised to 307,663,518 allowances (instead of 332,519,080 as published in May 2020). This is explained in the Commissions Notice (2020/C 428 I/01): https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020XC1211(07)&from=EN
[84] IBID

Figure 9 MSR First Waves of Intakes (2019)



Source: Vivid Economics based on European Union Transaction Log

Intakes to the MSR are expected to continue reducing the historical surplus in coming few years, with the TNAC remaining above the upper threshold. As long as the TNAC remains above the upper threshold, MSR intakes will continue. The COVID-19 pandemic has temporarily reduced emissions, putting an upward pressure on the TNAC. As such, MSR intakes are expected to continue for a few years, addressing the historical surplus built up over Phase 2 and 3 while also responding to the demand shock stemming from the COVID-19 pandemic.

The year in which the TNAC falls below the upper threshold will depend on the size of the COVID-19 demand shock. In a scenario where GHG emissions fall by 155 $MtCO_2e$ in 2020, but then rebound to market balance by 2023, the TNAC would fall below the upper threshold of 833 million allowances in 2023.[85,86] In the absence of the COVID-19 pandemic, the TNAC may have reached this outcome in 2022. With a counterfactual intake rate of 12% reaching this threshold would have taken a substantially longer period of time.

The MSR's invalidation mechanism, introduced in the 2018 Directive, makes a portion of MSR intakes permanent rather than temporary. The invalidation mechanism was introduced in the EU's 2018 amendment to the MSR Decision (EU 2015/1814) and will apply from 2023 and will permanently invalidate allowances held in the MSR in excess of the previous year's auction volumes. These rules impact the overall supply of allowances on the market over the entire program length, thereby reducing the overall emissions budget available to EU ETS sectors.[87] [88]

[85] The 155 $MtCO_2e$ drop in emissions is based on analysis using the PRIMES energy system model, estimating the impact of COVID on GHG emissions. Emissions pathways are fictional and static in the sense that they do not incorporate price effects in this analysis. The PRIMES model has also been used in the 2030 EC Impact Assessment https://eur-lex.europa.eu/resource.html?uri=cellar:749e04bb-f8c5-11ea-991b-01aa75ed71a1.0001.02/DOC_2&format=PDF. This shock is close to provisional EUTL estimates of the reduction in EU ETS emissions between 2019 and 2020 (171 $MtCO_2e$). However, this figure captures the impact of COVID and all other changes between the two years, and is therefore less representative of the size of the COVID shock.

[86] Latest estimates for 2020 based on EUTL data indicate a 171 $MtCO_2e$ drop in emissions between 2019-20. Given these figures were released after the analysis was conducted, and are within 16 $MtCO_2e$ of the PRIMES data, the modelled projections are considered to be a reasonable estimate.

[87] https://ideas.repec.org/p/hhs/nlsseb/2020_004.html

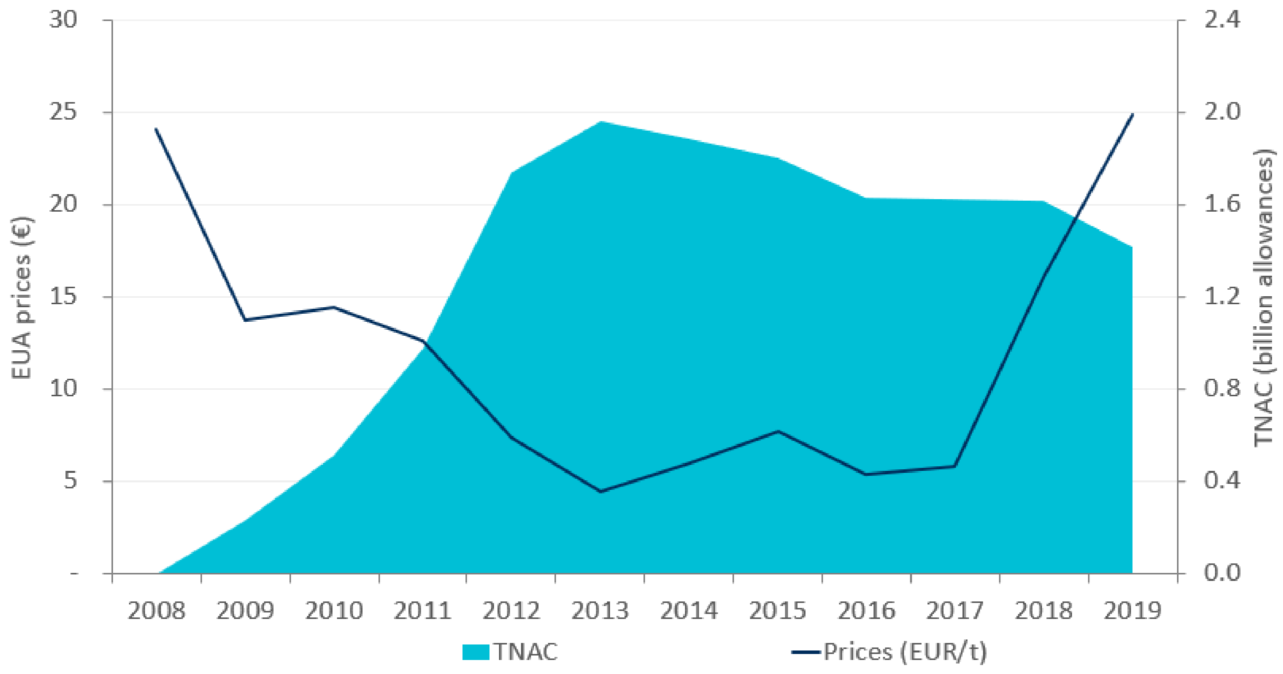
[88] Perino, G. (2018). New EU ETS Phase 4 rules temporarily puncture waterbed. Nature Climate Change, 8(4), 262-264.

3.2.2 Allowance prices and mitigation

The MSR and backloading measures helped restore historical prices from all-time lows. Allowance prices reflect perceptions of scarcity both today and in the future. The historical build-up of allowance surplus led to significantly reduced prices, reaching €4.46/t in 2013 and €5.35/t in 2016 (Figure 10). [89] With the introduction of the MSR and backloading measures, the market began to expect a tighter cumulative supply of allowances, contributing to higher allowance prices towards the end of Phase 3.

However, the increase in allowance price was dependent on broader amendments from the 2018 Directive and cannot be fully attributed to the MSR.[90][91] [92] A variety of factors, including forward looking expectations of the EU ETS and climate policy more broadly, contributed to price formation.[93] The 2018 amendments included several major policy changes, such as the strengthening of the MSR, with the temporary increase in intake rates and the introduction of an invalidation mechanism, as well as increased ambition through an increase in the LRF.[94] As such, the MSR cannot be credited with the full price increase. The full suite of policy interventions and market adjustments included in the 2018 amendments led to the rapid increase in prices seen over 2018-19 as shown in Figure 10.

Figure 10 Allowance price evolution compared to the TNAC



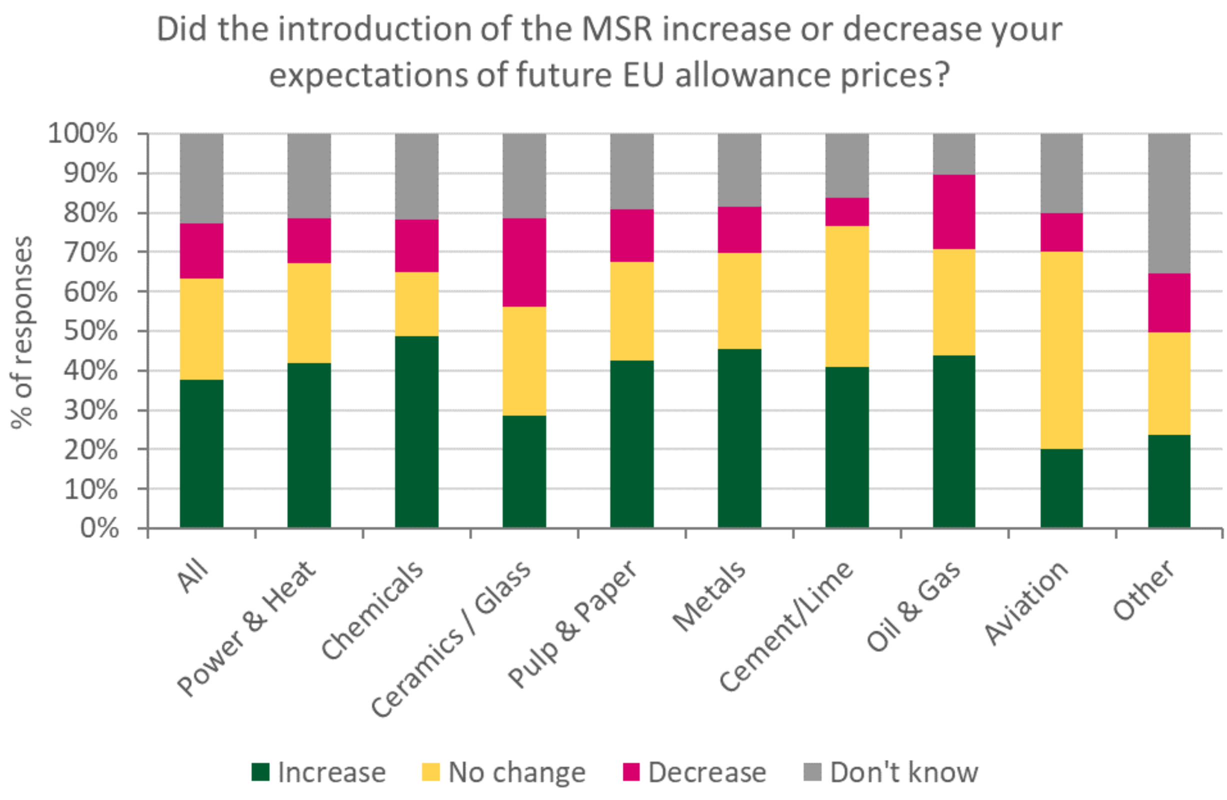
Note: EU allowance Prices (€) (LHS); TNAC (billion allowances) (RHS)
Source: Vivid Economics based on European Union Transaction Log, EEX/ICAP

There is inconclusive evidence as to the extent that the MSR contributed increased price expectations amongst market participants. Survey results of 934 covered entities show that the introduction of the MSR increased price expectations amongst 38% of respondents, compared to 26% claiming that it had no impact and 14% claiming that the MSR lowered their price expectations (see Figure 11). The result suggests that some firms

[89] EU allowance prices obtained from Quandl
[90] DIRECTIVE (EU) 2018/410
[91] https://ercst.org/background-note-the-eu-ets-market-stability-reserve-coping-with-covid-19-and-preparing-for-the-review/
[92] https://www.eionet.europa.eu/etcs/etc-cme/products/etc-cme-reports/etc-cme-report-3-2019-trends-and-projections-in-the-eu-ets-in-2019
[93] https://www.pik-potsdam.de/en/institute/departments/transformation-pathways/research/climate-and-energy-policy/events/quemin
[94] DIRECTIVE (EU) 2018/410

may not fully understand the functioning of the MSR, and its role in reducing allowance supply since it was introduced. These perceptions vary across different sectors, but the average firm tends to believe that the MSR has a small but positive impact on future prices. Targeted interviews with traders suggest that the price rise since 2017 was predominantly driven by the increasing policy ambition from the European Commission, which the 2018 amendments to the MSR helped to signal.

Figure 11 Survey response: historical impact of MSR on price expectations



Source: Survey responses

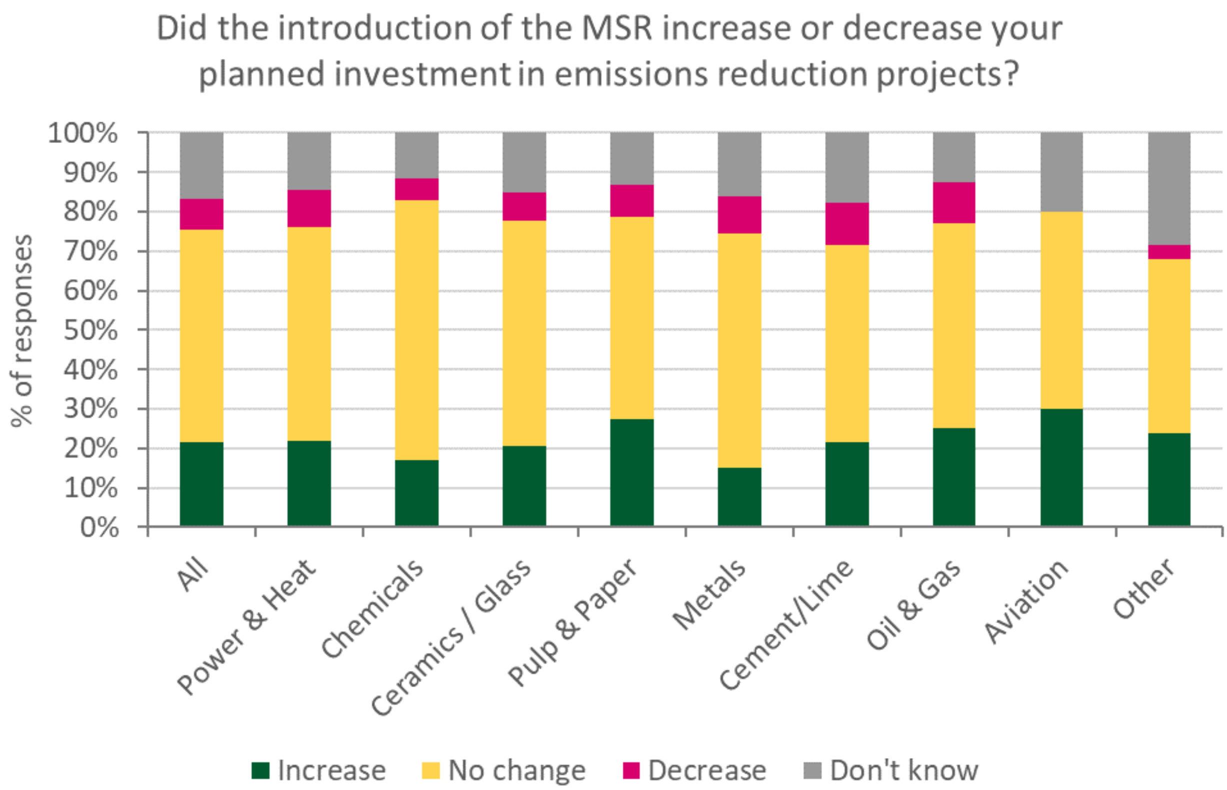
While the 2018-19 increase in the allowance price created more incentives for abatement, survey results indicate that the MSR had limited direct impact on abatement decisions. In theory, a higher carbon price would incentivise firms to reduce more of their emissions. Using a simplified estimation procedure, the observed €8.86/t price increase between 2018 and 2019 would have encouraged further abatement of between 140 to 180 $MtCO_2e$.[95] However, survey results indicate that the majority of covered entities did not increase their abatement in direct response to the introduction of the MSR (Figure 12). In each of the sectors, only 15% to 30% of firms increased their planned investment in emissions reduction projects due to the MSR. However, this result does not rule out the MSR *indirectly* supporting abatement investments by strengthening the perception of EU ETS ambition and increasing price expectations, a sentiment that is echoed by market analysts.

The MSR's mixed impact on abatement investment decisions is potentially tied to the sense from some liable entities that it did not make prices more predictable. In the survey, about 30% of covered entities claimed that the MSR made prices less predictable, compared to 20% who claimed that the MSR improved price predictability and 21% claiming no impact on price predictability. Firms claiming that the MSR improved price predictability are much more likely to have *increased* abatement investments in response to the MSR (Figure 13). Conversely, respondents that believed the MSR reduced price predictability are much more likely

[95] Derived using estimated slopes of marginal abatement cost curves (MACC) from Quemin (2020) and Perino and Willner (2016)

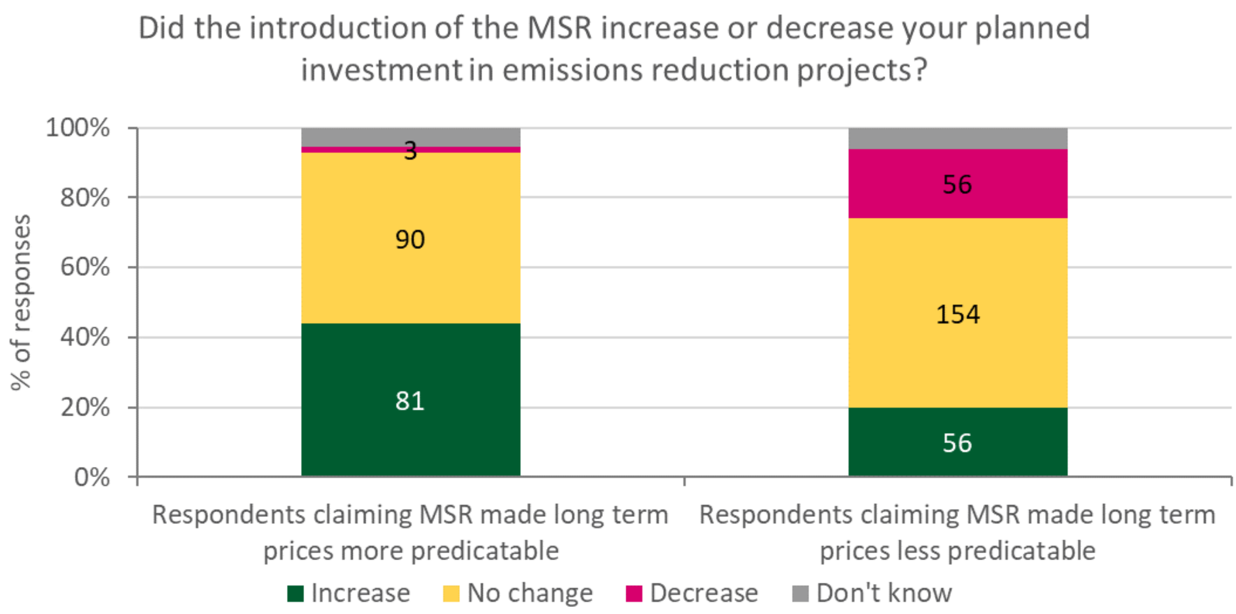
to have *decreased* abatement investments in response to the MSR. This result suggests that price predictability is critical to abatement investments, and that the MSR had heterogeneous impact on abatement because different entities perceived it differently.

Figure 12 Survey response: MSR impact on investments in abatement, by sector



Source: Survey results

Figure 13 Survey response: MSR impact on investments in abatement, by perception on price predictability



Source: Survey results

3.2.3 Competitiveness and the MSR

Competitiveness considers the potential impact on a range of factors that could affect a firm's performance.[96] Competitiveness is a concern where carbon pricing introduces changes to production costs that can impact the relative position of firms. In markets where international competition is strong and emissions intensities are high, firms are at risk of carbon leakage, where production, investments or other activities move to jurisdictions where carbon costs are lower. When there is no means of offsetting or equalising relative costs between regulated firms and competitors, carbon leakage can lead to a transfer of emissions outside of the EU's scope without reducing net global emissions. The EU ETS impacts competitiveness by creating additional production costs associated with carbon liabilities that may be passed on to consumers. The costs each firm faces varies depending on parameters relating to the EU ETS like the allowance price and levels of free allocation, as well as on exogenous factors, for example abatement opportunities or market structure.

The MSR affects competitiveness through several channels, including impacts via market prices, price volatility, market liquidity, strategic behaviour, market sentiment, predictability, complexity and transparency. The MSR's impact on competitiveness is yet to be directly discussed in the broader academic literature, given its recent introduction and limited evidence of carbon leakage from the initial phases of the EU ETS. MSR adjustments to auctioning volumes restrict short term supply, and therefore put upward pressure on allowance prices. However, many other factors, such as the perception of increasing ambition in the future and developments in mitigation technologies will also impact allowance prices. Disentangling the level of price rise that is attributable to the MSR relative to other events occurring concurrently is challenging, but it is broadly agreed that the MSR contributed, in part, to the price rise. Modelling discussed later in this section suggest allowance prices in 2020 would have been 4.50 EUR lower if the MSR was not in place.

Competitiveness impacts are most likely for regulated entities producing carbon intensive goods that are traded on international markets. The risk of a loss in competitiveness is identified by the EU as most pronounced for firms that have both a large increase in costs because of the ETS (typically because they are emissions intensive), or who are unable to pass on this increase in costs (typically because of international competition). These industries are referred to as emissions-intensive, trade-exposed (EITE) industries.

[96] https://www.jstor.org/stable/25048725?seq=1

Changes in competitiveness create a risk of carbon leakage, and potential impacts on growth and jobs. If international competitors do not need to comply with equally stringent carbon regulation, the carbon price creates a differential in production costs. Given free allocations throughout Phase 3 and Phase 4 for EITE sectors, these firms only experience a proportion of any MSR induced price rises. Interviews with market participants indicate that the most important aspects with respect to competitiveness considerations are the overall cap and decisions on free allocation or a potential CBAM for EITE sectors.

Price stability and predictability are important for investment decisions and therefore a firm's longer-term competitiveness position. Investment in mitigation and low-carbon technology is fundamental to a smooth progression to period of higher carbon prices. The MSR plays a supporting role in increasing certainty on the EU allowance price path, but the MSR also adds to regulatory complexity. To the extent that the MSR helps ensure price stability it will also support competitiveness. However, this is unlikely to significantly impact competitiveness as excessive volatility has not been observed since the introduction of the MSR. Meanwhile, survey responses from over 900 covered entities found mixed opinions on how the MSR affected short term price stability and long term price predictability. On short term price stability, 35% respondents think there is increased price volatility due to the MSR, compared to 19% reporting no change and 15% reporting a decrease. On long term price predictability, 20% respondents think there is increased price predictability due to the MSR, compared to 21% reporting no change and 30% reporting a decrease.

For EITE firms who are able to abate at low cost, EU allowance price increases may increase competitiveness. If EITE sectors receiving free allocation are able to mitigate at a lower price than the allowance price they would be able to sell excess free allowances. Allowance price rises could support competitiveness for these firms. An increase in allowance prices will increase the net value of the firms who hold allowances in excess of their current liabilities. In this sense, any MSR induced allowance price rises will benefit them in the short term.

To assess the competitiveness impacts of the MSR, we modelled the impacts to EITE sectors that occur because of an estimated EU allowance price rise induced by the MSR. As part of the MSR modelling performed in section 5 to assess the MSR's future performance, projections of EU allowance prices are made to assess the implications for regulated entities. The price difference between a baseline policy scenario with and without the MSR can be used to assess the potential competitiveness impacts from price rises due to the MSR. In 2020, the price differential between the baseline policy scenario with and without the MSR is 4.50 EUR.[97] The price differential is used as an input in Vivid's Full Industrial Market Model (FIMM+). This competition model is built to analyse interactions between rival firms and consumers within capital-intensive industries. The intention of the model is to depict individual economic markets and to capture the impact of changes in market structure, including the entrance or exit of individual firms, changes in the nature of demand, or, of particular relevance in the context of carbon leakage, changes in production costs.

The model results suggest limited impacts on competitiveness from MSR induced allowance price rises. The price rise tested has a minimal impact on key indicators of competitiveness and carbon leakage. Table 4 summarises the change in key indicators for the EU and rest of the world. As would be expected, emission intensities and direct emissions fall. Emission intensities (defined as direct emissions per production in weight terms) fall by 1.04% on average and emissions decline by 0.99% across the seven sectors. The small scale of the changes indicates the MSR's impact on competitiveness from price rises is limited.[98]

[97] The MSR model has been run without pinning historical price paths to be able to assess how EU allowance prices diverge between the scenario with and without the MSR.
[98] FIMM+ modelling results are not directly comparable to those from the Impact Assessment under the Climate Target Plan due to different modelling approaches and different time horizon. Nonetheless, to put the relative size into perspective, the results displayed in this section regarding the historical impact of the MSR are about an order of magnitude smaller compared to the 2030 impact of adopting a 55% target.

Table 4 Vivid's competition model highlights the MSR's limited impact on competitiveness

Competitiveness indicators	Percentage change (EU)	Percentage change (rest of the world)
Production	-0.03%	0.13%
Product prices[1]	0.14%	0.00%
Emissions intensity[1]	-1.04%	0.10%
Direct emissions	-0.99%	0.33%

Note: [1] Percentage change is the simple average across the seven sectors modelled. Modelled sectors are paper, refined petroleum, fertilisers, cement, steel, aluminium and other organic chemicals. The table displays counterfactual impacts for 2020 assuming 4.50 EUR increase in carbon price, under existing measures of free allocations.

4 Future risks to MSR functioning

To ensure the resilience of the EU ETS, the MSR must operate effectively in a wide range of potential future policy environments and deliver an appropriate response to a variety of shocks. The potential changes to the EU ETS (particularly enhanced ambition, changes to scope, and to free allocation provisions) will alter the composition and behaviour of market participants and subsequently the market balance (see section 2.3). It is also likely that the composition of demand for EU allowances will change significantly over the next decade, due to the decarbonisation of the power sector, potentially more active engagement from industrial emitters, and growing interest in EU allowances as an investment asset from the financial sector. Similarly, aviation may become a more significant source of demand, depending on the scale and timing of the sector's recovery from the economic impacts of COVID-19. This requires a consideration of the wide range of potential uncertainties that could affect MSR operation.

The changing environment poses some risks to MSR functioning. This section summarises some of these risks, particularly:

- Incomplete measurement of supply and demand
- Market balance not adequately reflected by thresholds
- Disproportionate MSR response to small changes in TNAC
- Complex interactions between auction volumes, invalidations and MSR intakes
- Potentially counterproductive MSR interventions
- Inability to prevent extreme prices

4.1 Incomplete measurement of supply and demand

The MSR adjusts future auction supply based on the TNAC. This means that the definition of the TNAC is central to determining the impact of the MSR and its success in addressing market imbalance.

The TNAC, as currently defined, excludes some sources of allowance demand and supply. Demand includes verified emissions from stationary installations and voluntary cancellations, but excludes demand from the aviation sector and linked markets. Supply is more complete, but also excludes linked markets from allowance supply calculations.

As such the TNAC is currently a partial measure of market balance, which will become of increasing importance if not rectified. Over time small annual differences will accumulate to represent large cumulative volumes. By 2019, the exclusion of net aviation demand from the TNAC increased reported TNAC volumes by 150 million allowances. Further changes in the broader policy and economic environment may affect the extent to which the TNAC maps against actual market balance. For instance, if net aviation demand grows over time, or if the EU ETS links with the UK ETS (which has a much larger relative demand and supply share relative to Switzerland).

If the TNAC definition does not accurately measure the deviation from market balance, MSR interventions will not deliver the intended outcome of the policy. If the TNAC remains inflated above true market surplus, intakes will remain higher for longer, reducing allowance supply further than intended and leading to upward pressure on prices. There will also be limited opportunities for releases from the MSR, increasing the risks of insufficient outflows from the MSR when the TNAC is maintained above the lower threshold despite allowance shortages. On the other hand, if the TNAC is below the right level, there will be fewer intakes than necessary, potentially leading to low prices and lower emissions reductions. There may also be more releases from the MSR than required, creating additional downward pressure on prices.

4.2 Thresholds may no longer reflect market balance

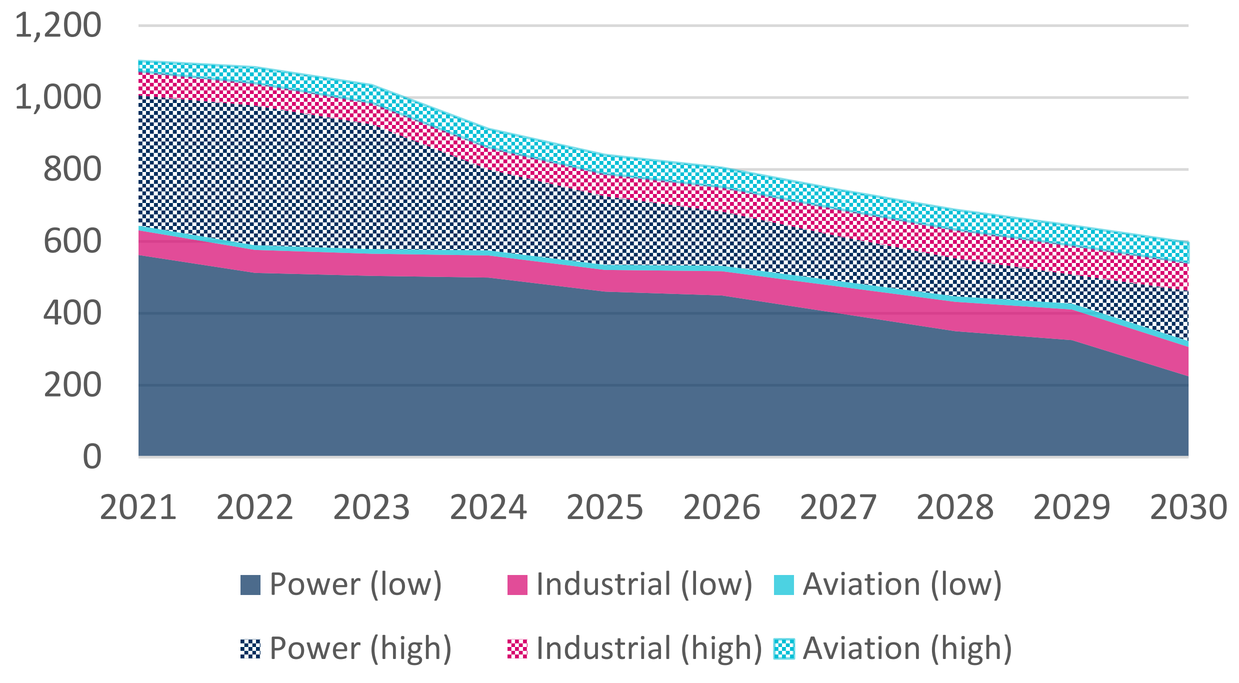
Changing patterns in allowance demand may mean that thresholds no longer reflect market balance. Since the MSR was established, demand for allowance banking has changed and will continue to evolve through Phase 4 of the ETS, driven by increasing EU allowance prices, and decarbonisation. Estimates of hedging demand from utilities are projected to decline, while hedging demand from industrials and demand for holdings from non-compliance entities are much less certain. As a result, the current thresholds for MSR interventions may no longer reflect an adequate range of market balance.

4.2.1 Changes in hedging demand

Historically, the surplus band of 400 to 833 million reflects the lower end of estimates of hedging volumes at the time.[99] However, this was deemed pragmatic given some level of consensus that hedging demand was likely to reduce over time, as renewable generation increases, and total emissions covered by the ETS fall.

Total hedging demand is expected to decline to 2030, though estimates of industrial hedging remain highly uncertain. As emissions fall in Phase 4, the demand for hedging from compliance entities is projected to fall accordingly. The estimates for total hedging demand to 2030 are between 350 and 600 million allowances, from 600 to 1,100 million today, assuming no changes in other aspects of ETS design (especially free allocations). Figure 14 shows our estimates for hedging demand to 2030. More detail on the methodology used to estimate hedging demand is available in Section 7.

Figure 14 Makeup of total hedging demand for EU allowances to 2030



Source: Vivid Economics own estimates, drawing from ICIS and BNEF estimates

[99] Department of Energy and Climate Change UK (2014) https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/391793/Assessing_design_options_for_a_market_stability_reserve_in_the_EU_ETS_Final_report.pdf

4.2.2 Long term financial sector holdings

There has been an increase in short- and long term investment in EU allowances from the financial sector. Short term trading has increased significantly in recent years, driven by increased price expectations. In February 2021, financial sector holdings increased substantially, potentially driven by an article with a positive outlook for EU allowance prices published in Bloomberg. Investment funds increased their net long positions by 15 million allowances, the largest weekly increase in financial sector holdings in the past 12 months. This contributed to a 16% rise in EU allowance prices within the week. It is not known whether the increased activity will be sustained over the long term.

Long term holdings by investors influences MSR functioning, by increasing overall demand for allowances. The size of long term speculative holdings in the market is currently estimated to range between 50 to 100 million allowances (see Section 7). This includes over-hedging by utility firms and the long term positions held by investors. A significant increase in total financial holdings could affect market balance by substantially reducing the allowance supply available to compliance entities below the MSR's upper threshold, but this scenario is considered unlikely by market participants. In the unlikely but theoretically possible situation where investment holdings are sufficient to 'corner' the allowance market, this could lead to a self-reinforcing cycle whereby MSR intakes increase price expectations and subsequent investment holdings.

A proportion of allowance holdings are likely to be illiquid and unresponsive to price increases. This could include compliance entities with fixed hedging strategies, passive speculators with long positions and non-compliance actors holding allowances in an attempt to drive climate action. These entities may not react to changes in prices by selling allowances, particularly in the short term. While the proportion of these entities is unknown, there are upside risks as the market becomes more publicly observed.

As a result, the quantity of allowances available to compliance entities may be overestimated by the TNAC. As all these holdings contribute to the TNAC, this figure is likely to overestimate the availability of allowances to market participants.

4.3 Disproportionate response to small changes in the TNAC (the 'threshold effect')

Intakes and releases are inconsistently affected by small changes in the TNAC. Around the upper and lower thresholds, intakes and releases act discontinuously. These variable dynamics can lead to fluctuations in auction supply and prices, potentially undermining confidence and reducing abatement activity.

The current intake and release mechanisms are discontinuous around the upper and lower thresholds. When the TNAC is slightly above the upper threshold, intakes into the MSR are at least 100 million allowances for a 12% intake rate, while below the upper threshold intakes remain zero. For example, if the TNAC in the prior year is 834m, the MSR subsequently withdraws approximately 100m allowances (12% of 834m) from auctions. If the TNAC is 832m instead, the MSR does not take any action. Similarly, for a TNAC above the lower threshold no allowances are released from the MSR, while a TNAC slightly below the lower threshold triggers releases of 100 million allowances.

This can lead to large fluctuations in allowance supply based on small variations in the TNAC. A small variation in measured TNAC close to the upper threshold could lead to intakes rather than no MSR intervention, and variations around the lower threshold has similar implications for releases. Intakes or releases of 100 million in 2030 equate to 12% of the total cap, or roughly 18% of auction volumes under the central policy scenario. This is likely to have a subsequent impact on prices, and firms' ability to hedge as desired.

This volatility in allowance supply can increase price uncertainty, undermine confidence in the EU ETS and reduce abatement. Variations in allowance supply and subsequently prices based on arbitrary differences in the TNAC could disengage market participants, undermining confidence and ultimately the climate ambition of the ETS and MSR.

4.4 Complex interactions between auctions, the MSR and invalidations

The current invalidation mechanism depends on auction volumes, which can be altered by external policy decisions or the operation of the MSR itself. The invalidation mechanism invalidates all allowances held in the MSR above the previous year's auction volume. Under this design, the invalidation quantity is affected by policy changes such as a phase out of free allocation, where an increase in auction volumes would lead to fewer invalidations. The invalidation quantity is also affected by fluctuations in auction volumes due to the intake and release mechanisms.

Invalidation quantities are affected indirectly by the intake and release mechanism. For instance, as intakes to the MSR reduce auction volumes, the invalidation mechanism will invalidate a higher quantity of allowances following a year with intakes. Allowances may enter the MSR holdings account as the result of an event that lowers the demand for allowances, such as a negative economic shock. In such instances, permanent invalidations make sense as the allowances are likely not needed in the market. However, there may be situations where a transitive market shock could result in a higher quantity of invalidations. Such an outcome would be at odds with the objective of the mechanism given the likelihood the shock would correct in a short period of time.

The interdependence of invalidations and other policy variables reduces the transparency of the invalidation mechanism. Linking invalidations to auction mechanism adds an element of uncertainty to invalidations, allowing external factors such as policy decisions and the TNAC to impact outcomes. This can reduce the ability of covered entities to understand and engaged with the EU ETS.

4.5 Counterproductive responses to intertemporal optimisation

The MSR does not distinguish between reasons for changes in the TNAC. The assumption implicit in the current MSR design is that a high TNAC reflects a market with a surplus of allowances, and a low TNAC reflects a market where the scarcity of allowances could undermine the efficient functioning of the market. However, there may be situations where changes in the TNAC reflect more complicated dynamics.

With anticipatory banking, a high TNAC could reflect a future expected scarcity of allowances. Anticipatory banking is driven by firms optimising their holdings and abatement decisions across time periods in response to policy changes. For instance, an expected increase in future policy ambition, would increase price expectations. This increase in future price expectations would also be reflected in increased current prices and increased abatement from firms. This in turn would result in firms increasing banking in the near term, increasing the TNAC.[100] In this case, the increase in the TNAC does not reflect an oversupply in the market, but a rational response to increased future policy ambition.

Under the current MSR design, anticipatory banking would result in higher intakes to the MSR and therefore price increases for compliance entities, assuming the TNAC is above the upper threshold. As a result, the MSR would compound the expected tightening in allowance supply, with a higher intake rate leading to larger impacts. This additional reduction in allowance supply due to the MSR would further increase prices and compliance costs. This implies that rational behaviour from compliance entities aiming to smooth their compliance costs over time could lead to MSR intakes, even in the absence of underlying market imbalance.

Conversely, if EU allowance demand is anticipated to fall due to overlapping climate policies, the TNAC may fall even as allowances become less scarce. Overlapping climate policies, such as an accelerated coal phase out or renewable energy deployment, can reduce expected EU allowance demand.[101] By the converse mechanism described above, this lower expected demand reduces future price expectations, which results in lower current prices and higher current emissions. In turn, this results in a lower TNAC.

Under the current MSR, anticipated overlapping climate policies can reduce MSR intakes, partially offsetting the abatement from overlapping policies. As the anticipated reduction in EU allowance demand reduces TNAC, the MSR may intake fewer allowances or release additional allowances, driving up overall EU allowance supply. In certain situations, this can lead to higher cumulative emissions from ETS sectors than without the overlapping policy (see Gerlagh et al, 2019).

In both cases, changes in the TNAC do not reflect a change in the underlying market surplus, but the intertemporal optimisation of compliance entities. The two cases above – anticipatory banking and anticipated overlapping climate policies – may both induce counterproductive responses from the MSR. With the former reinforcing increased price expectations and the latter potentially undermining emissions reductions from overlapping policies. As these two cases have opposite effects on the TNAC, they may act to mitigate each other to some extent. However, because these cases are dependent on different sets of policy decisions, the scale and importance of these effects is likely to change over time in unpredictable ways.

[100] The expectation of reduced future supply puts upward pressure on the TNAC. Whether or not the TNAC actually increases in a given year is a function of many variables, including the size of auction supply and MSR intakes. This is why the TNAC was on decline between 2018 and 2020 despite increased expectations of future climate ambitions

[101] The LRF adjustments try to accommodate for overlapping climate policies by tightening supply accordingly. But there remains a risk that decarbonisation takes place more rapidly than what is assumed in the LRF calibration.

4.6 Inability to prevent extreme prices

The MSR was primarily designed to reduce excessive market surplus in the long run, with the current design providing little protection against excess price fluctuations in the short term. The MSR is a quantity-based instrument that responds to changes in the TNAC. However, the TNAC is an imperfect indicator of the expected scarcity of allowances, which is better reflected in allowance prices. Therefore, the MSR is imperfect in providing price stability. Although the MSR does indirectly mitigate various shocks to prices, such as supporting market confidence against a sudden drop in expected future demand (for example, during the COVID-19 pandemic), its effect is often partial, depending on the size, duration, and direction of the shock.

Measures to protect against excessive price fluctuations are established under Article 29a of the ETS Directive but may be ineffective given recent price rises. Under Article 29a, the Climate Change Committee of the European Commission may take measures to increase allowance supply at auction, including the release of 100 million allowances from the MSR if, for more than six consecutive months, the EU allowance price is more than three times the average price from the previous two years. However, this provision is unlikely to be triggered. For instance, as of March 2021, it would require prices to exceed €87.50 for six consecutive months to trigger Article 29a. Such sustained high prices could have significant negative consequences for many compliance entities that fail to anticipate the price increase. Changes to the Article 29a mechanism are outside the scope of this review.

Given the limitations of the MSR design, and the very high prices required to trigger Article 29a, there are limited tools available to limit excessive price increases should they occur.

5 MSR design options and performance

There are a range of potential design options available to account for the risks associated with the changing policy and market environment. Changes to the rules, definitions and specific parameters captured within the MSR can improve the policy's functioning against an uncertain and changing landscape moving forward.

This section presents an assessment of each MSR design elements suitability going forward and provides recommendations for changes to MSR design. A summary of the options available for each MSR element are discussed in turn, before presenting evidence on the likely performance of each design option under different scenarios. In addition to modelling analysis performed for this review, the evidence base consists of suggestions from academic papers, market analysts, survey findings and public consultation (see overall approach in Section 1.1). Recommendations for each design element are then made on the basis of this evaluation.

A summary of the recommendations to address future risks is presented in Figure 15.

Figure 15 Summary of recommendations to address future risks

Risks to MSR functioning	Recommendations
The TNAC is an incomplete measure of market balance	Update TNAC definition to cover all sources of supply and demand
Thresholds may not reflect supply needed to maintain market balance	Revise thresholds and implement a declining trajectory
Small changes in the TNAC can trigger a disproportionate response	Update intake mechanism to respond to marginal surplus (TNAC minus upper threshold)
Invalidations unnecessarily linked to auction volume and MSR actions	Link invalidation mechanism to lower threshold instead of auction volume
Counterproductive MSR interventions in some scenarios	Freeze intakes/releases given counterproductive interventions
The MSR is unable to respond to extreme prices	Consider strengthening short-term response measures
Unforeseen risks from changing policy and market environment	Implement more frequent MSR reviews

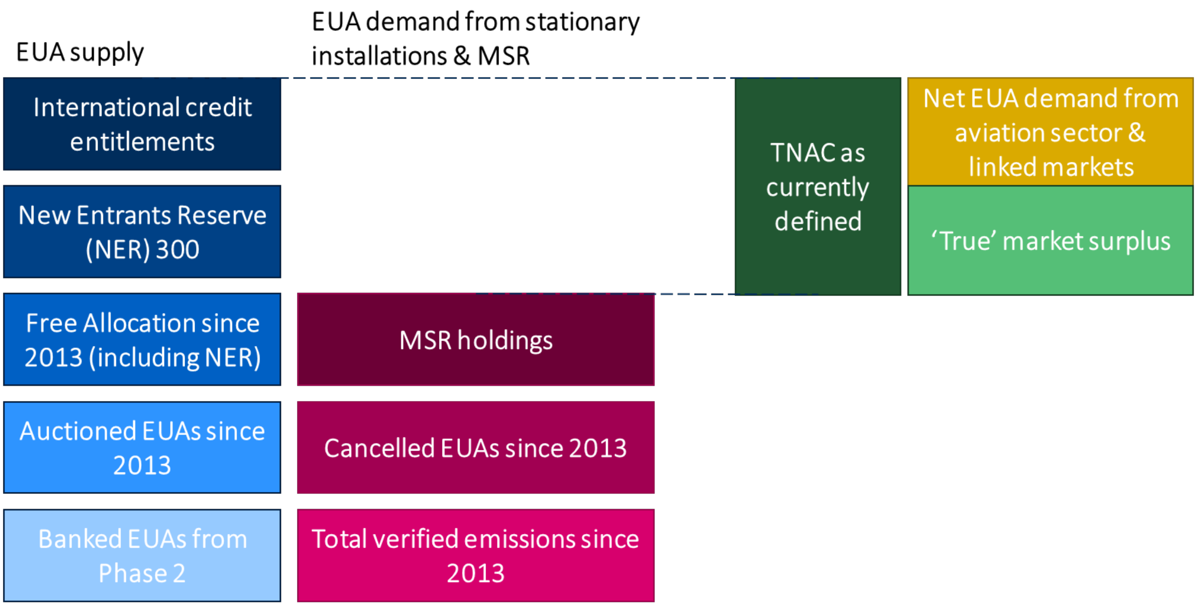
Source: Vivid Economics

Note that the modelling results provided here are based on the central policy scenario (see section 6.2.1 for details). This central scenario assumes an LRF of 5.04% will take effect in 2024 and that the EU ETS will cover domestic and intra-EEA aviation and maritime sectors. Further, we assume that the EU ETS is not linked to the UK ETS.

5.1 TNAC definition

The TNAC definition determines the calculated level of surplus identified in the market, and therefore when intervention occurs through the MSR and the scale of intervention. At present, the TNAC definition excludes certain sources of demand, leading to an overestimate of the number of allowances available to the market. When calculating the TNAC, allowance demand is calculated based on verified emissions and allowances cancelled in accordance with Article 12(4) of Directive 2003/87/EC.[102] This does not include EU allowances demanded by aviation operators and, since 2020, regulated entities under the Swiss ETS and supplies of allowances from these sources. A summary of the current TNAC definition is presented in Figure 16.

Figure 16 The TNAC definition doesn't consider allowance demand from aviation and linked markets



Source: Vivid Economics, based on ICIS (2021)

The definition could be adjusted to include all historic, current, and future sources of supply and demand. This would include EU allowances demanded by aviation operators, both historically and going forward, and regulated entities under the Swiss ETS, along with fungible sources of supply such as Swiss general allowances. The revised definition can also capture any new sources of EU allowance supply or demand which may arise in coming years, such as additional linked markets, the use of EU allowances under the Effort Sharing Regulation and any expansions in ETS scope.[103] A revised definition could also clarify how historically partially fungible allowances such as EUAAs are treated for TNAC calculations.

There have been calls from a wide range of stakeholders to include EU allowances demanded by aviation operators in the TNAC definition. Suggestions have been made to include aviation in the TNAC calculation since at least 2018 (ERCST, 2018).[104] In a recent contribution to an MSR review workshop, market analysts Bloomberg NEF recommend that 'the TNAC calculation should ideally include supply and demand from all

[102] Member states can cancel allowances at any time at the request of the holder. They may also cancel allowances from auction volumes that correspond to the 5-year average emissions of electricity generating plants that have closed.
[103] https://ec.europa.eu/clima/policies/effort/regulation_en
[104] ERCST (2018) https://ercst.org/wp-content/uploads/2019/01/ercst_brussels_27022018.pdf

participating sectors'.[105] Of 278 respondents to a recent public consultation on the strengthening of the EU ETS Directive, 62% also agreed that aviation allowances and emissions should be taken into account in the future.[106]

The TNAC definition could also account for allowance demand and supply in linked markets. The impact of not accounting for the supply and demand of allowances from linking partners depends on the size of the partner, and the design of any operating market stability measures.[107] If linking with relatively small partners, including these sources of demand and supply in the TNAC definition may not be necessary for effective MSR operation. For instance, this could occur with minimal requirements for that party to manage their own surplus using appropriately designed market stability measures. For larger linking partners, this may not be sufficient. As the size of the linked market may be such that its exclusion from the TNAC definition could result in the measured TNAC significantly deviating from the true market surplus.

5.1.1 Performance

An appropriate TNAC definition should accurately reflect the number of allowances available to compliance entities, ensuring MSR operations are based on this quantity. The definition of TNAC affects whether the MSR will be triggered and when above the upper threshold, the quantity of intakes to the MSR. As a result, the TNAC definition should accurately reflect all sources of supply and demand for EU allowances to ensure MSR operations are in line with the true market balance.

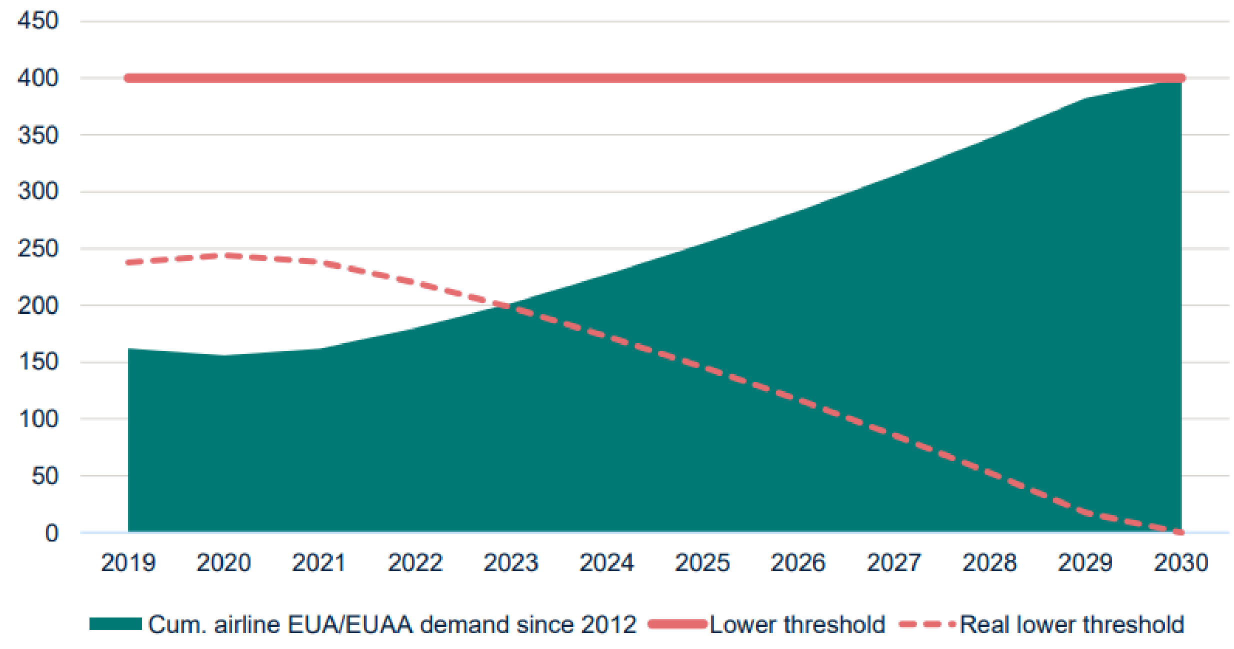
The inclusion of demand and supply from aviation in the TNAC calculation would have resulted in a smaller TNAC in every year of Phase 3. The aviation sector's allowance cap is determined separately from stationary installations, with aviation operators allocated EU aviation allowances (EUAAs). Airline operators can use both EU allowances and EUAAs for compliance, and given the historical growth in aviation demand, this has led to net demand for EU allowances. When included in calculations, net aviation demand reduces the TNAC. Cumulative net aviation demand was estimated to be equal to approximately 150 million cumulative allowances in 2019, with emissions exceeding EUAA allocations every year from 2012.

An inflated TNAC also leads to larger annual intakes. Under the 24% intake rate, the additional 150 million allowances captured in the current definition of the TNAC will lead to a further 36 million intakes each year the TNAC remains above the upper threshold. It may also inflate the TNAC above the upper threshold in future years, resulting in intakes that would not have otherwise occurred. Reduced supply increases prices and creates pressure for firms to engage in additional abatement. This tightens the market beyond the original policy intent.

Excluding aviation demand and supply from the TNAC definition also creates lower 'real' thresholds. In effect this means that the MSR continues intakes beyond desired levels, and that releases from the MSR become very unlikely. For releases to occur, the true surplus would need to be less than 250 million allowances, a level highly unlikely to be reached. If aviation demand and supply remain excluded from the TNAC definition, the calculated TNAC will be unable to fall below cumulative net aviation demand. If this exceeds the lower threshold then releases will not be possible. This limits the window in which the MSR can release allowances and jeopardises the potential response of the MSR to liquidity shortages. A projection of the real lower threshold implied by market analyst ICIS's projections for EU allowance demand from the aviation sector is presented in Figure 17.

[105] BNEF (2020) https://ec.europa.eu/clima/sites/clima/files/events/docs/20201203_discussion_3_en.pdf
[106] EC (2021) https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12660-Updating-the-EU-Emissions-Trading-System
[107] For more information, see https://www.vivideconomics.com/casestudy/interactions-between-market-stability-measures-in-linked-carbon-markets/

Figure 17 The 'real' lower threshold is projected to fall further as net EU allowance demand from aviation increases



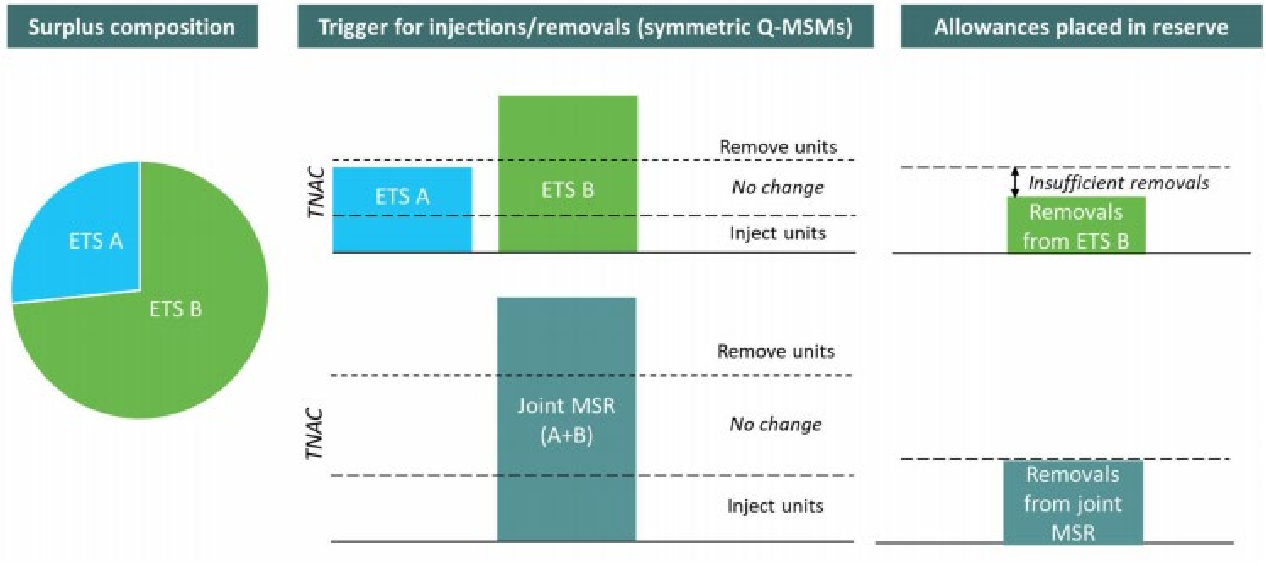
Source: Adapted from ICIS (2021)

Going forward, this discrepancy between allowances available for covered entities and the reported TNAC will be compounded by the growth of the aviation sector. Prior to 2020, the aviation sector was a net buyer of EU allowances every year. Assuming aviation demand rebounds following the COVID-19 impact, the sector is likely to remain a net buyer of EU allowances. This will lead to a growing the difference between market balance and the reported TNAC.

Excluding linked market allowances from the TNAC definition could lead to arbitrary differences in the MSR response based on the relative holdings of EU allowances or linked market allowances. Given fungibility between EU allowances and allowances in linked markets, the total surplus of these allowances will provide a better indicator of the need for MSR interventions, rather than the relative holdings of EU allowances and allowances from linked markets. If supply of, and demand for, linked allowances are not accounted for in the TNAC definition, the MSR will act differently given arbitrary changes in the composition of holdings. For instance, if participants prefer to hold EU allowances and surrender linked market allowances, the TNAC will be higher than in the scenario where EU allowances are more likely to be surrendered. In turn, this could lead to additional intakes to the MSR and higher subsequent prices for the same level of overall allowance surplus.

Even when linked jurisdictions have their own quantity-based market stability measures, a joint approach where the MSR responds to all allowances can lead to more predictable outcomes than the use of separate measures. Figure 18 presents an illustrative example of two identical linked ETSs, operating identical quantity-based market stability measures. This market is in oversupply and based on the joint surplus in the system a significant number of units should be removed based on policy-makers' preferences regarding the joint bank. However, the top panel shows that if separate market stability measures are operating, an inadequate number of allowances may be removed from the system if participants have an arbitrary preference for banking allowances from ETS B. This is because the surplus in ETS A is insufficient to trigger the removal of allowances from its system. However, a joint MSM addresses this issue by considering only the joint surplus across these jurisdictions and removing the appropriate number of allowances.

Figure 18 Parties using quantity based MSMs may need to adopt a joint approach as banking can differ arbitrarily



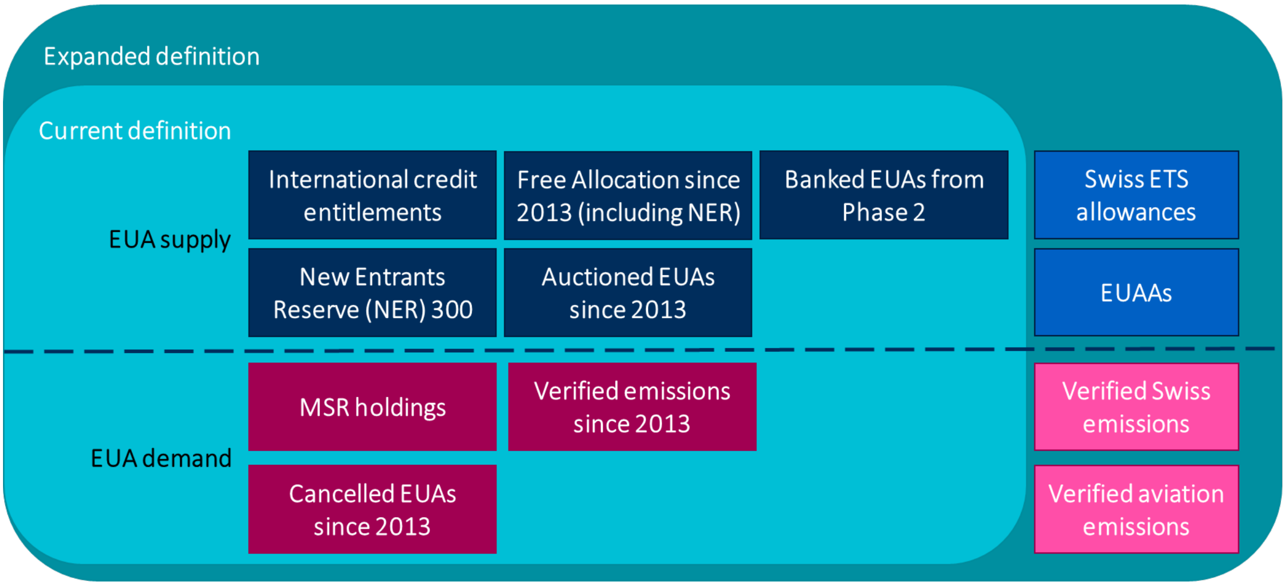
Source: Vivid Economics

New sources of supply and demand will also influence the allowance quantity available to compliance entities. Any difference between Swiss emissions and allowance supply will further impact the available market balance. Any additional linked markets, such as potential linking with the UK ETS, will further influence the availability of allowances to compliance entities. Whether linked markets increase or decrease the allowance supply available to EU compliance entities will depend on whether linked markets are net suppliers or purchasers of allowances. Another policy which will influence on allowance supply is the Effort Sharing Regulation (ESR). The ESR allows nine Member States (and Norway and Iceland) the choice to use a limited amount of ETS allowances for offsetting emissions in effort sharing sectors in 2021 to 2030. The allowances to be used for compliance under the ESR will be deducted from the amounts that would normally be auctioned under the EU ETS. If these allowances aren't removed from the supply side of the TNAC definition, this will further inflate the TNAC relative to the true volume of allowances available to compliance entities, driving up intakes and lowering the 'real lower threshold'.

5.1.2 Recommendations

We recommend revising the TNAC definition to capture all sources of allowance demand and supply in the EU ETS and linked markets, including aviation and the Swiss ETS. Immediately, this will capture all net EU allowance demand from aviation and Swiss markets, both historically and going forward. It should also capture adjustments to auction quantity due to the Effort Sharing Regulation (ESR). In addition, the definition should be made flexible to potential changes in ETS scope, such as linking with additional jurisdictions and expansion to cover additional sectors. This involves adapting the current supply and demand equations used to calculate the TNAC to include aviation and Swiss markets, as laid out in Figure 19.

Figure 19 The revised TNAC definition accounts for net EU allowance demand from the aviation sector and linked markets



Source: Vivid Economics

5.2 Thresholds

The upper and lower thresholds determine the TNAC levels at which the MSR is triggered to adjust auction supply. The upper threshold is the level above which the intake mechanism remains active, while the lower threshold determines when the MSR releases allowances. In general, the wider the range between the upper and lower threshold, the less frequently the MSR will drive deviations of allowances supply from the cap trajectory, but this may also reduce responsiveness to shocks or fluctuations in market outcomes.

The MSR's current upper (833 million) and lower (400 million) thresholds for intervention represent a conservative estimate of the level of hedging demand in the EU ETS when the MSR was designed in 2014.[108] This was deemed pragmatic given some level of consensus that hedging demand was likely to reduce in following years, as emissions in sectors covered by the EU ETS reduced.

As market size and behaviour change over time, it is appropriate to consider changing threshold levels. Thresholds can be adjusted to reflect changes in the size of the market and changes in hedging behaviour. The ongoing reduction in ETS covered emissions imply the market size is declining continuously. Lowering both thresholds can keep the MSR responsive to surplus while ensuring that releases from the MSR are not activated when market balance is sufficient to meet demand. This can help to maintain a more consistent relationship between MSR activity and market balance. Separately, changes in ETS coverage due to expansions in scope, linking or de-linking can also be reflected in thresholds to the extent they increase or reduce banking behaviour.

The main options to change the thresholds include:

- **Make a one-off adjustment** to the level of upper and lower thresholds.
- **Set thresholds to decline over time**, such as declining in line with the overall ETS cap.

[108] Department of Energy and Climate Change UK (2014) https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/391793/Assessing_design_options_for_a_market_stability_reserve_in_the_EU_ETS_Final_report.pdf

- A combination of both approaches.

There are mixed opinions on how the thresholds should be changed. In the recent public consultation regarding the strengthening of the EU ETS Directive, 46% of respondents believed that the thresholds are fit for purpose, 18% believed that they should be increased, and 37% believed that they should be reduced. Amongst academia and market analysts, there is a much clearer consensus that thresholds should be lowered in the future as hedging demand within the EU ETS falls. However, there are different propositions on how to reduce the thresholds including one-off adjustments and/or continuously declining thresholds.

5.2.1 Performance

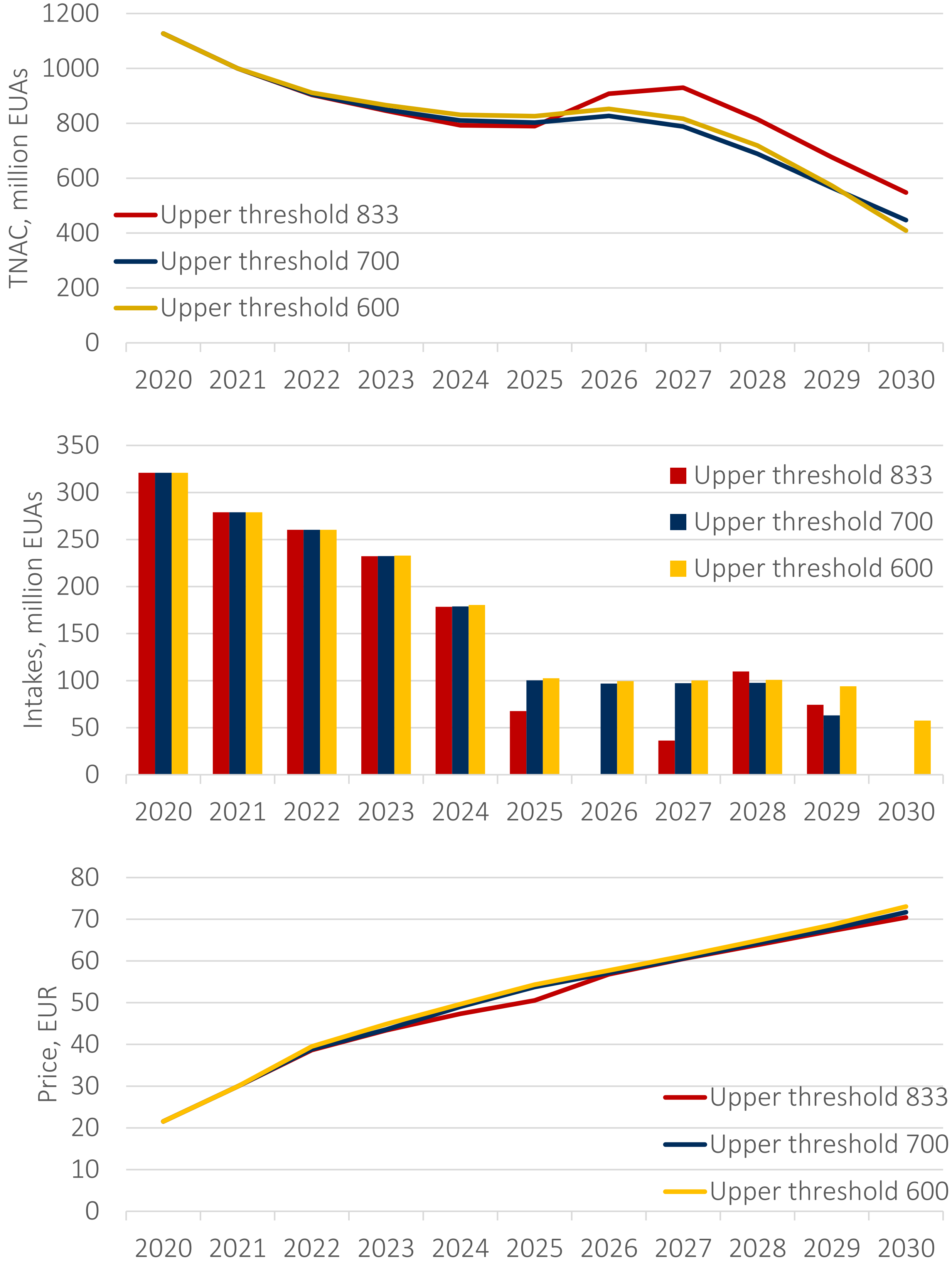
Well defined thresholds enable efficient intertemporal optimisation through allowance banking while ensuring the MSR remains responsive to shocks. Thresholds should be defined to permit a reasonable range of hedging and other holdings within the ETS, while ensuring that deviation from 'reasonable' market balance triggers an MSR intervention. The appropriate value for thresholds therefore depends on the likely demand for hedging from all key sources including electricity generators, industrial participants, and aviation and maritime. They should also consider the potential scale of demand from long term investors, noting that demand from this source is likely to be relatively small (less than 100 million allowances annually) based on insights from expert interviews.

Reducing the upper threshold can lead to a greater quantity of intakes, reducing cumulative auction supply. A lower upper threshold is likely to increase the number of years during which the MSR is triggered, leading to larger cumulative intakes to the MSR and reducing cumulative auction supply. To the extent that this reduces a surplus of allowances, this helps eliminate this surplus and provides upward pressure to prices. This may then affect compliance entities' abatement and hedging decisions. In the case of a very low upper threshold, this may reduce liquidity in the EU allowance market and increase the costs associated with sourcing allowances, but this is unlikely given the current liquidity of the secondary market.

Analysis finds that reducing the upper threshold reduces cumulative auction supply and increases prices to 2030. Modelling conducted for this review (Figure 20) suggests that a reduction in the upper threshold from 833 million to 600 million leads to additional intakes totalling 269 million allowances of during Phase 4.[109] This reduces cumulative allowance supply from 11.6 billion to 11.3 billion and increases prices by €1.5 on average (peaking at €4 in 2025), driving cumulative emissions reductions of 131 MtCO_2e across the period. An upper threshold of 700 million leads to 158 million additional intakes relative to the original design. Note that the direction and relative size of price impacts are more informative than the absolute levels, with the overall impact relatively limited compared with broader changes in the ETS policy framework. However, while the price impacts in response to threshold changes suggested by this modelling are quite small, other models suggest slightly higher short term price variations. For example, ICIS analysis found that lowering thresholds to 600 million leads to similar additional cumulative intakes (229 million during Phase 4 as compared to 269 million in the Vivid model) but generates a larger price response (increase of approximately €10 in 2027, before reducing to €5 by 2030).[110]

[109] Modelled scenarios assume current MSR design features, with the exception of including aviation in the TNAC definition and the changes in the upper threshold analysed.
[110] ICIS (2021) https://analytics.icis.com/wp-content/uploads/2021/02/ICIS_2021-02-12_European-carbon-market-to-shift-gears.pdf

Figure 20 A lower upper threshold increases intakes into the MSR, spurring higher EU allowance prices



Note: Modelled scenarios assume current MSR design features, with the exception of including aviation in the TNAC definition and the changes in the upper threshold analysed.

Source: Vivid Economics

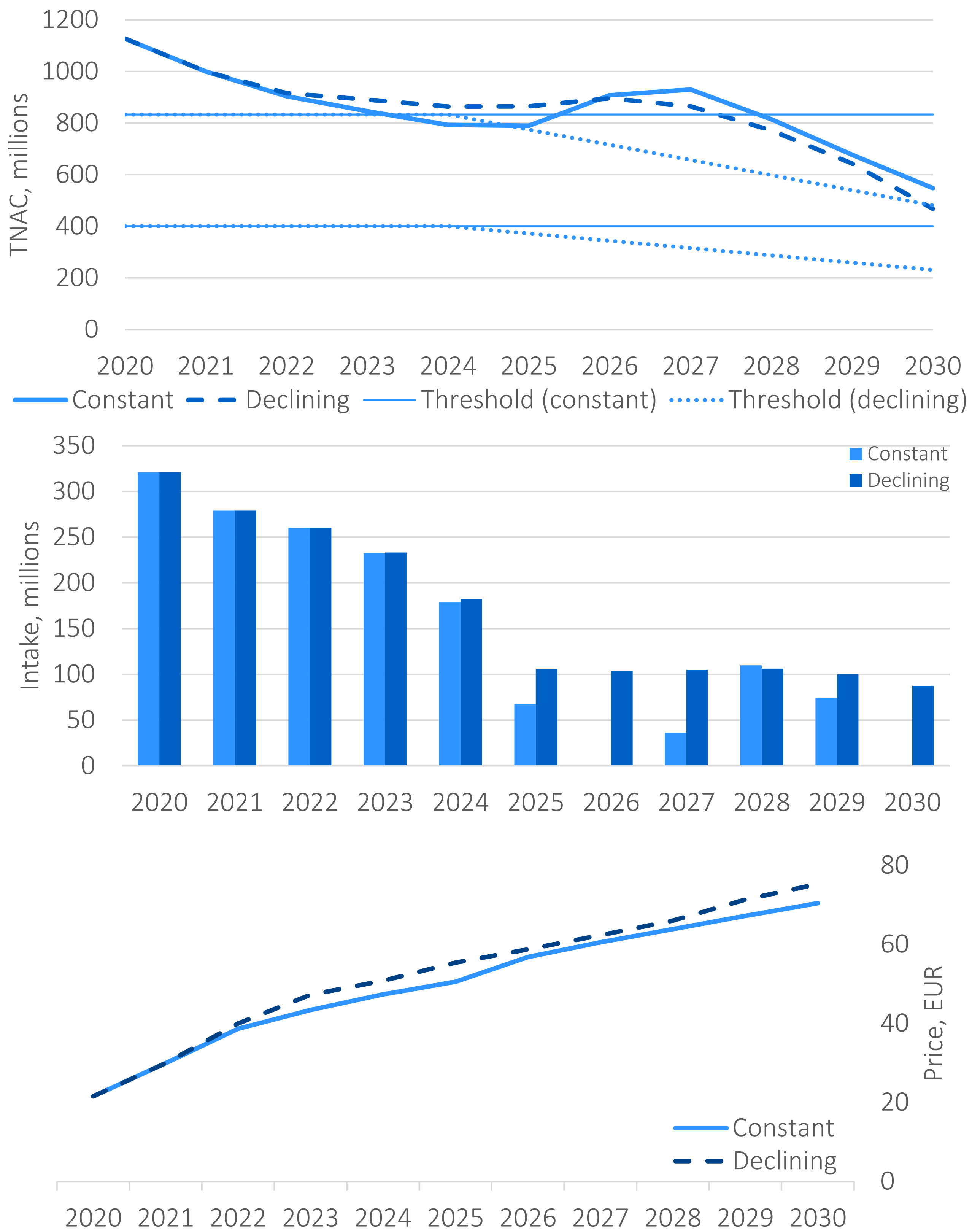
Reducing the lower threshold could increase risks related to an undersupply of allowances. The lower threshold determines the point at which the MSR releases allowances to provide additional liquidity in the case of a shortage of allowances. While TNAC is not expected to fall below the lower threshold in Phase 4 under most market projections, there are tail risks associated with reducing the lower threshold. Entities are unable to borrow allowances from future supply, which means that an MSR release is required to stem excessive prices (and high compliance costs) in an overly tight market. This suggests that setting the lower threshold at too low a level may have significant risks if not accompanied with additional short term response measures.

Thresholds which align with hedging demand can increase MSR resilience, though this is subject to significant uncertainty. The estimates for total hedging demand to 2030 are between 350 and 600 million allowances, from 600 to 1,100 million today (see Annex 2). This assumes no changes in other aspects of ETS design, particularly with regard to the share of free allocations or sectoral scope. A reduction in free allocations is expected to lead to additional hedging behaviour from industrials, while an expansion of scope would lead to further hedging demand from newly covered entities.

Setting dynamic thresholds which decline over time can ensure the threshold range remains appropriate for the size of the ETS. As the covered emissions of the ETS fall, allowance demand is also likely to fall, as hedging demand is typically a function of expected future emissions. Thresholds can be set to decline by a proportional or absolute amount over time, or in line with some other fixed trajectory, such as the ETS cap, which already follows the LRF. This approach is more transparent and predictable as compared to directly using estimated levels of hedging demand as a basis for updating the thresholds, because actual hedging demand is very difficult to monitor.

Modelling results confirm that declining threshold could lead to additional years of intakes, slightly reducing cumulative allowance supply. Figure 21 shows the outcome of modelling the current MSR design with constant thresholds and thresholds declining from 833 million and 400 million in 2024 to 481 million and 231 million in 2030 in line with reductions in the ETS cap. This was modelled to compare the direct impact of this type of design change, noting that outcomes will differ if a declining threshold is used in conjunction with a one-off adjustment to thresholds. In our modelling, the TNAC falls below the constant upper threshold in 2024 and 2025, reducing intakes to the MSR in subsequent years. By contrast, with declining thresholds, the TNAC remains above the upper threshold in all years leading up to 2030. This results in an additional 325 million allowances of intakes to the MSR compared with constant thresholds, reducing cumulative allowance supply from 11.6 billion to 11.3 billion allowances. This leads to an increase in average prices across the period of around 3 EUROs. In a similar analysis by ICIS, when the upper threshold is set to decline to around 380 million by 2030, the MSR would have an additional 379 million intakes compared constant thresholds. However, prices are much more responsive to changes in cumulative allowance supply under ICIS modelling.

Figure 21 Declining thresholds ensures the intake mechanism remains active for longer



Note: Modelled scenarios assume current MSR design features, with the exception of including aviation in the TNAC definition and the changes in thresholds. The declining scenario has thresholds declining from 833 million and 400 million in 2024 to 481 million and 231 million in 2030.

Source: Vivid Economics

5.2.2 Recommendations

This review recommends setting thresholds at 700 million and 400 million in 2024, declining with the cap to 2030. Note there is significant uncertainty regarding future hedging demand and alternative thresholds around this level could be appropriate. Some analysis, such as conducted by ICIS, has suggested upper thresholds of 600 million allowances or lower from 2024. In many cases these analyses have focused on the declining hedging needs of the power sector but may not have considered the potential increase in hedging demand from industrial emitters.[111] Hedging demand is expected to fall to between 600 and 900 million allowances by 2024. An upper threshold within these bounds can ensure that the MSR remains responsive to a surplus of allowances in the case of further negative demand shocks. Most modelling exercises suggest that the TNAC is expected to remain above the 400 million threshold throughout Phase 4. Given the potentially high compliance costs that will be incurred should the market develop a considerable shortage, this review recommends maintaining the current threshold to 2024. Implementing thresholds that decline with the cap from 2024 ensures that they are aligned with the projected decrease in hedging demand. This reduces the risk of thresholds becoming misaligned with underlying EU allowance demand as covered sectors decarbonise.

Note that alternative thresholds should be considered if substantial changes are made to free allocations or ETS sectoral coverage. Our analysis suggests that if free allocations for some industrial sectors are phased out, hedging demand could increase by 50-100 million allowances in 2030. This reflects additional hedging demand from industrial participants, who would need to plan to meet their compliance needs if they cannot rely on their free allowance allocation. In addition, thresholds should be scaled up to reflect the additional sources of hedging demand in new sectors. The appropriate level for thresholds should be re-evaluated in future reviews of the MSR.

5.3 Intake & release mechanism

The intake and release mechanisms determine the scale of intervention and hence responsiveness of the MSR to a given market imbalance. The intake mechanism determines how a surplus of allowances is treated, while the release mechanism responds to a perceived shortage of allowances. The parameters underlying the mechanism, such as intake rate and release quantity, and the mechanism definitions directly determine the extent to which the MSR responds to market imbalances, and has implications for auction supply, prices and abatement as a result.

The MSR currently intakes 24% of the TNAC when TNAC exceeds the upper threshold and releases 200 million allowances when TNAC is below the lower threshold, with both provisions halved from 2024. When the TNAC is above the upper threshold of 833 million, allowances are added to the MSR holdings account from future auction volumes at a rate of 24% of the previous year's TNAC. When the TNAC is below the lower threshold of 400 million allowances, 200 million allowances are released from the reserve and auctioned. These intake and release rates apply only to the 2019-23 period, as a result of a decision to temporarily double rates as part of the 2018 MSR amendments. From 2024, the intake rate will reduce to 12% of the previous year's TNAC, and the release rate will reduce to 100 million allowances.

An alternative intake mechanism could involve changing parameters and intake rules:

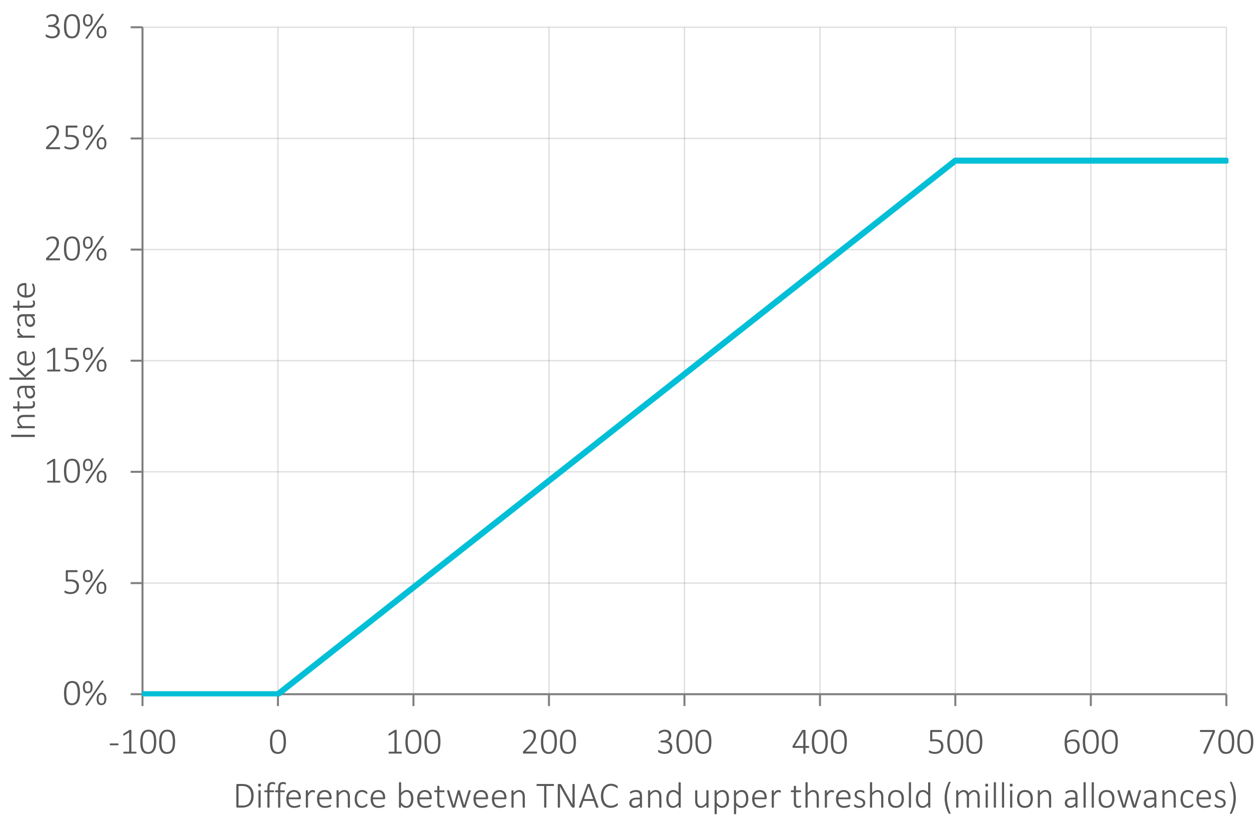
- **The intake rate could be increased from its planned level of 12% from 2024.** This could include maintaining the current rate of 24% from 2024 onwards or considering alternative rates. A continuation of the current rate was recently proposed by Denmark and Italy, arguing that the MSR's 24% intake rate should be preserved through Phase 4, due to the risks posed by a large number of

[111] For instance, ICIS analysis notes that 'The 600m level is an approximate hedging requirement we estimate for utilities at the beginning of TP4.'

surplus EU allowances. There have also been calls for higher intake rates, such as the 36% rate proposed by not-for-profit associations Carbon Market Watch and WWF.[112]

- **The intake rule could be changed to a marginal surplus response**. This would make intakes proportional to the difference between the TNAC and upper threshold. For instance, with an intake rate of 50%, a TNAC of 800 million allowances and an upper threshold of 700 million allowances, this rule would intake 50 million allowances into the MSR (50% * (800-700)). Intake rules based on the difference between the TNAC and the upper threshold can remove threshold effects entirely.
- **The intake rule could also be changed to a dynamic or variable intake rate.** This option would take an increasing proportion of the total TNAC into the MSR, as a function of the difference between TNAC and the upper threshold. An example mechanism which reaches 24% intake rate once the difference reaches 500 million allowances is presented in Figure 22. This set up avoids threshold effects while providing a similar response to larger market imbalances as the current rule.

Figure 22 A dynamic intake rate dependent on distance of TNAC to upper threshold



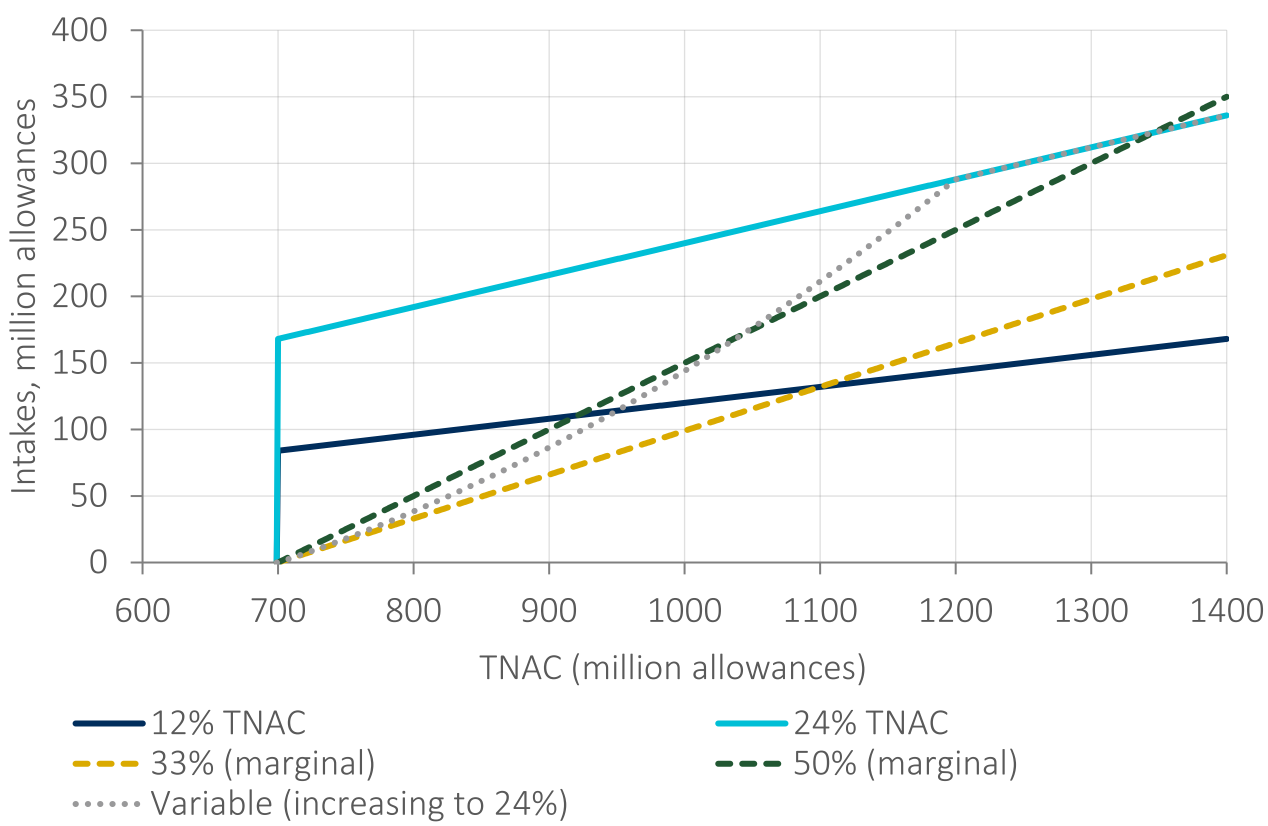
Note: This is indicative of the dynamic intake mechanisms available to policymakers, noting that the specific parameters chosen will impact responsiveness in practice.
Source: Vivid Economics

These different intake mechanisms are presented in Figure 23. This demonstrates the threshold effects that exist given the current MSR design, and how the alternative specification rules can reduce these impacts. Both the marginal surplus and variable intake approach seek to directly target the problem of excess surplus in the market, by only reducing allowance surpluses to the extent that they exceed threshold. As such, market interventions occur more gradually, which also means that these approaches reduce the impacts of

[112] https://carbonmarketwatch.org/publications/carbon-market-watchs-response-to-the-public-consultation-on-the-eu-emissions-trading-system-eu-ets-review/ ; https://wwfeu.awsassets.panda.org/downloads/wwfs_asks_for_a_revised_eu_emissions_trading_system_that_is_fit_for_purpose.pdf

choosing a given threshold level. Further these approaches enable the response of the MSR to be calibrated over time, as they automatically adjust intakes to the excess surplus level as threshold levels are adjusted.

Figure 23 Comparison of different intake rules



Note: All mechanisms assume an upper threshold of 700 million allowances.
Source: Vivid Economics

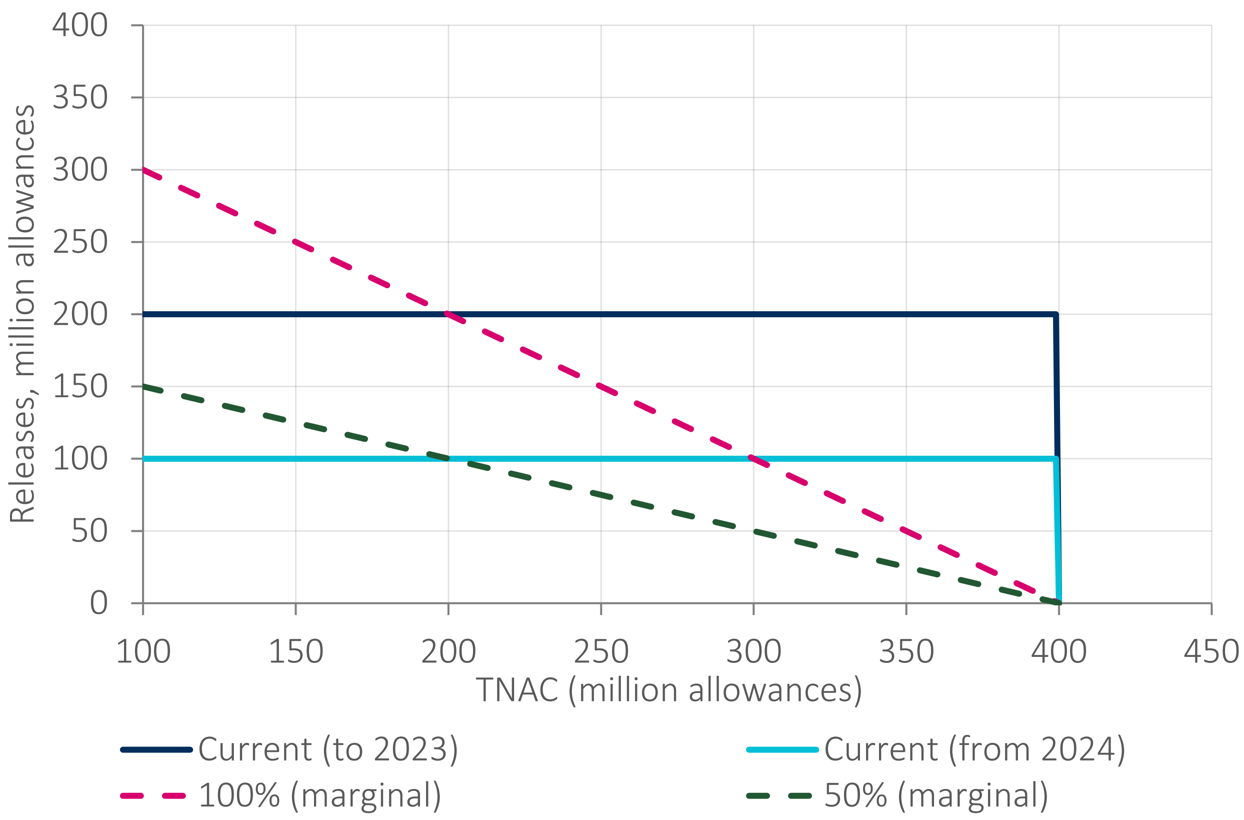
Similarly, the release mechanism could be revised in terms of the quantity of allowances release and implementing a proportional release based on the difference between TNAC and the lower threshold:

- **Altering the quantity of allowances.** The number of allowances released could be changed, with a larger quantity providing a greater response to market illiquidity but leading to greater price fluctuations in the case of releases.

- **Adopting a proportional release mechanism.** The release quantity could be scaled down as the overall ETS cap falls, ensuring releases scale with the size of the market. For example, rather than a fixed release quantity of 100 or 200 million allowances, the release mechanism could be proportional to the difference between TNAC and the lower threshold. At the extreme, a 100% release rate would release the difference between TNAC and the lower threshold, while a lesser rate would lead to a partial response.

These different intake mechanisms are presented in Figure 24. The current release rule leads to a release of 200 million allowances as soon as the TNAC falls below 400 million, providing an initial injection of liquidity to the ETS market. From 2024, this release quantity is due to be halved to 100 million allowances. This demonstrates a similar threshold effect to the current intake rule, where a small deviation in the TNAC can lead to a large fluctuation in release quantity. In addition, this quantity is then fixed, regardless of the difference between the TNAC and the lower threshold. Conversely, the proportional release mechanism is shown for a release rate of 50% and 100%. These options remove the threshold effect by responding to the difference between the TNAC and the lower threshold. For instance, for a TNAC of 250 million allowances, the 100% proportional rule releases (100% * (400 – 250)) = 150 million allowances, while the 50% rate releases 75 million allowances. This leads to a gradual response as the TNAC falls below the lower threshold.

Figure 24 Comparison of different release mechanisms



Note: All mechanisms assume a lower threshold of 400 million allowances.
Source: Vivid Economics

5.3.1 Performance

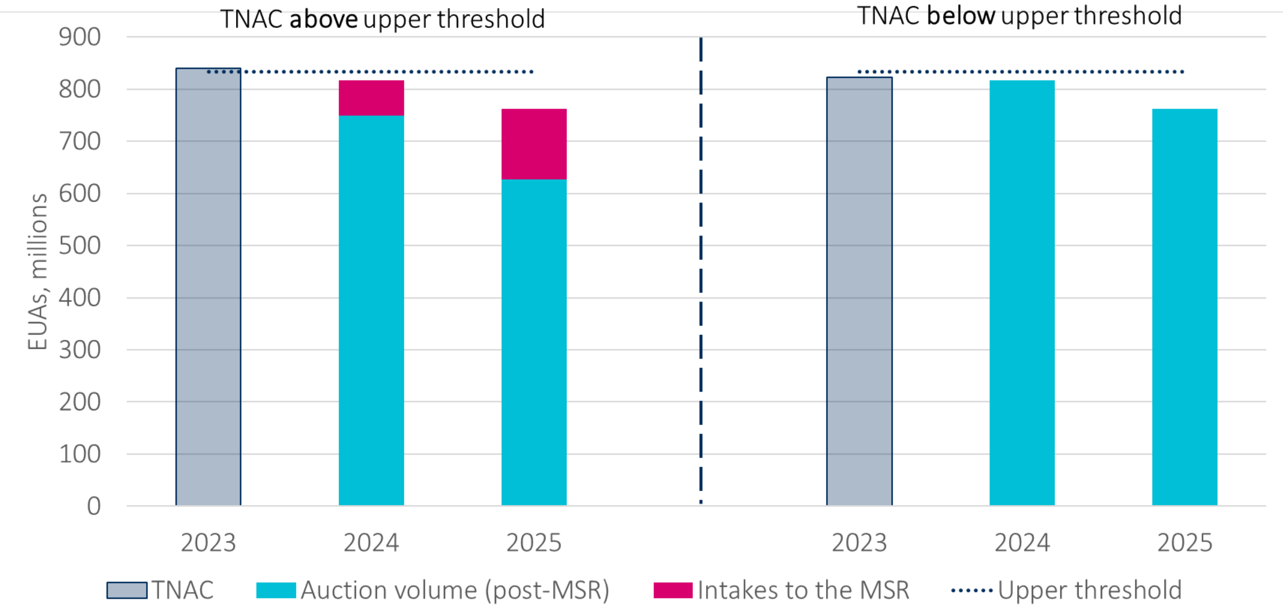
A well performing intake mechanism will reduce surplus allowances from all sources in a timely and predictable manner. An effective intake mechanism will continue to reduce any historical surplus of allowances and any additional surplus allowances, such as those which may persist following the impact of COVID-19. The intake mechanism should remove surplus allowances smoothly and should not contribute to large year-to-year fluctuations in auction volumes.

A well performing release mechanism should provide liquidity to the allowance market when TNAC is below the lower threshold. The release mechanism should provide sufficient liquidity in the case of TNAC falling below the lower threshold to help prevent prices spiking and driving up compliance costs.

Several market analysts and member states suggest that the 12% intake rate from 2024 may be insufficient to return an ongoing surplus to market balance quickly, though increased policy ambition could change this. Marcu et al. (2020) observe that most market analysts expect that the shift to an intake rate of 12% of the TNAC from 2023, could lead to a significant rise in the TNAC in the period to 2030. Furthermore, Marcu et al. (2019b) conclude, based on pre-COVID projections from various studies, that the current design of the MSR will not be able to absorb surpluses from new sources of imbalance which might emerge during Phase 4 of the EU ETS. In addition, Denmark and Italy argued that the MSR's current 24% intake rate should be preserved throughout Phase 4 (2021-30) instead of its current default setting of returning to 12% after 2023 due to the risks posed by a large number of surplus EU allowances. Following the reduction in emissions attributed to COVID-19, these findings are likely to be exacerbated. On the other hand, a more ambitious cap and consequently a lower cumulative allowance supply could counteract these considerations.

However, the current design results in threshold effects which can be exacerbated by high intake rates. The MSR currently has discontinuous responses around the upper threshold. For instance, a TNAC of 830 million allowances in 2023 will not trigger intakes into the MSR, while a TNAC of 835 million allowances will lead to intakes of over 200 million, which represents over 20% of expected auction volume in 2023. Figure 25 presents an illustrative example of these effects.

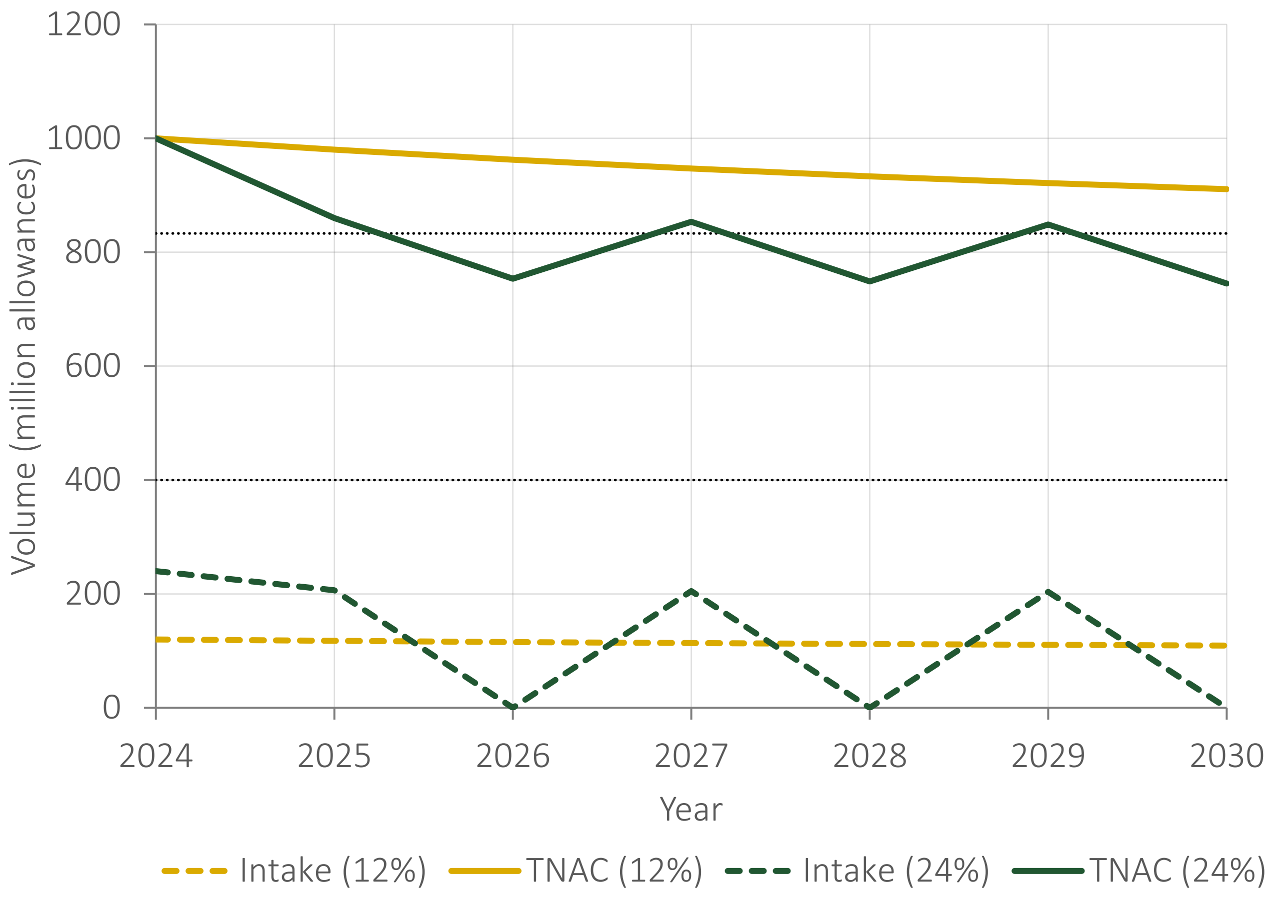
Figure 25 Threshold shocks under the existing MSR intake mechanism can lead to large variations in auction volumes



Note: Results are presented for the current MSR design in 2023 (24% intake rate, 833 million upper threshold)
Source: Vivid Economics

In addition, higher intake rates can lead to oscillatory behaviour around the threshold. Osorio et al. (2020) and Quemin (2020) show that an increase in the intake rate without adjustments to the intake rules may lead to the TNAC oscillating around the threshold. This results in the MSR alternating between years with large intakes from auctions and years without MSR adjustments. In practice, this is likely to increase price volatility, and may undermine confidence in the market. Figure 26 shows how an intake rate of 24% may lead to oscillatory behaviour in intakes and TNAC, keeping emissions levels fixed across the two MSR designs. Oscillatory behaviour can also occur for a 12% intake rate under the current intake rule, but it is more likely with higher intake rates.

Figure 26 Higher intake rates can lead to oscillatory behaviour under the current intake rule



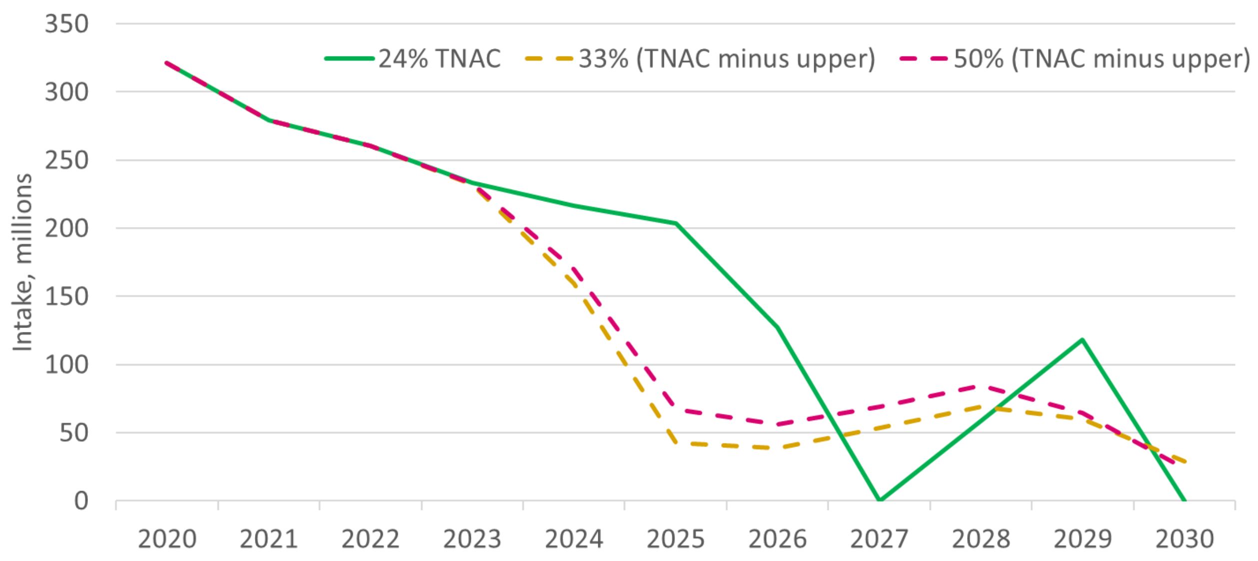
Note: The dashed horizontal lines represent the MSR thresholds.
Source: Vivid Economics based on Osorio et al. (2020) https://www.econstor.eu/bitstream/10419/217240/1/Paper_MSR_Osorio_etal_vf.pdf

Higher intake rates can also amplify an induced holding shock, where holdings by non-compliance entities lead to intakes into the MSR. An induced shock can occur when entities hold allowances in an attempt to drive up the TNAC and trigger intakes to reduce allowance supply. If these holdings cause TNAC to exceed the upper threshold, a higher intake rate will have a greater impact on auctioned allowances in the following periods, reducing supply and increasing upward price pressure.

A marginal surplus response or dynamic intake rate can remove threshold effects and oscillatory behaviour but remain susceptible to induced holdings shocks. By responding to the difference between TNAC and the upper threshold, these rules avoid any oscillatory or discontinuous behaviour around the threshold. As with all intake rules they are subject to induced holdings shocks, where entities can drive further intakes into the MSR by increasing holdings and inflating TNAC above the upper threshold. However, they tend to intake fewer allowances than the current rules for levels of TNAC below very high levels, which may reduce the potential impact of induced holdings somewhat.

A marginal surplus response leads to smoother intakes to the MSR relative to the current intake rule. Figure 27 shows our modelling of different intake rules, including for marginal surplus responses of 33/50% intake rates and maintaining the current intake rule of 24% of the total TNAC. During 2024-2030, intakes to the MSR under the marginal surplus response rules are smoothed over time compared to the current intake rule, which has fluctuations between years with and without intakes as the TNAC crosses the upper threshold. Under this example, total cumulative intakes to the MSR are slightly less under marginal surplus response rules than maintaining the intake rate at 24%, at 1.2/1.3 billion compared with 1.5 billion. However, this outcome is highly dependent on the evolution of the TNAC and the thresholds chosen.

Figure 27 Marginal surplus response rules lead to smoother intake trajectories



Note: Model results assume current MSR design, with the exception of including aviation in the TNAC definition and a constant upper threshold of 700 million allowances.

Source: Vivid Economics

A marginal surplus response can be complemented by declining thresholds to ensure that the intake amount accounts for the long term decline in hedging demand. Because intakes are proportional to the difference between the TNAC and the upper threshold, the absolute size of intakes may decline quickly over time as the TNAC decreases and approaches a constant upper threshold. In principle, if intakes are aimed at removing excessive market surplus, the relevant margin should depend on a declining upper threshold that broadly reflects the decline of hedging demand within the EU ETS.

The discontinuity of the current release mechanism can boost liquidity relatively quickly compared to a proportional response. The lower threshold is currently low relative to estimates of hedging demand. As a result, falling below the lower threshold is likely to imply a liquidity shortage, in which case a discontinuous response may provide additional support compared with a proportional response. A proportional response would increase auction supply based on a 'release rate' and the difference between TNAC and the lower threshold. However, even with a release rate of 100%, a proportional release mechanism would require TNAC to fall substantially below the lower threshold within a single year in order to provide more liquidity support than the current rule (Figure 24). As a result, proportional mechanisms are likely to reduce the responsiveness of the MSR to low TNAC balances.

5.3.2 Recommendations

This review recommends that the MSR intake formula be adjusted so that intakes become a function of the marginal surplus, that is, the difference between the TNAC and upper threshold. This approach avoids threshold effects and increases the consistency and strength of MSR responses to a market surplus by defining the intake mechanism as a constant proportion of the marginal surplus. This is simpler than a dynamic intake rule, which requires decisions on the trajectory of the intake rate and the maximum intake rate. This also simplifies communications regarding MSR operation to market participants and stakeholders.

Setting intakes at 33-50% of the marginal surplus provides a simple and intuitive means of achieving consistent interventions for similar TNAC outcomes. The volume of allowances exceeding the threshold is an intuitive measure of surplus. This reduces the complexity faced by liable firms and other entities looking to participate in the market, particularly compared to a dynamic intake. Furthermore, the design responds in a manner that is consistent given changes in market balance of a similar magnitude and direction, scaling its response with the size of the marginal surplus. The exact intake rate should be decided in conjunction with other MSR parameters. For example, a rate at the higher end of the 33-50% range may be more suitable if the MSR design also includes a freeze provision to reduce the risk of excessive tightening (see section 5.5.1 for more detail on the proposed freeze provision).

Additionally, this review recommends retaining the current release mechanism till 2024, with a provision for the quantity released to decline with the cap after 2024. Given the unlikely but severe implications of a liquidity shortage and resulting high prices, it is prudent to maintain the ability to release a large number of allowances. However, this amount should decline with the cap as the overall market shrinks.

5.4 Invalidation

The invalidation mechanism aims to permanently remove any surplus of allowances from the ETS. While the MSR intake mechanism removes allowances from immediate auction supply, the invalidation mechanism permanently removes these intakes from ETS supply. This allows the MSR to effectively reduce cumulative ETS sector emissions in response to lower EU allowance demand, rather than merely shifting emissions to later periods.

From 2023, the invalidation mechanism will permanently remove allowances held in the MSR above the previous year's auction volume. Modelling analysis conducted for this review finds that 2.1 billion allowances are expected to be invalidated in 2023, based on a projected MSR stock of 2.8 billion allowances. In Phase 4, the total quantity of invalidations is expected to be between 3 and 4 billion allowances, depending on the MSR design and associated evolution of market balance. External estimates suggest similar levels of invalidations. Under increased ambition (emissions 55% below 1990 levels by 2030), Refinitiv estimate 3.9 billion allowances will be invalidated under the current MSR design in Phase 4, increasing to 4.5 billion if the intake rate is maintained at 24%.[113]

Alternative design options could invalidate allowances based on different criteria. This could include:

- Allowances held in the MSR above a different threshold than auction volumes in the previous period. For instance, this threshold could be set as a proportion of various ETS parameters (such as the cap), or MSR parameters (such as the lower threshold).
- Allowances held in the MSR for over a certain period (such as 5-10 years). This approach would invalidate all allowances withdrawn into the MSR in a given year after a certain period. For instance, a 5-year invalidation rule would cause all allowances withdrawn into the MSR in 2024 to be invalidated in 2029.
- Invalidating a proportion of the MSR stock each year. This approach would define a proportion of the MSR stock to invalidate each year. This could be defined in relative terms, such as 20% of the stock, or in absolute terms, such as 200 million allowances per year.

In addition, the invalidation mechanism could be removed entirely. Under the current design this would allow the build-up of allowances along with intakes into the MSR, before releases as TNAC falls below the lower threshold in the future. While this may reduce prices and ambition in the long run, the increased ambition of the EU ETS following the ongoing EU ETS review may reduce the importance of the invalidation mechanism in maintaining market balance.

[113] Refinitiv (2020) https://ec.europa.eu/clima/sites/clima/files/events/docs/20201203_discussion_1_en.pdf

5.4.1 Performance

The inclusion of an invalidation mechanism means that intakes to the MSR can lead to permanent supply adjustments. By reducing the overall supply of EU allowances during the lifetime of the EU ETS, the invalidation mechanism puts upward pressure on prices. There is also evidence that invalidation bolsters price expectations. When surveyed, 42% of compliance entities reported that the invalidation mechanism increased price expectations. In addition, academic literature suggests that the invalidation mechanism plays a role in 'puncturing' the waterbed effect, meaning complementary policies within ETS sectors, for instance Member State policies, can lead to additional emissions reductions (see Section 2.3.2 for a full discussion).

At present the invalidation mechanism is impacted by fluctuations in auction volumes, without clear rationale for this relationship. The invalidation mechanism design invalidates all allowances held in the MSR above the previous year's auction volume. As a result, MSR intakes (which reduce auction volumes) or changes in auction volumes (for instance, due to the phase out of free allocations) can cause fluctuations in invalidations. This adds unnecessary complexity to the system. In addition, decreasing auction volumes mean that the MSR stock is on a gradually declining glidepath, eventually reducing to zero.[114] This may affect the availability of allowances should the MSR need to release allowances to auctioning. However, this scenario is unlikely to occur in Phase 4.

Alternative design mechanisms can remove the link between invalidation and the MSR's operations or external policy circumstances. For instance, invalidations could be made dependent on variables which are not influenced by MSR operations, such as MSR thresholds or the cap trajectory. By setting the invalidation rule independently of MSR activity and unrelated policy decisions, the invalidation mechanism could provide further assurance regarding the predictability of the MSR's operation regarding invalidations and potential future MSR releases.

Invalidating allowances after a fixed period in the MSR or in a fixed quantity each year provides simplicity but may lead to adverse consequences. Under these rules, invalidation quantities can be easily predicted based on the past intake schedule and the MSR stock. However, the invalidation schedule and quantities under these rules are somewhat arbitrary depending on the parameters chosen. As a result, these rules could stop the MSR from providing releases in times of liquidity. For instance, if all intakes to the MSR are invalidated after five years, there will be no releases available if the TNAC falls below the lower threshold six or more years after the last intake period. A similar outcome can occur under a fixed invalidation proportion or quantity.

5.4.2 Recommendations

We recommend invalidating allowances above the lower threshold, equivalent to four years of releases from the MSR. This rule will lead to a declining MSR stock with declining lower thresholds while ensuring that liquidity of at least four years of releases from the MSR remain available in all years. By design, this rule ensures that the MSR stock is sufficient to enable releases when the TNAC falls below the lower threshold. This change also removes the relationship between the MSR intake and invalidations, as the lower threshold is independent of MSR operations. While this will ensure the MSR invalidation rule is more predictable, it is unlikely to have material market impacts in Phase 4 of the ETS.[115]

5.5 Short term response measures

Short term response measures allow the MSR to respond to market imbalances in a quicker timeframe than the current intake or release mechanism. The MSR intake and release mechanisms have a long term focus and take a minimum of one year to begin adjustments in response to an imbalance. However, firms do

[114] The current invalidation rule will lead to a zero MSR stock in line with auction volumes. While this might prevent the MSR from providing liquidity in these years, this isn't likely to happen until 10+ years after Phase 4 of the ETS is concluded.

[115] As the TNAC is expected to remain above the lower threshold in all analysis conducted as part of this analysis, the MSR stock remains positive in all scenarios. As a result, the specifics of the invalidation mechanism are not expected to influence market outcomes materially.

respond to anticipated MSR adjustments to some extent, as evidence by the strong EU allowance prices despite the COVID-19 pandemic. However, changes in market fundamentals and the behaviour of market participants can change rapidly, driving rapid changes in prices. For instance, prices in 2019 were over four times 2017 levels following the introduction of the MSR and increased climate policy ambition. Prices have also increased rapidly in 2021 to date, with some commentators suggesting prices could reach over €100 by the end of the year.[116] The potentially rapid development of price levels in the secondary market may mean that short term response measures could be appropriate to ensure market balance.

This section outlines two options for short term response measures: a freeze provision and a price-based intake or release mechanism. Short term responses are broadly defined as those which respond to market imbalances quicker than the current intake / release mechanism of the MSR, which is within a year. We examine two options for short term response measures:

- **A freeze provision would stop MSR interventions, by pausing MSR intakes or releases when a decision rule is triggered that suggests these interventions could be counterproductive.** For instance, allowances are currently withheld from auctions from September 2020 to August 2021 due to the TNAC in 2019 exceeding the upper threshold of 833 million. If a freeze provision was to be activated in these months these allowances would instead be auctioned, overriding the scheduled intakes to the MSR to avoid unnecessary or counterproductive intakes.
- **A price-based intake or release mechanism provides an additional intervention trigger, releasing allowances from the MSR when prices exceed an upper threshold or triggering intakes to the MSR when prices fall below a lower threshold.** The MSR currently has provisions for a release of allowances when prices are high, under Article 29a of the ETS Directive.

These measures aim to maintain the role of the MSR as a primarily quantity-based mechanism, while providing responsiveness to low-probability but potentially high-impact of counterproductive MSR interventions or in the event of excessive price fluctuations.

5.5.1 Freeze provisions

A freeze provision directly targets potentially counterproductive interventions of the MSR in the market. It acts to stop intakes to the MSR when a decision rule is triggered that suggests these interventions could be counterproductive. As discussed in Section 4, a high TNAC is not always indicative of market surplus. The TNAC may be high even when supply is tight, for example, a high level of hedging demand or long term investment from the financial sector could result in a high TNAC. In this scenario, intakes are not needed to reduce the surplus of allowances and may be counterproductive to the aims of the MSR.

To implement an appropriate freeze provision, it is necessary to identify when an MSR intervention could be counterproductive. There are limited options available, particularly as the preferred indicator of market imbalance, the TNAC, can be unreliable in these situations. Given this, the identification of price levels that may be associated with a counterproductive intervention appears an appropriate alternative. This could be implemented by identifying an upper price trigger above which MSR intakes are likely to be counterproductive, and a lower price trigger below which MSR releases are likely to be counterproductive.

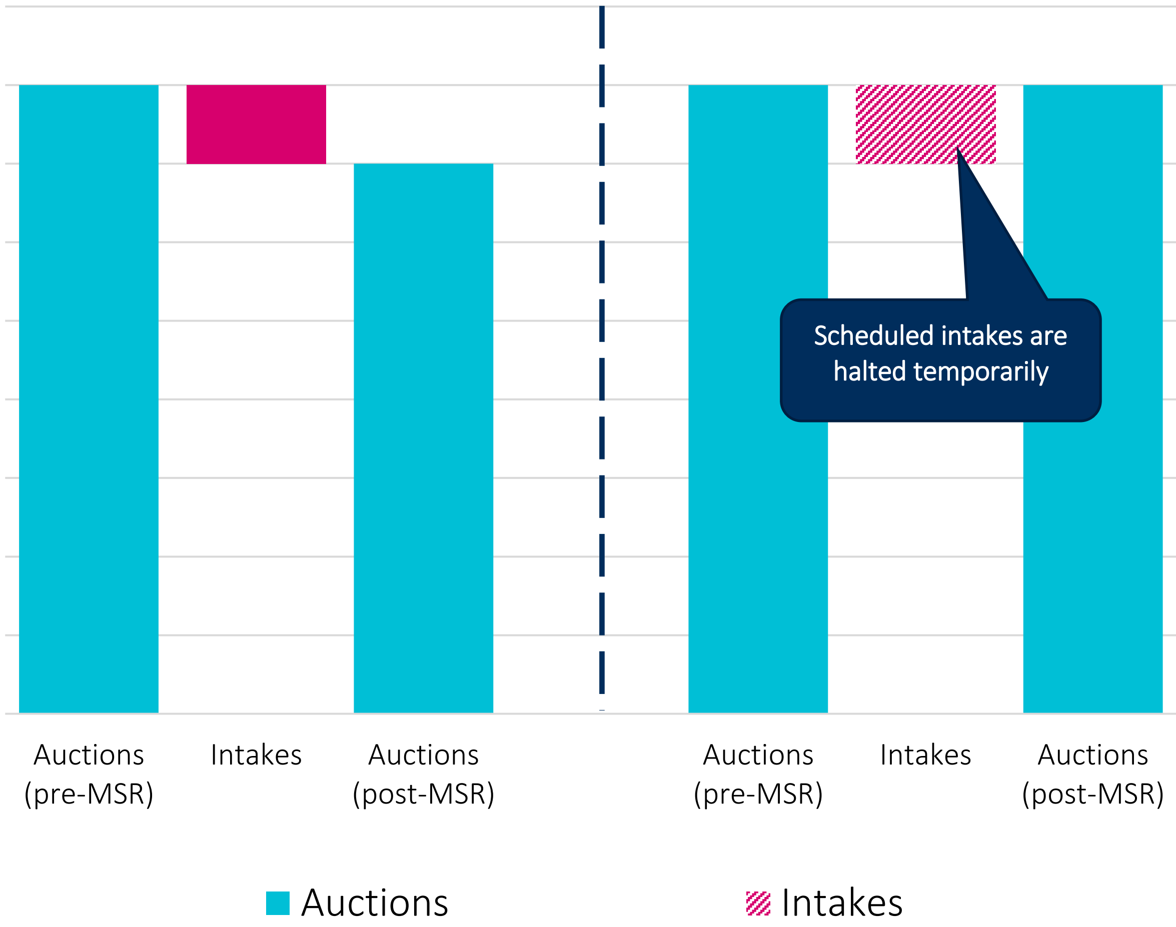
It is important to note that a freeze provision does not target a certain price outcome, using price only as an indicator of when MSR interventions may be counterproductive. In situations where the TNAC is within the upper and lower thresholds, a freeze provision will have no impact regardless of the resulting price level. Similarly, should prices exceed (fall below) the upper price trigger while releases from (intakes to) the MSR are continuing, no action would be taken as the direction of the MSR intervention is consistent with the identified market scarcity (surfeit).

[116] https://www.ft.com/content/915f168a-0d7d-4cb6-abe1-6dbf8f40188f

(1) Performance

A freeze provision can stop intakes from occurring when prices indicate that an MSR intervention would be counterproductive, in a quick timeframe. Figure 28 shows an example of how this provision could work in practice. The left-hand panel shows the current functioning of the MSR, where an intake would result in lower auction volumes, even when this intake is counterproductive. The right-hand side shows a scenario where the freeze provision is activated, and intakes are paused if prices are above the upper price trigger when MSR intakes are occurring. Similarly, a freeze provision can avoid counterproductive releases from the MSR when prices are below the lower price trigger.

Figure 28 A freeze provision would halt intakes in the short term



Note: This in an illustrative example of how freeze provisions on intakes might work in the case where TNAC exceeds the upper threshold and the freeze provision is activated due to high prices.
Source: Vivid Economics

A freeze provision in response to short term price indicators can improve outcomes and avoid contradictory policy responses. A freeze provision would ensure that the intake or release mechanisms are suspended if given price conditions are met, preventing the MSR from exacerbating market imbalance through counterproductive interventions. This could occur if intertemporal optimisation leads to a much higher or lower level of TNAC than currently expected, such as an expectation for scarcity in future driving up the TNAC today or conversely overlapping climate policies driving down allowance demand and reducing the TNAC. Further details on potential drivers are discussed in Section 4.5.

The price triggers should be calibrated based on available short term mitigation in the market. The availability of short term abatement options varies significantly at different price points, with significant mitigation often available from fuel switching at relatively low prices, and mitigation options (beyond reduced production) being very scarce at relatively high prices. At relatively high prices, additional tightening of supply (and resulting increases in prices) does not drive more mitigation as the available abatement options have been largely exhausted. Instead, prices would increase rapidly as firms try to buy allowances to meet their compliance needs, potentially impacting competitiveness and generating volatility. MSR intakes in such a scenario should therefore be paused. The upper threshold for the freeze provision should be set at a price beyond which short term abatement options start to decline substantively, but at a sufficiently high level to maintain longer term mitigation incentives. The lower bound should reflect the point below which significant mitigation options are expected to be available in covered sectors. This is likely to be the price level at which significant fuel switching may take place, as fuel switching is a relatively responsive form of abatement and the existence of unutilised opportunities for fuel switching would indicate that additional releases are not needed.

Freeze provisions can be triggered when auction prices are above the upper price trigger level, or below the lower price trigger level for a sustained period. The specific trigger criteria should ensure sufficient responsiveness to avoid sustained MSR operations after trigger levels have been reached while reducing potential risks of gaming. A reasonable approximation of this requirement could be for the freeze to take effect once average auction prices exceed or are below the relevant trigger price for one month, and this freeze continue for two months after average auction prices have returned to within the threshold range. Any intakes or releases from the MSR would be cancelled during the freeze period.

(2) Recommendations

We recommend that a freeze provision pauses MSR intakes when average auction prices exceed €80 for a period of one month, and this freeze continue for two months after average auction prices have fallen below this price trigger. The upper threshold of €80 has been identified to reflect a point beyond which short term abatement options are expected to tail off, meaning that EU allowance price increases are unlikely to incentivise additional abatement in the short term, except by reducing firms' production levels. Market analysts ICIS have complied a list of all abatement technologies in industrial sectors which can be induced by carbon pricing.[117] Of the 35 technologies technically feasible by 2025, 60% are cost-effective for a price of €80, compared to only 42% at a price of €60. Prices above this level are likely to result in an inelastic market where price increases do not motivate further investment due to a lack of abatement options. This could potentially cause high prices and volatility in the market.[118]

We recommend that a freeze provision activate to stop releases of allowances from the MSR when average auction prices fall below €35 for a period of one month, and this freeze continue for two months after average auction prices have risen above this price level. This means the MSR would not release allowances if EU allowance prices drop below this price level regardless of the TNAC. Low prices suggest that releases are unlikely to be needed for additional liquidity, as there are abatement options readily available at these price levels. Below €35, there is a significant amount of potential for shifting from gas to coal within the power sector, offsetting some of the emissions reductions in recent years.[119]

The appropriate level of price triggers for a freeze provision are likely to change over the course of Phase 4 of the EU ETS, as such we recommend that these price triggers be assessed in future reviews of the MSR. Future reviews may also consider alternative indicators of counterproductive MSR interventions to inform the operation of freeze provisions.

[117] This includes technologies in the metals, chemicals, oil & gas, cement & lime, heat, and Carbon Capture and storage (CCS) sectors.
[118] Additionally, this price level is expected to be sufficient for driving emissions reductions in line with EU ambition during Phase 4. The Carbon Pricing Leadership Commission estimate prices between €36 and €72 are aligned with the Paris Agreement in 2020, rising to €45-€90 by 2030.
[119] ICIS industrial abatement database.

5.5.2 Price-based mechanisms

The EU ETS currently allows provides for short term adjustments in the event of excessive price increases. Under Article 29a of the ETS Directive, the European Commission is required to hold a committee meeting if, for more than six consecutive months, the EU allowance price exceeds three times the average allowance price from the previous two years. If high prices are not deemed to correspond to changing market fundamentals, the committee will discuss the potential of either bringing forward auction volumes or auctioning up to 25% of the New Entrants' Reserve. If either of these measures is enacted, 100 million allowances are also released from the MSR over a period of 12 months – even when the TNAC is more than 400 million. If the TNAC is already below 400 million allowances, only 100 million allowances will be released from the reserve. In case less than 100 million allowances are in the reserve, all allowances in the reserve shall be released.

There are several options for adjusting the current short term response measures to address the risk of excessive price increases. This includes adjusting the parameters associated with the current Article 29a adjustments to increase responsiveness or target interventions to specific price levels, or complementing this with other measures. There are several options that could be considered including:

- **Altering the temporal conditions that allow short term responses.** This would change the period in which prices are required to exceed three times the average allowance price in the previous two years (currently set at six consecutive months), for Article 29a to be triggered. Less stringent conditions include shortening the time period (such as to three consecutive months) or removing the requirement that the months be consecutive (for instance requiring prices to exceed the threshold level for six out of twelve preceding months).

- **Lowering the price level required to intervene.** For example, the Article 29a requirement for allowing releases could be lowered from three times the average allowance price of the past two years to twice the average allowance price of the past two years. If the average allowance price in the past two years was €30, this would allow interventions if the allowance price was above €60 for six cumulative months, while current legislation would require prices to clear above €90 for the same period.

- **Specifying absolute price levels for intervention.** Under this option, the price level allowing for Article 29a intervention would be pre-specified. This would remove the interaction between previous prices and the intervention mechanism. For instance, an absolute price level of €100 would allow for the release of 100 million allowances if allowances remained above €100 for at least six consecutive months.[120] This price level could also be set to evolve over time, for example increasing at 5% (or €5) annually.

- **Introduce an alternative rules-based mechanism.** This would avoid the discretionary component of Article 29a, which currently requires a committee decision in order to release allowances. This requirement could be removed or complemented with an additional rule-based trigger, for example if prices exceed a higher price level than required by the discretionary measure. This would provide certainty to market participants that high prices lead to automatic allowance releases.

There are also alternative price-based mechanisms that could be considered to reduce the risk of excessive prices. Alternative price-based adjustments for high prices include cost containment reserves, which would

[120] This price level is notional and is not indicative of policy intention. However, it is deliberately higher than the upper price level suggested for the freeze provision (€80). This is because the freeze provision implies a halt on scheduled action, while a price threshold for Article 29a would imply additional action. We recommend stopping counterproductive action before conducting additional action, and as such the range of prices required for price-based mechanisms is wider than that of the freeze provisions.

release allowances at certain price levels, or a hard price cap (a level at which firms can purchase additional allowances indefinitely).

A price-based mechanism could also be incorporated for low prices. This could include an auction reserve price, a price below which auctions are not settled. Any allowances not auctioned can then be re-entered into later auctions or placed directly into the MSR. This was suggested for consideration in a recent French-German study on European industrial policy strategy.[121]

(1) Performance

A short term response measure that reacts to high price-levels or changes can provide additional certainty for market participants and increase the accuracy and speed of response to market imbalances. Perino et al (2021) argue that allowance prices are a more reliable indicator of (expected) changes in scarcity than the TNAC. In addition, a price-based mechanism can react more quickly than relying on the annual publication of the TNAC, which is also delayed by several months. As a result, a price-based mechanism may address most if not all the risks identified that the current MSR mechanism is unable to respond to. In addition, Edenhofer et al (2021) note that a rules-based price mechanism can reduce price uncertainty for firms and reduce the risks associated with discretionary regulatory interventions and with politically undesirable price levels, making an ETS more politically and economically stable.[122]

Price-based mechanisms can respond to price variations which are not addressed by the intake or release rules of the MSR. For instance, high EU allowance prices could coincide with TNAC remaining above the upper threshold, for instance if high levels of holdings are due to market participants anticipating higher future prices. This could see continued intakes into the MSR even while prices increase to excessive levels. Further, even if the TNAC is below the upper threshold and intakes are not occurring, releases may also not occur when needed to reduce excessive prices. In some cases, the converse could also be true, with low prices accompanying TNAC below the upper threshold which prevents the MSR's intake mechanism from providing price support. Additional short term response measures can ensure that excessive price volatility, or excessively high or low prices can be countered quickly and directly.

In response to high prices, the current provisions require several conditions to be met in order to release allowances and may not be sufficient in the case of short term changes in prices. Under Article 29a of the ETS Directive, the European Commission is required to convene a meeting of the Climate Change Committee (CCC) if, for more than six consecutive months, the EU allowance price exceeds three times the average allowance price from the previous two years. If this price evolution does not correspond to changing market fundamentals, the committee may opt to release 100 million allowances. However, a price three times historic levels may indicate severe strains on the ETS, such as severe liquidity constraints. Following the recent evolution of EU allowance prices (to March 2021), prices would need to exceed €87.50 for six consecutive months for intervention to be considered. This price level could create significant negative impacts if sustained in the near term. Options to increase the responsiveness of the mechanism include lowering the price threshold, reducing the time for which high allowance prices are required, and introducing a rules-based response mechanism.

Lowering the threshold for potential intervention can provide greater flexibility. Article 29a currently requires that The EU allowance price exceed three times the average allowance price of the past two years before intervention. Lowering this threshold, for instance to twice average allowance prices from the past two years, could permit earlier intervention, while still ensuring that such interventions only occur in exceptional circumstances.

In addition, the discretionary response measure could be complemented with a rules-based intervention mechanism. Under the current provision, the EC's Committee on Climate Change must determine that price

[121] BWMi & French Ministry of the Economy and Finance (2021) https://www.bmwi.de/Redaktion/EN/Downloads/G/german-non-paper-european-industrial-policy.pdf?__blob=publicationFile&v=2
[122] Edenhofer et al, 2021 https://www.bruegel.org/wp-content/uploads/2021/03/PC-06-2021-090321.pdf

changes are not due to changing market fundamentals in order to intervene. This discretionary measure is able to identify whether intervention is appropriate for given market circumstances. However, the discretionary element of this rule could be removed or complemented with a rules-based mechanism to provide more certainty on the circumstances when intervention will occur. This would maintain a predictable rules-based approach to interventions and remove the potential for subjective judgements to effect decision making.

The required timeframe for which prices must remain elevated before intervention, could be shortened to enable a quicker response to price spikes. The current design requires prices of three times the average allowance price from the previous two years to be sustained for six consecutive months before an intervention is considered. This is a requirement that is unlikely to be met under even extreme market outcomes. A more time limited response that enables for near immediate intervention following extreme price increases would enable a more rapid response to high prices. This could be easily incorporated into the current framework.

The MSR currently has no mechanism to deal with low prices outside the intake mechanism, which relies on the TNAC exceeding the upper threshold to respond to low prices. If prices fall to low levels, but TNAC remains below the upper threshold, the MSR would not reduce supply by intaking allowances. This could undermine long term incentives for mitigation, such as fuel switching to fossil fuels in industry or power in the case of ambitious emissions reductions elsewhere in covered sectors.

An auction reserve price could ensure prices remain above a pre-determined level, boosting price expectations and certainty. An auction reserve price sets a level below which allowances will not be sold at auction. In the EU ETS, unsold auctions can be automatically moved into the MSR, where they might eventually be invalidated. This would provide market participants with some certainty regarding the lower bound on prices, strengthening abatement incentives through all future periods. Auction reserve prices typically increase over time in practice, with the glidepath laid out clearly to provide additional certainty for market participants. 38% of the 900 ETS compliance entities which responded to the survey said that a price floor would increase their price expectations for 2030, with 58% stating that it would not change price expectations or unsure.

An auction reserve price is preferred to other instruments for a price floor. Other ETSs currently use auction reserve prices, such as those operating in California and Quebec, whereby no allowances will be auctioned below the reserve price. An auction reserve price would be much easier to implement than the alternative of a top-up tax (for instance, the UK Carbon Price Floor) in which compliance entities need to pay an additional top-up carbon price above the EU allowance price for their emissions. A top-up tax is only effective when used for a subset of emissions, as if applied across the EU ETS as a whole, this would simply reduce the price of EU allowances by a level corresponding to the tax level.

However, a price floor may increase the complexity and uncertainty around the ETS. For instance, if the TNAC is below the lower threshold but prices are below the price floor, there may be counteracting actions from the price floor and release mechanism if a freeze provision on releases is not included. In addition, survey responses from over 900 covered entities found mixed opinions on how a price floor would affect ETS volatility. Almost 30% of respondents were uncertain about the impact on volatility, with the remainder split roughly equally into groups that thought it would increase, decrease, or have no impact on price volatility.

(2) Recommendations

We recommend reducing the threshold for price-based adjustments to be considered from the levels currently set out in Article 29a and considering whether an auction reserve price would provide longer-term price predictability in the context of the changing ETS policy and market environment. The current conditions enabling intervention under Article 29a are unlikely to be met even if prices are at very high levels for a sustained period. Recalibrating the conditions for intervention would provide greater flexibility to correct unforeseen imbalances that the MSR may not be well-equipped to handle. A price floor in the form of an auction reserve price may provide additional certainty on price developments and help inform abatement decisions for market participants. However, while a price floor is likely to be more easily understood than the MSR, it may still increase the complexity of the ETS, given interactions with the MSR's intake and release mechanisms. The EC should consider whether an auction reserve price is necessary given the increased ambition and recent market developments with regard to prices. The level for a price floor can be set low relative to recent allowance prices, to ensure it is binding only in exceptional circumstances.

Note that this recommendation is additive to the freeze provisions in Section 5.5.1 because the two measures are complementary to each other. The freeze provision *prevents* the MSR from further intervention when it is likely to be counterproductive. The price-based adjustment *triggers* MSR intakes or releases to handle extreme prices.

5.6 Summary of recommendations

The MSR has been successful in reducing the historical build-up of surplus allowances, but should be updated to better align with the evolving policy and market environment. Having largely dealt with the persistent surplus of early Phases and bolstered by announcements of broader climate ambition, the market is now providing appropriate incentives for long term mitigation. It is therefore important that MSR interventions support the overall market objectives and occur only when needed, and that responses are proportionate to the size of market imbalances. Recommended changes account for the recent increase in EU climate ambition and the changes in market conditions that are likely to continue as the allowance market evolves.

To ensure that the MSR continues to maintain market balance in the longer term, this review recommends several alterations to its current design. The analysis for this review identified several potential challenges for the MSR's future operation and corresponding options to improve its design. At present the MSR doesn't incorporate all relevant sources of allowance demand and supply. Sources of demand and supply which were negligible when the MSR was conceived are growing in size. In particular, the TNAC definition should account for demand and supply from the aviation sector, and more fully integrate linked markets. Secondly, current thresholds were decided during Phase 3 of the ETS, and no longer reflect the declining size of the overall market. These thresholds should be lowered, and an adjustment introduced to better calibrate these threshold levels with the declining emissions and market demand over time. A further challenge to MSR operation, relates to threshold effects associated with the current intake rule, where a small change in the TNAC results in a disproportionate change in intake quantities. The intake rule should be amended to remove these threshold effects by calculating intakes as a proportion of the marginal surplus (that is, the amount by which TNAC exceeds the upper threshold). Lastly, the current invalidation rule is dependent on auction volumes, which are itself impacted by MSR activity. The review recommends making invalidations independent of auction volumes to reduce complexity.

The MSR has been effective in tackling long term imbalances, but additional provisions may be needed to reduce the risks of short term volatility and extreme prices. The expected tightening of the EU ETS cap over Phase 4 is expected to fundamentally change the market from one with a persistent surplus to one of scarcity, in which the risk that the MSR may unduly tighten supply should be managed. The potential impacts of anticipatory banking and investment holdings of EU allowances could create a situation where the TNAC may become an unreliable indicator of oversupply. To the extent that these holdings trigger the MSR, it may increase scarcity in an already tight market. In contrast, it is also possible that releases from the MSR could be triggered at low prices, despite the market maintaining sufficient liquidity. To avoid such counterproductive interventions, a freeze provision should be introduced, to ensure that the MSR does not intervene in the market when this could be detrimental to market balance. Price-based mechanisms may also play a role in supplementing the operation of the MSR, by addressing short term variation in price levels. We recommend that alterations of the design of Article 29a provisions also be considered.

While recommended changes to the MSR have been designed to make it more robust to a wide range of market circumstances, more regular reviews may be required. The operation of the MSR is influenced by a range of uncertain and interrelated factors including market sentiment, hedging strategies, technological development, abatement costs and the efficacy of overlapping policies. Additionally, emerging phenomena such as potential anticipatory banking or large scale holding from non-compliance entities would benefit from close monitoring in the medium term as it is difficult to predict how important these dynamics may be going forward. The current review relies on analysis of information from a wide range of sources, but there is a need for regular monitoring to ensure the MSR's design remains fit for purpose given the changing market environment. Given the pace of change in the market, more regular reviews are likely appropriate.

Table 5 summarises the recommendations given for each of the design options analysed.

Table 5 Summary of design options analysed

Design option	Current design	Recommended design	Rationale
TNAC definition	TNAC currently does not capture all sources of allowance demand and supply, including from aviation and linked markets	Revise the TNAC definition to capture all sources of allowance demand and supply in the EU ETS and linked markets, including aviation and the Swiss ETS	Capturing all sources of demand and supply ensures MSR operations reflect true market surplus
Upper threshold	833 million allowances	Reduce the upper threshold to 700 million in 2024, after which it declines in line with the overall emissions cap	The reduction to 700 million reflects a reduction in estimated hedging demand, and a declining path captures ongoing reductions in expected hedging demand
Lower threshold	400 million allowances	Maintain the lower threshold at 400 million allowances to 2024, after which it declines in line with the overall emissions cap	400 million remains below current estimates of hedging demand, which is gradually reduced to reflect the declining ETS market
Intake mechanism	12% of TNAC, doubled to 24% until 2023	Set intakes at between 33-50% of the difference between the TNAC and the upper threshold value (the 'marginal surplus')	Removing threshold effects reduces the risks of volatility; a higher intake rate increases the responsiveness of a given MSR design to shocks
Release mechanism	100 million allowances, doubled to 200 million until 2023	100 million in 2024, after which it declines in line with the overall emissions cap	Maintaining a discrete release mechanism limits the risk of supply shortages; reducing releases in line with the ETS cap ensures they are proportional to overall allowance supply
Invalidation mechanism	From 2023, invalidate allowances above the previous year's auction volume	From 2023, invalidate allowances above the lower threshold (equivalent to four years of releases from the MSR under the recommendations in this report)	This rule will lead to a steadily declining MSR stock, while ensuring that at least four years of releases from the MSR remain to provide liquidity if triggered.

Design option	Current design	Recommended design	Rationale
Freeze mechanism for intakes and releases	None currently included	When average auction prices exceed €80 (fall below €35) for a month, intakes to the MSR (releases from the MSR) are stopped until prices return below (above) the threshold for two months	When prices are above €80, intakes to the MSR are unlikely to drive substantive amounts of additional abatement, and increase total compliance costs. Conversely, prices below €35 imply releases are unlikely to be needed for liquidity.
Short term response measures	Article 29a of the EU ETS allows for intervention if prices exceed three times the average price of the past two years for six consecutive months. This may in turn trigger the release of 100 million allowances from the MSR.	Consider lowering the threshold and timeframe of potential interventions to provide more flexibility in responding to short term price shocks; consider complementing with an auction reserve price	A faster potential short term response to price spikes can help maintain market stability
Review period	Every five years	Every three years, specifically reviews in 2024 and 2027	Ensuring MSR policy parameters, particularly the thresholds, are appropriate given rapidly evolving market environment.

Source: Vivid Economics

6 Annex 1: Modelling

6.1 Methodology

6.1.1 Introduction

This study draws on modelling from the Vivid EU ETS model, which builds on the modelling approach from Quemin and Trotignon (2019). The model is calibrated to represent the average EU ETS compliance entity, and considers the EU ETS a competitive market where firms can bank emissions allowances. The model is dynamic as the number of banked allowances from a given year will affect the total supply of allowances in the subsequent year. Firms are required to surrender allowances for compliance each year that match their emissions and bank any remaining allowances that they hold across years. Since a decentralized competitive market equilibrium can be characterized indirectly as the solution to joint cost minimization among all firms (e.g. Montgomery, 1972; Rubin, 1996), the model uses a representative firm approach which is well-documented and widely employed in the literature (e.g. Fell et al., 2012; Kollenberg & Taschini, 2019). Solving the model would return a series of equilibrium prices, banking, and emissions within the EU ETS scope on an annual basis.

The representative firm in the model minimises its abatement cost with rolling horizons and limited foresight. In the model, the firm optimises the level of emissions in each year within a time horizon, considering its forecast of baseline emissions and supply of allowances.[123] Baseline emissions in this model is a theorical construct to represent the emissions in a given year if there is no carbon price incentive. The supply of allowances is determined by the EU ETS cap and augmented by MSR dynamics. The difference between the baseline emissions and the supply of allowances over this time horizon determines the total abatement required from the firm, thus entering its optimisation problem as a budget constraint. The firm minimises the net present value of abatement costs over this time horizon given this budget constraint. The forecast of baseline emissions may deviate from the actual baseline emissions due to an assumption on limited foresight. Shocks to the system will affect the firm's expectations and therefore its optimal choice of emissions and abatement. Finally, equilibrium prices are calculated by mapping the firm's abatement to a marginal abatement cost curve.

Specifically, the firm solves for the following constrained optimisation problem in each year. Given a forward-looking horizon length of h years, the firm in year-t selects year-t emissions e_t and bank the remaining allowances b_t by solving:

$$\min_{\{e_\tau\}_{\tau=t}^{t+h}} \sum_{\tau=t}^{t+h} \beta^{\tau-t} C_\tau(\hat{u}_\tau^t - e_\tau)$$

$$\text{subject to} \quad 0 \le e_\tau \le \hat{u}_\tau^t, \;\; b_\tau = b_{t-1} + \hat{f}_\tau^t + \hat{a}_\tau^t + \hat{o}_\tau^t - e_\tau \ge -\hat{f}_{\tau+1}^t$$

$$\text{and} \sum_{\tau=t}^{t+h} e_\tau = \sum_{\tau=t}^{t+h} [\hat{f}_\tau^t + \hat{a}_\tau^t + \hat{o}_\tau^t] + \hat{f}_{t+h+1}^t + b_{t-1}$$

Where $\hat{f}_\tau^t, \hat{a}_\tau^t, \hat{o}_\tau^t, \hat{u}_\tau^t$ denotes the firm's year-t forecast of free allocations, auctions, offsets, and baseline emissions for year $\tau \ge t$. The objective function specifies that the firm seeks to minimise the net present value of its abatement costs over the time horizon from year τ to year $\tau + h$. Annual abatement cost $C_\tau(u_\tau^t - e_\tau)$ is a function of abatement, defined as the difference between baseline emissions u_τ^t and actual emissions e_τ. In the model, marginal abatement costs are assumed to be linear in the level of abatement. The discount factor β is derived from the interest rate, $\beta = \frac{1}{1+r}$. The number of banked allowances in a given

[123] More precisely, the firm decides on emissions in year t after making forecasts of up to year t+9.

year b_τ equals the number of unused allowances from the annual supply facing the firm ($b_{\tau-1} + \hat{f}_\tau^t + \hat{a}_\tau^t + \hat{o}_\tau^t - e_\tau$). There are three constraints the optimisation problem:

- The firm must choose an emissions level that is less than or equal to its baseline emissions.
- The firm needs to comply with the cap over the anticipation period.
- Borrowing (i.e. negative banking) is limited to the number of free allocations in the subsequent year, $\hat{f}_{\tau+1}^t$. This mimics the fact that firms within the EU ETS can tap into free allocations distributed in the first quarter in a given year to meet liabilities for the previous year.

The MSR enters the model by adjusting the auctions ahead of the firm's optimisation in each period. The MSR adjustment to auctions in period t is a function of the TNAC in period $t-1$ and $t-2$. The model uses TNAC from two years previous because of the schedules of TNAC estimation and MSR auction adjustment: TNAC in year $t-1$ adjust the auction from September in year t to August in year $t+1$. This means that a third of the "effect" of TNAC in period $t-1$ will be adjusted on the auctions in period t and two thirds on the auction in period $t+1$. The result of this is that adjusted auctions in period t are calculated as:

$$a_t^{\text{adjusted}} = a_t - \frac{1}{3} M_t(b_{t-1}, s_t) - \frac{2}{3} M_{t-1}\left(b_{t-2,} s_{t-1}\right)$$

Where s_t is the stock of allowances within the MSR stock in year t, and M_t is the intakes/withdrawal of the MSR given the MSR policy in year t. For example, the current setup of MSR can be expressed as:

$$M_t(b_{t-1}, s_t) = \begin{cases} \max\{b_{t-1} \times IR_t, s_t\} & \text{if} \quad IT_t < b_{t-1} \\ 0 & \text{if} \quad RT_t \leq b_{t-1} \leq IT_t \\ -\min\{RQ_t, s_t\} & \text{if} \quad b_{t-1} < IT_t \end{cases}$$

Where IT_t is the upper threshold and RT_t is the lower threshold of the MSR that triggers intakes and releases, currently at 833 million and 400 million, respectively. IR_t is the rate at which allowances are taken into the MSR, and RQ_t the quantity of allowances that is released into the auctions when the TNAC is below RT_t. The exact specification of M_t will change as particular design options for the MSR are considered. Further to the above, the model also considers the invalidation mechanism of the MSR. The invalidation mechanism, which is expected to begin in 2023, can be expressed as:

$$s_{t+1} \mapsto \max\{a_{t-1}, 0\}$$

The firm takes the MSR into account when making its intertemporal optimisation. The solution is estimated by finding a fixed point of the firm's optimisation and the forecasted response by the MSR. To find this fixed point, the firm repeatedly updates its optimal plan for emissions and abatement given how its course of actions will affect future MSR response and allowance supply. This is repeated until convergence is obtained.

The main drivers of emissions, prices and TNAC pathways are the baseline emissions, cap trajectory, interest rate and the length of anticipation period. Section 6.1.2 will describe further how these inputs are derived for the model.

- **Baseline emissions and cap trajectory:** the cumulative difference between the cap and baseline emissions over the anticipation period determines the necessary abatement over time. A tightening of the cap or increase in baseline emissions will both increase the level of abatement required from the firm, which would spread the burden by abating more in every year.
- **Interest rate:** a higher interest rate implies greater discounting of future costs, making the firm shift its costly abatement from today into the future, aiming to reduce the net present value of cumulative abatement costs.

- **Length of anticipation period:** a longer length of anticipation will make the firm account for the abatement required over a long time horizon. Because the cap declines faster than the baseline emissions, looking further into the future means anticipating a stronger need for abatement, thereby reducing emissions and increasing abatement today. Another consequence of a longer anticipation length is that it tends to attenuate the impact from unanticipated shocks.

The MSR affects the optimisation problem in two ways: first by changing the supply of allowances, second by affecting the firm's anticipation of future supply. After the MSR releases or takes in allowances it changes cap and thus changes the total amount of abatement necessary over the anticipation period. A larger MSR intake would tighten supply and require the firm to abate more, reducing its planned emissions. But the firm also forecasts the effect of the MSR on auctions because of the choices it plans to make for the years $t + 1$ to $t + h$. The firm's optimal decision will therefore involve planning ahead on how its action will affect MSR intakes or releases.

Increasing the auction share under the cap tends to increase the TNAC. As the firm can meet its emissions obligations for a given year by using free allowances allocated in the first quarter in the next year, a higher auction share would reduce the number of free allowances that the firm can use to meet its compliance obligations. In other words, this represents a tighter borrowing constraint in the model. However, the constraint is not binding in most periods in most model runs, so changing the share of free allocations will only have marginal effects.

The model is the best-in-class representation of the MSR available in the academic literature. This includes explicit representation of MSR intakes, releases, corresponding thresholds, the invalidation mechanism, and the calculation of TNAC on an annual basis. In particular, the model captures the fact that the TNAC for a given year is reported in May in the subsequent year, then affecting auction volumes from September to August. Given the rules-based nature of the MSR, some other models in the academic literature estimate the TNAC simply by taking an exogenous emissions pathway as given. However, the advantage of optimisation models such as the one used in this review is that the emissions pathway is endogenous to the given policy design. In other words, changes in policy parameters will affect the perceived scarcity of emissions allowances and therefore the firm's behaviour on emissions and abatement. For instance, a higher MSR intake rate should represent a tightening of future allowance supply and therefore reduce emissions today and increase TNAC. The model used in this study accounts for this while capturing realistic aspects of firm behaviour, namely limited foresight and rolling horizons, as noted above.

Despite its advantages, there are limitations to the model as it abstracts from some important characteristics of the EU ETS. The modelling outputs are not intended to be used as forecasts for prices and emissions. However, when combined with qualitative and quantitative insights, it can provide useful indications of the direction and size of impact. The key limitations of the model in the context of this study are as follows:

- **It draws on a simplified Marginal Abatement Cost Curve (MACC).** In the model, the firm chooses emissions and abatement by optimising intertemporal abatement cost. Crucial to this optimisation problem is the shape of the MACC, including its steepness and concavity. While this is calibrated to yield plausible modelling results, the MACC parameters used for the optimisation are not flexible enough to mirror MACCs from bottom-up industry research. This also means that the equilibrium price as described by the model may be inaccurate, particularly when the slope of the actual MACC may increase at higher levels of abatement.

- **The level of abatement and emissions depend critically on the assumed baseline emissions**. Baseline emissions represent the level of emissions without a carbon price, but incorporating announced policies within covered sectors, such as energy efficiency measures and regulated coal phase out. Modelling results are sensitive to both the level and shape of baseline emissions over time because it determines the total level of abatement required from the firm.

- **Calibration of model parameters for the future EU ETS scope is imperfect**. The calibration of the model involves estimating the appropriate interest rate, length of forward-looking horizon, MACC, and baseline emissions. However, the UK exit from the EU ETS in 2021, the fungibility of aviation allowances in Phase 4, and the likely extension to maritime navigation all meant that parameters calibrated from historical data are not necessarily accurate for the future scope of the EU ETS. Furthermore, firm behaviour might change going forward with reductions in free allowances, forcing industrial companies to hedge more.

- **It does not model endogenous demand for allowances from non-compliance entities**. The model is designed to investigate the behaviour of a representative firm that faces the costly behaviour of abatement under a limited supply of emissions allowances. Other holders of allowances, such as financial entities or national governments, are not modelled endogenously. For example, the model is unable to analyse how policy choices may induce speculative demand for allowances.

- **There is no endogenous technological progress**. Investments in abatement technology will generally lower future emissions and abatement costs. However, conditional on the level of banked allowances brought over from the previous year, modelling outputs in a given year is independent of emissions or abatement in previous years.

It should be noted that this model is fundamentally different from energy system models and their results are not directly comparable. As opposed to optimising energy system costs, this model abstracts from the different technological conditions for various sectors and focus on the interaction between MSR dynamics and market equilibrium within the EU ETS. From a policy perspective, increases in climate ambition within the EU is represented as either a tightening of the EU ETS cap or changes in the baseline emissions. This allows the analysis to be more tractable, enabling a clear channel for MSR design options to interact with and affect market outcomes in terms of emissions, banking, and prices.

6.1.2 Model parameterisation

To better handle the requirements of this review, parameters have been updated from the model in Quemin and Trotignon (2019). First, this is necessary to reflect the change of scope of the EU ETS. Second, the updated parameters also aim to reflect more realistic firm behaviour and abatement cost functions to give a better sense of the magnitude of effect on price and emissions from the policy scenarios we analyse. Below is a summary of the main adjustments to the model.

Baseline emissions

Baseline emissions has been adjusted to account for COVID-19, the coal phase-out as well as more granular emissions trends from the EU commission's 'with existing measures' scenario. The baseline emissions represent emissions from covered entities in absence of a carbon price signal. The parameterisation has been updated such that changes to installations' emissions that have already been set in motion (i.e. will occur as a result of other implemented policies or market changes) should be included. Some changes that are of a more uncertain nature will be modelled as shocks (discussed further below). The adjustments to baseline emissions include:

- the COVID-19 pandemic has already had a significant impact on the realised emissions in 2020, so these estimated impacts are included in the baseline. To model the magnitude of the effect on baseline emissions the updated model draws on data from the Price-Induced Market Equilibrium System (PRIMES) energy model. The gives the size of the effect in 2020 (a reduction of about 155 $MtCO_2e$), to include the potentially lasting effect of the pandemic the model assumes that the effect of the pandemic will half in 2021, further half in 2022 and then remain at this level through at the modelled period.

- the baseline is adapted for the already planned phasing-out of coal-fired power-plants. This will shift the demand for allowances downwards – estimates from Carbon Market Watch provide an indication of the size of this downwards shift. However, Carbon Market Watch assumes that all coal-fired plants that are closed will be replaced with renewable energy sources. In practice, at least some of the phased-out coal is likely to be replaced with gas or other fossil fuels. Thus, the baseline scenario assumes that only half of the effect of the coal phase out will make its way to baseline emissions.

- baseline emissions are adjusted to reflect the effects of policies other than EU ETS. The baseline has been updated with more granular emissions projections. For this the year-on-year trend from the EU commission's 'with existing measures scenario' was used.

Marginal Abatement Cost Curve (MACC)

The MACC parameter, which defines the slope of the MACC, is assumed to increase over time rather than being constant. In the original specification of Quemin and Trotignon (2019), the marginal abatement cost curve is assumed to be the same regardless of the level of baseline emissions in a given year. This was a simplifying assumption made to facilitate the numerical optimisation and make interpretation of results more straightforward. However, an assessment of the literature and of existing MACCs shows that marginal costs tend to increase over time as low-cost abatement options are used up. This means that in later periods the abatement in absolute terms should be more expensive. This is implemented in the model as an increasing MACC parameter.

Interest rate and anticipation period

The updated model has a higher interest rate and shorter planning horizon as compared to the original academic model. There is evidence that firms use interest rates higher than the assumed interest rate of 3% in the Quemin and Trotignon (2019) model. For instance, a recent review of renewable energy investments found that weighted average capital costs (WACCs), the average after-tax cost of companies' capital sources, varied from between 3.5-12% in EU-28 countries.[124] According to a European study on discount rates, the typical level for commercial and industrial investors range from 6 % to 15 %.[125] The PRIMES energy model used a subjective discount rate of 9% for the power sector and 12% for industry.[126] Considering this evidence base, the model for this study applies the interest rate of 8% instead of 3% to discount the future. This allows the model to generate more realistic dynamics. Additionally, the firms planning horizon has been shortened slightly, from 12 to 10 years to rectify unrealistically forward-looking behaviour (which results in very high levels of banking).

Growth rates

The firm's growth rate projections have been lowered to better align with the growth rate of the industries covered by the EU ETS. The original model assumes a 2% real GDP growth rate. While this might be a plausible forecast for the economy, the sectors covered by EU ETS have historically displayed a lower growth rate. For instance, the Eurostat industrial production index for EU-27 countries grew at an average rate of 0.8% per year between 2011 and 2019.[127] As such the growth rate in the model has been adjusted to 1%.

Adjustments to EU ETS scope

The model has been further adapted to examine the sectoral and country coverage most relevant to the EU ETS in the near term. This consists of three main departures from the original calibration from Quemin and Trotignon (2019):

1. UK exit from the EU ETS
2. Domestic and intra-EEA aviation included in the EU ETS scope with fungible allowances
3. Domestic and intra-EEA maritime navigation assumed to join the EU ETS

Due to the nature of the model, it cannot accommodate scope changes in the EU ETS that occur in the *middle* of the time horizon. This is because the exit or entry of market participants represent a fundamental change

[124] DiaCore (2016) The impact of risks in renewable energy investments and the role of smart policies
[125] Steinbach and Staniaszek (2015) Discount rates in energy system analysis
[126] Ecofys (2015) The crucial role of discount rates in European Commission energy system modelling
[127] See https://ec.europa.eu/eurostat/statistics-explained/index.php/Industrial_production_(volume)_index_overview

to the size and behaviour of the representative firm, complicating the firm's intertemporal optimisation process.

Throughout this analysis, we implement the model by treating all three scope changes as present from the beginning. For the forward looking analysis in this review, the model draws on historical data up to 2020 and begins optimisation from 2021 onwards.[128] This allows the model to mimic the UK exclusion and the inclusion of aviation allowances as fungible with EU allowances that began in 2021. The inclusion of maritime into the modelling scope represents a minor deviation between the modelling scope and the actual scope of the EU ETS but is unlikely to alter conclusions from the analysis.

The three scope changes imply adjustments to the level of the cap (and the absolute reduction represented by the LRF) as well as baseline emissions. For the year 2021, the cap in the model is constructed as the total of three sources:

1. The cap for stationary installation, using actual data
2. The cap for aviation, using actual data
3. A hypothetical cap for domestic and EEA maritime navigation (for the specified MRV scope) using historical emissions from the PRIMES model for the year 2005

Beyond 2021, a common LRF is applied across the sectors. As for the baseline emissions, the original baseline emissions series for EU ETS stationary installations from Quemin and Trotignon were augmented by removing the UK component. Next, baseline emissions for aviation and maritime navigation were obtained from the reference case in PRIMES and then extrapolated into the future using IEA's reference technology scenario. The sum of baseline emissions for stationary installations, aviation and maritime navigation then results in the baseline emissions for the representative firm in this model.

6.1.3 Quantification of magnitude and direction of shocks

The shocks analysed have been quantified using available data and analyst judgement of plausible risks to the EU ETS. To ensure that the shock analysis is representative of the risks faced by the EU ETS, we have assessed the largest and most likely risks under each impact channel. Determining likelihood of different shocks has been informed through literature review and interviews with industry and market experts. Quantification of the size of the risk has been informed by estimates from published analysis and internal calculations.

The regulated phase out of coal power

The regulated phase out of coal power represents a significant potential source of excess EU allowances due to a reduction in allowance demand. We have used estimates from Carbon Market Watch to estimate the size of this downwards shift. However, we have estimated that around half of the emissions reduction associated with the coal phase will make its way into baseline emissions. The additional reduction is treated as a potential shock, as it is unlikely that all coal shutdowns will translate to a switch to renewable energy.

The estimated magnitude of the EU coal phase out is used to inform:

- **The anticipated reduction in EU allowance demand.** The coal phase out is expected to reduce EU allowance demand by up to 277 m by 2030. As half of this reduction is built into baseline emissions, the shock size used for an anticipated reduction in EU allowance demand increases from 27 m in 2021 to reach 138.5 m by 2030. This is expected to be larger than other sources of anticipated reduction in EU allowance demand seemed likely, such as other policy measures or significant progress in industrial abatement technologies.

[128] The model is set up with the aim to generate plausible results for 2021 onwards. For this reason, it was necessary to begin the optimisation process in 2021 using a 2019 and 2020 TNAC that accurately reflects the total number of allowances in circulation (this differs from reported TNAC as our model was fully adjusted to include aviation and maritime). As a result, the variables up to 2020 were pinned down exogenously so that the optimisation begins with appropriate initial conditions.

- **The induced holdings shock.** The coal phase out is expected to be the largest source of potential induced holdings. The shock used assumes that the EU allowances associated with Germany's coal phase out commitments between 2021 and 2025 are held, without cancellation. This leads to around 630 m allowances being held by non-compliance entities from 2025, driving up TNAC and prices in the ETS. However, there are various potential sources of induced holdings, for instance long term investors may benefit from holding a large share of available allowances or environmental NGOs may choose to hold allowances as a means of driving additional climate action.

The impact of COVID-19 on emissions

The effect of the COVID-19 pandemic represented the largest shock to economic and environmental outcomes in recent years. To estimate the magnitude of the shock, we have taken the estimated size of the COVID impact in 2020 from the EU's Price-Induced Market Equilibrium System (PRIMES) energy modelling. The gives an estimate of the size of the effect of about 155 $MtCO_2e$ in 2020.

The estimate magnitude of the COVID-19 shock is used to inform:

- **Unexpected increases or decreases in EU allowance demand.** As a historically unprecedented shock, this represents a large tail risk to EU allowance demand. This is expected to be larger than other short term impacts on emissions, such as changes in abatement costs due to technological progress or a shift in nuclear usage. The 155 $MtCO_2e$ emissions impact is used to estimate both an upwards and downward demand shock in 2025, in addition to the adjustments to baseline emissions already made for COVID-19's impact.

6.2 Scenarios modelled

This section introduces the scenarios that underly modelling results in Section 6.3, which contribute to recommendations in Section 5. Section 6.2.1 begins by defining the baseline policy environment that is used as default throughout the review. This central scenario assumes an LRF of 5.04% will take effect in 2024 and that the EU ETS will cover domestic and intra-EEA aviation and maritime sectors. Further, we assume that the EU ETS is not linked to the UK ETS. Section 6.2.2 introduces the MSR design options that are investigated using the model, combining several possible changes to the MSR. Section 6.2.3 explains the scenarios designed as stress tests for the different MSR designs. Some, like an economic recession or boom, are likely to occur at some point in the future. Others, like a significant increase in speculation in carbon assets, are 'tail risks' - cases that not likely to materialise, but which could have an outsize impact on MSR functioning if they did occur. Finally, Section 6.2.4 identifies additional variations in EU ETS policy choices, including different stringencies of cap and the operation of a CBAM.

6.2.1 Baseline policy environment

A large number of policy changes that will impact MSR functioning are being finalised simultaneously, requiring some assumptions on the future policy environment for the purpose of this MSR review. A key aspect of the changing policy environment is the EU's ramped up ambition for emissions reductions, targeting 55% reduction in emissions by 2030. This increase ambition can be achieved through a mix of different policies, including the EU ETS. All these changes will affect the functioning of the MSR and have a bearing on the appropriate parameters for future design.

The key policy changes for the functioning of the MSR are the tightening of the cap and change in scope of the ETS. This analysis assumes that in order to meet the 55% overall reduction target, the sectors covered by the ETS will have to reduce emissions by 65% in 2030 compared with 2005 levels (as per the MIX55 scenario).[129] This increase in ambition compared to current policy design can be met through a combination of adjusting the linear reduction factor (LRF) and rebasing the cap.

[129] European Commission (2020) https://ec.europa.eu/clima/sites/clima/files/eu-climate-action/docs/impact_en.pdf

In the baseline policy environment, we assume a 5.04% LRF applies from 2024 till 2030. After 2030, the cap is assumed to decline linearly to reach net-zero at 2050. The scope of the ETS also plays a significant role in determining future dynamics through the volume of emissions covered, firm behaviour and hedging demand. For our baseline, we have aligned with DG CLIMA's REG scenario, which features an extension of the ETS to intra-EU maritime navigation.

Full details on the assumptions within this scenario are presented in Table 6.

Table 6 Central policy scenario

Variable	Central scenario assumption	Considerations
EU ETS		
Cap and LRF	LRF increases from 2.2% to 5.04% from 2024 to 2030. Post 2030, the cap decreases linearly to reach net zero in 2050. There is no rebasing.	The share of increased ambition borne by the ETS will be reflected in the degree to which the cap is tightened, which can be done by legislating an absolute decrease in cap in a certain year (called 'rebasing' the cap) and/or increasing the rate at which the cap tightens each year (called the linear reduction factor or LRF).
Free allocations for EITE industries	No change to current policy	If no further carbon leakage policy is introduced, free allocations for some industrial sectors is expected to remain at current levels.
CBAM	No change to current policy	The carbon leakage framework is not expected to change under the baseline scenario.
Aviation	EU allowance and EU aviation allowances fully fungible	EU allowances and EU aviation allowances are fully fungible. This has no material impact under all cases as the aviation sector remains a net source of demand for EU allowances.
Sectoral extension	Domestic maritime included in the scope	In September 2020, the European Parliament determined that ships of gross tonnage exceeding 5,000 tonnes should be included in the ETS.[130]
Linking	Linked with Swiss ETS, no UK link	The EU ETS and Swiss ETS have been linked since 1 January 2020. There are no current plans to link with the UK ETS.
Broader policy environment		
Impact of COVID-19	COVID-19 causes a 155Mt reduction in emissions in 2020, 78Mt for 2021 and 39Mt for all subsequent years.	COVID-19 has resulted in a significant downturn in economic activity and emissions since the start of the pandemic in 2020. It is unclear whether this shock is temporary, or will have a long lasting impact on emissions. Here we assume a sharp dip in 2020 emissions, and a slow partial recovery thereafter.

[130] European Parliament (2020) https://www.europarl.europa.eu/news/en/press-room/20200910IPR86825/parliament-says-shipping-industry-must-contribute-to-climate-neutrality

6.2.2 MSR designs analysed

The modelling analysis examines the different options to alter the design of the MSR. There is a large number of permutations to consider because the MSR can be adjusted along several parameters, such as intake rates, release quantities, and threshold levels. To keep the analysis tractable, these options are grouped together and presented as three overarching design options. The aim of the analysis is to identify a MSR design features that will support its efficient operation over the course of Phase 4 of the EU ETS, which contribute to recommendations in Section 5, alongside other sources of evidence.

We consider a baseline scenario and three alternative future design options for the MSR:

- **Baseline scenario - current MSR design with updated TNAC definition:** where the operation of the MSR continues as currently legislated, with the exception that the TNAC definition is updated to account for net demand from aviation and linked systems.
- **Option 1 - Updated parameters scenario**: where, in addition to the alteration of the TNAC definition, other parameters are adjusted. Volume based triggers are adjusted such that if the TNAC falls below 400 million allowances, allowances are then released from the MSR and added to future auctions; whereas if the TNAC exceeds 700 million allowances, then these allowances are deducted from auctions and added to the MSR. The rate of additions to the MSR is increased to 24% of the TNAC. This option relates to the discussion under Section 5.1 on TNAC definition.
- **Option 2 - Changed design scenario**: where, in addition to the alteration of the TNAC definition, the thresholds, intake and release mechanism of the MSR is adjusted address potential risks identified in the academic and policy literature. The upper and lower thresholds are set at 700 million and 400 million in 2024, reducing annually at the same rate as the cap from 2025. The intake rate to the MSR is increased to 33%, but applies only to the TNAC quantity above the upper threshold. The rate of release from the MSR is set at 25% of the lower volume-based trigger (i.e. 100 million allowances initially, then reduced at the same rate as the cap from 2025).

  Under this design, as the cap reduces towards zero, so do the accompanying thresholds. As thresholds are compressed this can reduce the impact of the MSR. This suggests a reassessment of this approach may be required in future years. As such in our modelling we halt any reduction in thresholds from 2030, at which time their appropriate level may be reassessed. This option relates to the discussion under Sections 5.2, 5.3, 5.4.
- **Option 3 - Additional short term response scenario**: where the updates in the Changed design scenario are paired with additional short term response measures, specifically an auction reserve price and a price safety-valve. The auction reserve price is set at €25 in 2025 and increases at 3% thereafter. The price safety-valve allows but does not require the release of allowances from the MSR for auctions, with immediate effect, if prices reach three times the average price of the two preceding years. This option relates to the discussion under Section 5.5.

These design options act to change the MSRs response function to a given level of the TNAC. Option 1 is the most aggressive in terms of removing allowances when the TNAC is above its upper threshold, except in the case of extremely high TNAC values.[131] In contrast Options 2 and 3 feature a response that gradually increases as the TNAC increases. For very large TNACs exceeding 1,100 million allowances the baseline scenario is least aggressive in removing allowances from circulation. These changed parameters therefore alter the scale of the MSR's impact on market balance given the level of the TNAC. Note that this interacts with the altered definition of the TNAC, which now also takes account of the scale of net demand from aviation operators and linked systems. Table 7 provides a summary of the baseline scenario and the three options.

[131] If TNAC reached in excess of 2 billion allowances, Options 2 and 3 would lead to high intakes.

Table 7 Summary of options considered for modelling analysis

	Baseline policy scenario (MSR0)	Option 1: Updated parameters scenario (MSR1)	Option 2: Changed design scenario (MSR2)	Option 3: Additional short term response (MSR3)
TNAC definition	Account for net demand from aviation and any linked markets			
Upper threshold	833m	700m from 2024	700m in 2024, then declines with cap	700m in 2024, then declines with cap till 2030
Lower threshold	400m	400m from 2024	400m in 2024, then declines with cap	400m in 2024, then declines with cap till 2030
MSR Intakes	12% of TNAC	24% of TNAC	33% of TNAC minus upper threshold	33% of TNAC minus upper threshold
MSR Releases	100m	100m	25% of lower threshold	25% of lower threshold
Invalidation mechanism	Invalidate excess above prior year auction volume	Invalidate excess above prior year auction volume	Invalidate allowances held in excess of the MSR upper threshold	Invalidate allowances held in excess of the MSR upper threshold
Auction reserve price	-	-	-	€25 in 2024, with a 3% real annual increase from 2025
'Safety valve' auction cost containment	-	-	-	3 times the average price in the two preceding years

Source: Vivid Economics

Baseline MSR design (MSR0)

Table 8 Summary of how the baseline design differs from current MSR design

MSR design parameter	Current MSR design	Baseline design
TNAC definition	Accounts for demand from installations regulated under EU ETS scope	In addition to current definition, accounts for aviation and linked markets.

Note: For this analysis, Swiss market considered linked and UK market considered unlinked

The baseline scenario is used as a benchmark, to assess how proposed MSR designs perform as compared to the current design. Policymakers should only change the design of the MSR if alternative options offer substantive benefits. This scenario tests the performance of the current design in a new policy environment, identifying whether the MSR design remains robust to future challenges. It also provides a baseline against which to measure the performance of alternative MSR designs.

Option 1: Current MSR design with updated parameters (MSR1)

Table 9 Summary of how Option 1 design differs from current MSR design

MSR design parameter	Current MSR design	Option 1
TNAC definition	Accounts for demand from installations regulated under EU ETS scope	In addition to current definition, accounts for aviation and linked markets.
Upper threshold	833m	700m from 2024
Lower threshold	400m	400m from 2024
MSR intakes	12% of TNAC	24% of TNAC

Note: For this analysis, Swiss market considered linked and UK market considered unlinked

The intent of this option is to update current parameters in a manner that would provide for the MSRs continued efficient functioning, while maintaining the MSR's underlying design. As such this approach aims to adjust the numerical value of parameters rather than adjust the way in which the system operates. By doing so it seeks to take account of the implications of enhanced ambition and other policy changes developed as part of the European Green Deal and the ensure the EU ETS's resilience to external shocks and a changed policy environment. This option provides a high level of continuity for EU ETS participants.

Thresholds in 2024 are adjusted to reflect the declining level of hedging demand over time, with the upper threshold set to 700 million allowances and the lower threshold set at 400 million allowances. These choices reflect an analysis of hedging demand, ensuring that the gap between the lower and upper threshold (which represents a range where the market is in balance) is approximately equal to 300 Mt. This takes account of the changing composition of hedging demand, which to date has been dominated by power utilities. Over the period to 2030 this will change, with hedging demand from industrial interests, aviation and maritime expected to represent an increasingly large share of hedging demand. We balance this against the expected decrease in utilities hedging as emissions from power generation decrease. Further detail on the hedging analysis is available in Section 7.

The intake rate is adjusted to remain at 24% from 2024, in contrast with current legislation to reduce this rate to 12% from this point in time. This change would provide market participants with continuity regarding the impacts of the MSR on auction supply and reflects findings in the literature that a 12% intake rate may be insufficient to respond to market shocks. In contrast, higher intake rates considered in the literature have been associated with potential induced volatility, as threshold effects lead to oscillations in intakes and releases from the MSR.

Option 2: Reduce threshold and feedback effects (MSR2)

Table 10 Summary of how Option 2 design differs from current MSR design

MSR design parameter	Current MSR design	Option 2
TNAC definition	Accounts for demand from installations regulated under EU ETS scope	In addition to current definition, accounts for aviation and linked markets.
Upper threshold	833m	700m in 2024, then declines with cap until at least 2030

MSR design parameter	Current MSR design	Option 2
Lower threshold	400m	400m from 2024, then declines with cap until at least 2030
MSR intakes	12% of TNAC	33% of TNAC minus upper threshold
Invalidation mechanism	Invalidate excess above prior year auction volume	Invalidate allowances held in excess of MSR upper threshold

Note: For this analysis, Swiss market considered linked and UK market considered unlinked

This option provides an additional degree of freedom, where the method of calculating the MSR's alteration of auction supply are adjusted alongside its numerical parameters. This approach seeks to address a range of context-specific weaknesses of the MSR that have been identified in the literature, by market experts and covered entities. As such this approach seeks to enhance the resilience of the EU ETS, by ensuring that the MSR can respond effectively to a wide range of potential market outcomes.

This option seeks to address three problems identified with the current MSR's design, specifically to:

1. **reduce threshold and feedback effects from the discontinuous impacts of the MSR**, in particular to address threshold effects, whereby a small difference in TNAC could be associated with significantly different MSR responses and associated risks of oscillatory behaviour in the case of large intakes;
2. **remove feedback effects from the invalidation mechanism**, specifically to ensure that the MSR's changing of auction volumes does not change the quantity of allowances permanently invalidated; and
3. **introduce dynamic adjustments to parameters**; this seeks to ensure that the MSR's parameters remain at appropriate levels over the medium term. In the longer-term additional analysis will be needed in particular, regarding developments in underlying market behaviour, to ensure the MSRs specific parameters remain fit for purpose.

In addition, potential design options considered based on:

- **Predictability**. The extent to which the MSR responds in a manner that is predictable to market participants and reduces overall market uncertainty.
- **Consistency**. The extent to which the MSR responds in a manner that is consistent given changes in market balance of a similar magnitude and direction.
- **Simplicity**. The extent to which the design alteration reduces, or minimises, the complexity faced by liable firms and other entities looking to participate in the market.

The definition of both the upper and lower threshold is adjusted, such that they are set to decline in proportion to the annual decline in the cap after 2024. The upper threshold is set to 700 million allowances in 2024 and the lower threshold is set at 400 million allowances in 2024, as in Option 1 above. However, in this option we adjust the thresholds such that they remain a constant share of the cap. This links the thresholds to the main supply parameter in the EU ETS, the cap as adjusted by the LRF. As hedging demand is anticipated to reduce with emissions over time, this should ensure that thresholds remain fit for purpose over the medium term. In the longer term the changing share of emissions between industries and uncertainty regarding behaviour of market participants means that appropriate threshold levels may deviate from those implied by this design.

The most substantive change proposed is to the way in which MSR intakes are calculated. Rather than calculating intakes to the MSR as a proportion of the TNAC, this option calculates intakes as a proportion of the TNAC in excess of the upper threshold. We set the proportional removal parameter to 33%. This means that with an upper threshold of 700 million allowances, a TNAC of 800 million allowances would result in the MSR intaking 33 million allowances the following year.[132]

The proposed mechanism invalidates allowances held in excess of the MSR upper threshold, decoupling invalidation from auction volumes. Under the current design, the auction volume in a given year (itself affected by MSR intakes or releases), goes on to affect the amount of invalidation by the MSR in the subsequent year. A potential phase out of free allocations (due to the introduction of a CBAM or alternative measures to safeguard competitiveness) will increase the share of allowances allocated via auctioning, resulting in fewer invalidations. Finally, the volume of auctions may decrease over time due to the tightening cap, which will also reduce invalidations. These factors introduce unnecessary complexity and feedback in the system, making it difficult for market participants to respond efficiently.

Option 3: Addition of short term response mechanisms (MSR3)

Table 11 Summary of how Option 3 design differs from current MSR design

MSR design parameter	Current MSR design	Option 3
TNAC definition	Accounts for demand from installations regulated under EU ETS scope	In addition to current definition, accounts for aviation and linked markets.
Upper threshold	833m	700m in 2024, then declines with cap till 2030
Lower threshold	400m	400m from 2024, then declines with cap till 2030
MSR intakes	12% of TNAC	33% of TNAC minus upper threshold
Invalidation mechanism	Invalidate excess above prior year auction volume	Invalidate allowances held in excess of MSR upper threshold
Auction reserve price	-	€25 in 2024, with a 3% real annual increase from 2025
'Safety valve' auction cost containment	-	3 times the average price in the two preceding years

Note: For this analysis, Swiss market considered linked and UK market considered unlinked

Option 3 builds on the design of Option 2 by including an auction reserve price and a 'safety valve' price ceiling to mitigate short term volatility and anchor expectations. These price-based measures are designed to prevent price collapses or price spikes in the short term – a distinct and complementary role to the existing quantity-based design of the MSR. Releasing allowances into auction when prices are increasing too quickly or are too high not only reduces prices in the short term, but also ensures price expectations are anchored. Compliance and non-compliance entities are assured that prices will not shoot up drastically, reducing the chances of a price spiral occurring at all.

The modelling analysis helps to assess the key trade-offs between different future options for MSR operation. However, the model does not explore short term price volatility because the model is deterministic and

[132] Under this design, the MSR intake would be a function of how much the TNAC exceeds the upper threshold of 700 million allowances (in this example, that amounts to 100 million allowances). The MSR would intake 33% of this excess, amounting to 33 million allowances.

operates at an annual resolution. As such, the modelling analysis cannot fully explore the performance of Option 3 and distinguish that from Option 2. A range of other evidence, including a detailed qualitative evaluation of the individual design features of the MSR, and its interactions with elements of EU ETS design, is considered in developing the final recommendations, particularly in Section 5.5 with regards to short term response measures.

6.2.3 Stress tests

In addition to the baseline policy scenario outlined above, we have tested the MSR options against various stress tests to assess the modelling outputs' sensitivity to changes in the market and policy environment. We consider two types of stress test:

- **Shocks**, such as a reduction in economic demand or an increase in complementary policy ambition due to coal phase outs. These can largely be incorporated into the model based on reasonable estimates of magnitude to assess the outcome, with some complementary qualitative analysis as required.
- **Induced imbalances,** such as strategic speculative behaviour aiming to destabilise the ETS by purchasing large quantities of allowances. These imbalances have been designed by identifying areas of potential risk in the current MSR design and constructing scenarios which could lead to destabilising outcomes based on these risks. Given the nature of these risks, we will complement modelled results with a discussion of the potential risks and outcomes. We identify two potential induced imbalances below.

Shocks may operate through different impact channels, but ultimately have the same effect on market outcomes. For example, increased speculation and increased hedging demand both provide a temporary increase in demand for allowances. On the other hand, a reduction in economic activity (and associated emissions) or a coal phase out both permanently reduce demand for allowances. These shocks have different root causes, but ultimately pose the same challenges for the functioning of the MSR.

We therefore classify the stress tests based on their ultimate impact channel. They are:

- **An anticipated increase or decrease in EU allowance demand.** These shocks include announcements of complementary policies such as coal phase outs, and technological breakthroughs for low-emissions technologies. Their effect on future emissions can be anticipated before the effects start to materialise. These shocks can be modelled as an exogenous change in market participants' expectations for future emissions. While shocks can also result in an unanticipated increase in EU allowance demand, this less likely than a decrease in demand for allowances due to sustained decarbonization efforts across the economy. This analysis therefore focuses on the impact of an anticipated reduction in allowance demand, modelling the announcements of further coal phase outs beyond what is confirmed by 2020.
- **An unanticipated increase or decrease in EU allowance demand**. Temporary shocks of this type include a change in long term speculation or hedging demand from compliance entities, while permanent shocks include a change in abatement costs or economic activity relative to expectations. To estimate the impact of an unanticipated reduction in EU allowance demand, we analyse a shock similar in size to the 2020 COVID-19 shock, but occurring in 2025. COVID-19 represents a large shock by historic standards, illustrating the impact of a tail risk to EU allowance demand materialising. We also assess the impact of a similar magnitude of shock but in the opposite direction (i.e. an unanticipated increase in EU allowance demand). This could happen for example due to a sudden nuclear incident causing nuclear energy to be replaced with natural gas or coal.
- **Induced holdings to stimulate tightening.** This could occur where market actors deliberately hold allowances in order to induce additional tightening from the MSR, inflating the prices. For instance, speculators or actors seeking to enhance the overall ambition of the EU ETS could buy and hold

enough allowances to corner a large share of the TNAC, triggering the MSR repeatedly and creating a price spiral. To assess the impact of induced holdings, we analyse the prospect of non-compliance entities holding a significant number of allowances from 2025.

The plausible magnitude of shocks used in stress tests is informed by numerous sources, including literature review, interviews and surveys with market participants and quantitative analysis. For stress tests based on external factors such as coal phase out in member states, a literature review and internal analysis has provided sensible estimates of magnitude. To analyse factors with less publicly available data, such as hedging and speculative demand, we have complemented our understanding with input from interviews and surveys with market participants.

The stress tests implemented here are summarised in Table 12.

Table 12 Stress tests analysed in the model

Type of stress test	Specification of stress test implemented	Other causes of similar stress	Key issue for current MSR design
Anticipated decrease in EU allowance demand (see section 6.4.1)	Communicated policy measures, specifically coal phase out.	Technological breakthrough with deployment delay.	Anticipated reductions in EU allowance demand can lead to an increase in cumulative emissions under current ETS policy.[133] A reduction in future demand means firms need to bank less. They then have more liquidity in the current period, reducing prices.
Unanticipated decrease in EU allowance demand (see section 6.4.2)	Economic activity (and emissions) below expectations.	• Reduced demand for hedging. • Reduction in abatement costs. • Additional complementary policy measures e.g., larger coal phase out.	MSR has a partial and delayed response to negative demand shocks and price drops. Its effectiveness depends on timing of shock.
Unanticipated increase in EU allowance demand (see section 6.4.2)	Economic activity (and emissions) exceeds expectations	• Increased long term speculation. • Increasing hedging demand from industrials. • Increase in current abatement costs. • NGOs or governments buy and bank allowances permanently. • Complementary policies underperform, e.g., energy efficiency and renewable targets.	Sudden increases in demand for EU allowances can lead to an increase in EU allowance prices. The MSR is not suited to positive demand shocks, as it was designed to remove a surplus.

[133] Rosendahl (2019) https://www.tse-fr.eu/sites/default/files/TSE/documents/sem2020/environment/rosendahl.pdf

Type of stress test	Specification of stress test implemented	Other causes of similar stress	Key issue for current MSR design
Induced holdings to stimulate tightening (see section 6.4.3)	Non-compliance entities hold a large number of allowances for long term investment	• Speculators seek to corner market to induce price increases. • Actors seek to hold allowances to induce tightening and increased emissions reductions from ETS sectors.	The MSR removes allowances from future auctions if the TNAC is above the threshold, regardless of the price level. Actors without compliance obligations could use this to multiply their impact on the emissions market by holding a large share of the TNAC over multiple years to drive price rises and additional mitigation.

Source: Vivid Economics

6.2.4 Policy variations

In addition to the policy assumptions identified above, we have tested three key policy variations to assess the modelling outputs' sensitivity to assumptions. These policy changes remain uncertain but are likely to have a significant impact on MSR performance. The changes considered include:

1. **Variations in cap**. This includes scenarios with lower and higher ambition than the current baseline assumption outlined in Table 6. The options tested roughly align with AMB2b, AMB2a and AMB1. We also test an option that keeps the 5.02% LRF beyond 2030, resulting in covered sectors reaching net zero emissions in 2039. A detailed description of the LRF and rebasing for each of these caps is provided in Table 13 below.
2. **The use of a carbon border adjustment mechanism (CBAM)**. A CBAM would replace free allocations as a mechanism to address carbon leakage risk. This has implications for the number of auctioned allowances, and subsequently the invalidation mechanism of the MSR. Additionally, the phase out of free allowances could cause changes in market behaviour. The design of a CBAM is still being finalised and will likely result in a graduated phase out of free allocations in a subset of sectors.
3. **Further sectoral expansion.** The ETS could potentially expand to cover the buildings and transport sectors, which would increase total ETS coverage and change the composition of covered sector participants.

Table 13 provides an overview of these policy variations.

Table 13 Policy variation sensitivities

Variable	1) Baseline	2) Rebasing in 2024	2a) Delayed LRF adjustment	2c) High LRF continues past 2030	3) Baseline with CBAM	4) Baseline with sectoral expansion
EU ETS						
Cap (LRF and rebasing) [134]	LRF increased to 5.04% in 2024-2030. No rebasing. Post 2030 there is a linear decrease in cap to hit net zero in 2050.	Rebase by 163 Mt and adjust the cap to 3.85% in 2024. Post 2030 there is a linear decrease in cap to hit net zero in 2050.	Increase LRF to 6.17% in 2026-2030. No rebasing. Post 2030 there is a linear decrease in cap to hit net zero in 2050.	LRF increased to 5.04% in 2024. No rebasing. The 5.04% LRF continues past 2030, resulting in the cap hitting zero in 2039.	Same as (1)	Same as (1)
Comparable EC cap scenario	AMB2a	AMB2b	AMB1	AMB2a till 2030	n/a	n/a
Free allocations	No change in policy	No change in policy	No change in policy	No change in policy	Free allocations phased out for steel and cement from 2023-2030	No change in policy
CBAM	No	No	No	No	Yes	No
Aviation	EU allowance and EU aviation allowances fully fungible					
Sectoral extension	Domestic maritime	Domestic maritime	Domestic maritime	Domestic maritime	Domestic maritime	Domestic maritime, buildings and transport
Linking	Linked with Swiss ETS, no UK link					
Broader policy environment						
Impact of COVID-19	As in central scenario. COVID-19 causes a 155Mt reduction in emissions in 2020, 78Mt for 2021 and 39Mt for all subsequent years. COVID-19 has resulted in a significant downturn in economic activity and emissions since the start of the pandemic in 2020. It is unclear whether this shock is temporary, or will have a long lasting impact on emissions. Here we assume a sharp dip in 2020 emissions, and a slow partial recovery thereafter.					

[134] Option 1 is aligned with Option AMB2a of the EC's ongoing Impact Assessment analysis. Option2 aligns with Option AMB2b and reflects tighter cumulative emissions in the 2021-2030 period.

6.3 Performance of the different MSR options in a new policy environment

This section explores how each MSR design option performs against various metrics. These metrics include the evolution of market surplus, allowance price and emissions, price volatility and other considerations like auction revenues, competitiveness, and social impacts.

All results reported include adjustments to the TNAC definition. The TNAC presented here differs from the historically reported TNAC as adjustments were made account for net demand from the aviation sector. This adjusted figure stands at 1.18 billion for the calendar year of 2019. In all of these modelling results, the term TNAC refers to this adjusted definition (which accounts for aviation, sectoral extension, and linked markets). All changes in MSR policies are assumed to take effect in 2024 and enter market expectations from 2022.

Results focus on the 2021-30 period. Significant changes in the market are expected over the coming decade, including in participant behaviour, abatement technology, and non-ETS regulation. As a result, modelling outcomes beyond 2030 are highly uncertain and should be considered as indicative only. Further reviews of the EU ETS and the MSR are already legislated for this period and will need to provide specific recommendations for the period beyond 2030.

The modelling results presented in this review depend on specific assumptions about market behaviour and expectations. Some of these assumptions are key to explaining the differences observed across scenario runs. Box 3 provides guidance on interpreting the results in the following sections, and section 6.1 provides more detail on the limitations of this modelling approach.

Box 3 Guidance on interpreting modelling results

Key assumptions to keep in mind while interpreting the modelling results include:

- **Imperfect foresight with a 10-year forward looking horizon**: the market is assumed to forecast the (MSR-adjusted) supply of allowances and baseline emissions for the next 10 years. This means, for instance, that an anticipated tightening of the cap between 2024-2030 can influence emissions and banking patterns in 2021. If post-2030 cap trajectories differ, the model would show different pre-2030 emissions, banking, and prices. Therefore, the comparisons of different 2024-2030 cap trajectories have been aligned post-2030 to a common LRF of 5.04%.
- **Price acts as an indicator of the scarcity of future supply of allowances**: with the forward looking behaviour described above, prices respond more to the tightness of supply relative to demand in the medium/long term instead of the short term. As such, temporary shocks limited to a given year has limited impact on modelling results. Meanwhile, changes in overall EU ETS policy ambition can significantly affect the price path.
- **The presence of an MSR tightens future auction supply, increasing abatement and prices:** while different MSR designs vary in the timing and size of intakes, they all significantly reduce the supply of allowances as given from the cap.
- **Modelling at an annual resolution does not examine short term volatility:** the model is not designed to investigate short term shocks or changes to the system.
- **Results are not comparable to energy system models** due to fundamentally different approaches to modelling.

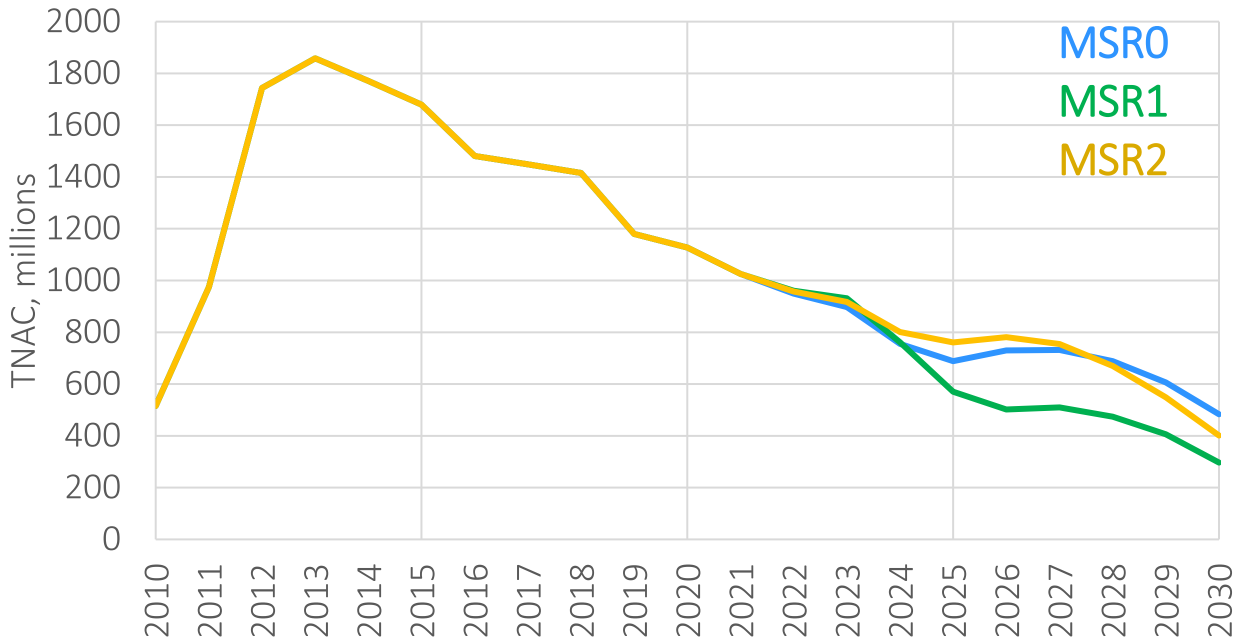
6.3.1 Market surplus (TNAC) and MSR dynamics

Consistent with recent observations of market behaviour, modelling suggests that the expectation of substantially enhanced ambition in the EU ETS increases short term price expectations. This expectation of high ambition and accompanying prices, alongside the economic shock accompanying COVID-19 contribute to substantial banking over Phase 4 of the EU ETS.

TNAC remains above the upper threshold until the middle of this decade, with MSR1 driving down TNAC faster than the alternative designs. In the modelling analysis performed, TNAC lies above 833 million before 2024 across all MSR options, resulting in continuous intakes during this period. The evolution of TNAC over time is jointly determined by annual supply of allowances and the emissions pathway. A more stringent MSR removes a larger supply of allowances through intakes (downward effect on TNAC), with a secondary effect of lowering annual emissions (upward effect on TNAC). On balance, the first effect dominates the second. However, the TNAC trend is uncertain in the near term as the speed of economic recovery and industrial activity following the COVID-19 impact remains unclear. The pathway for TNAC under respective MSR options is shown in

Figure 29.

Figure 29 TNAC under different MSR options



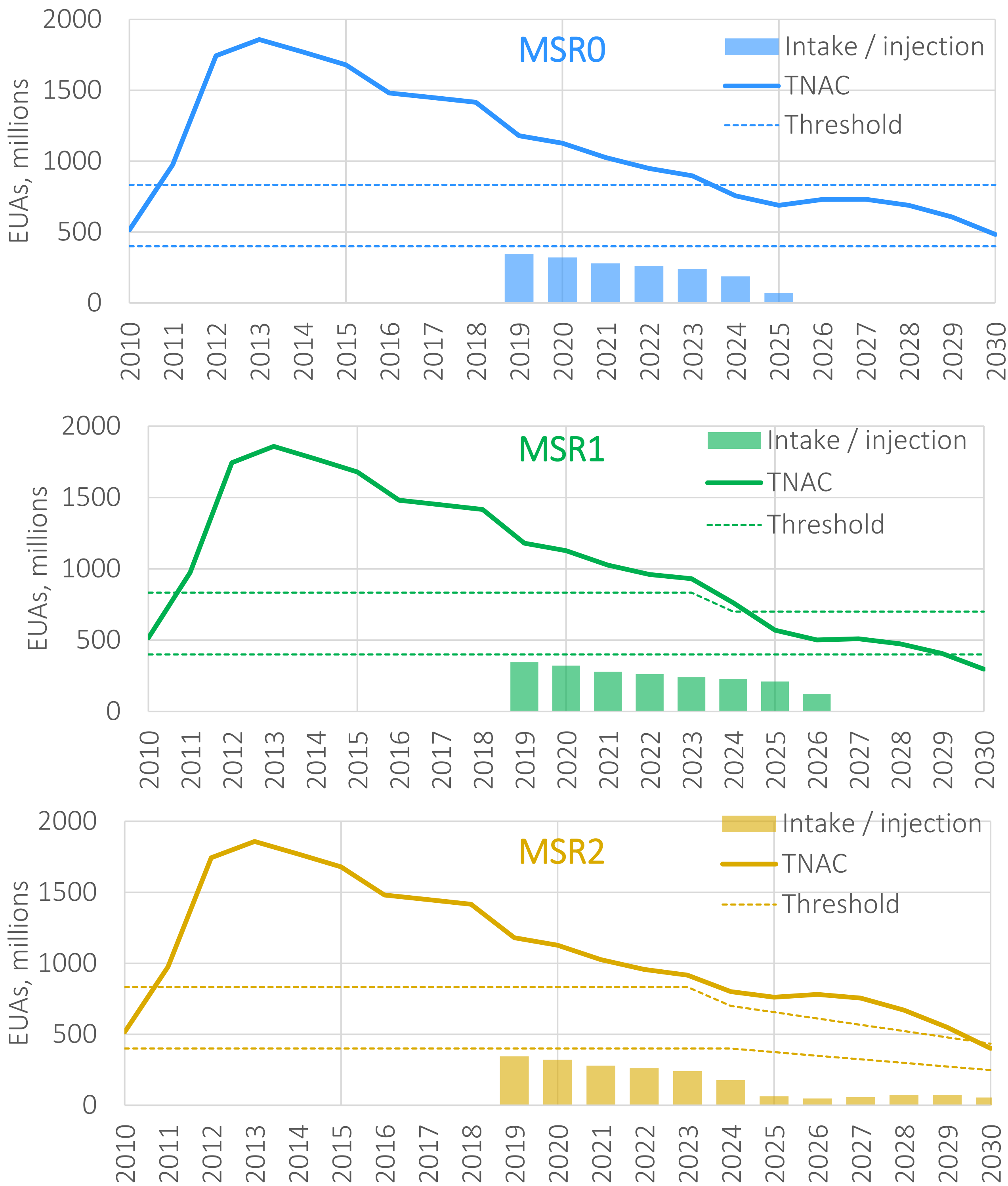
Source: Vivid Economics

Over the period of 2021-30, cumulative MSR intakes are greater under MSR1 and MSR2 than MSR0. The volume of intakes under MSR1 is greater than the baseline option because intakes are set as 24% of TNAC under MSR1, as opposed to 12% of TNAC under the baseline. By contrast, the volume of intakes under MSR2 is defined as 33% of the *difference* between TNAC and the upper threshold, resulting in much larger intakes when the TNAC is larger. Overall, cumulative intakes under MSR2 are very similar to those under MSR1. However, intakes are concentrated at the start of the decade under MSR1, while the declining threshold and removal of threshold effects under MSR2 causes the intake mechanism to persist for longer. The evolution of TNAC alongside the size of annual intakes and thresholds under different options are shown in Figure 30.

MSR1 reduces TNAC relatively quickly at the expense of a threshold effect when TNAC dips below the intake threshold, which MSR2 is able to avoid. The threshold effect occurs when the volume of MSR intakes drops suddenly, which is the result of calculating intakes as a fixed percentage of the TNAC. The threshold effect is most visible as a jump in auction volumes and a kink in the TNAC pathway. In the given scenario for MSR option 1, this occurs in 2027/28. By contrast, MSR2 is able to avoid the threshold effect. This is because intakes under MSR2 is calculated as a percentage of the difference between TNAC and the intake threshold, resulting in smaller intakes as TNAC approaches the intake threshold. The presence of threshold effects can introduce uncertainty to market participants, who face ambiguity about the short term auction supply as TNAC approaches the upper threshold. The realisation of TNAC being right above or below the threshold can represent a sizeable shock to annual auction volumes, resulting in sharp changes in prices.

MSR3 results in a similar market surplus to MSR2 under the baseline. MSR3 follows the design of MSR2, with the only difference being the introduction of an auction reserve price and a ‘safety valve’ cost containment measure. In all cases explored in the modelling analysis, the price under MSR option 2 does not fall below the auction reserve price nor exceed the cost containment price. As a result, the modelling exercise cannot meaningfully distinguish MSR options 2 and 3. In practice, the key differences between MSR2 and MSR3 lie within their responses to short term volatility, which is not captured by the model. With the auction reserve price and ‘safety valve’ cost containment measure, MSR option 3 can anchor price expectations to a narrower range, preventing extreme price swings that may be caused by any significant economic shocks or speculative market behaviour (see Section 6.4).

Figure 30 TNAC and MSR intakes under alternative MSR designs



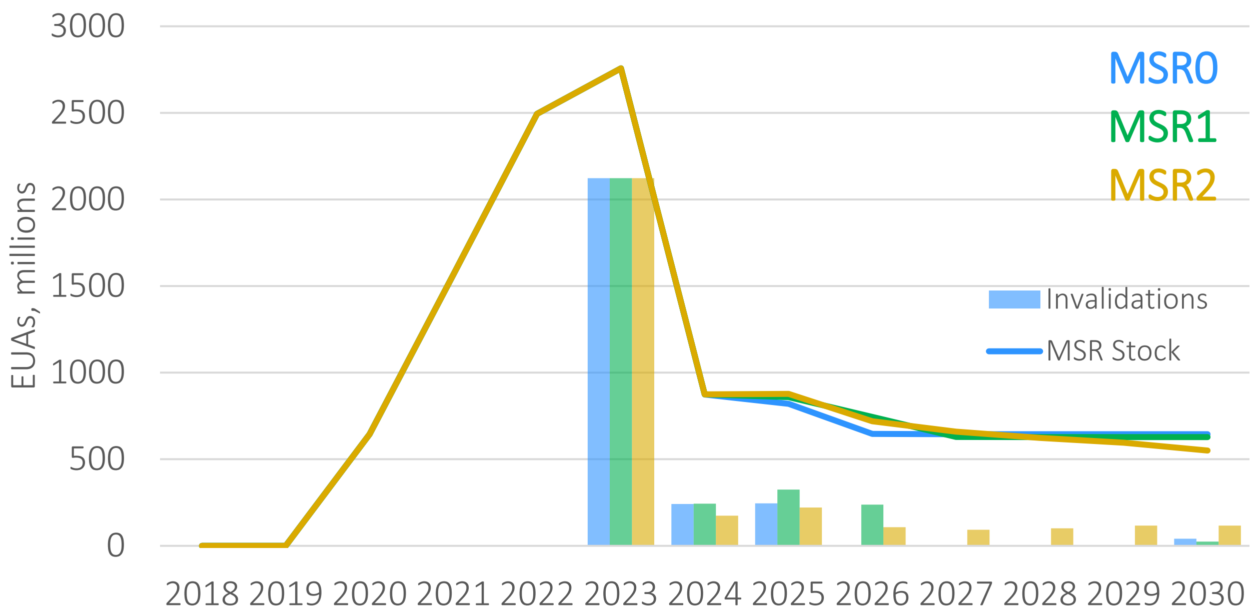
Note: Injections begin the year after the TNAC falls below the lower threshold

Source: Vivid Economics

Across all options, the vast majority of allowances that are placed into the MSR eventually get invalidated. MSR0, as currently legislated, invalidates allowances within the MSR in excess of the prior year auction volume. The EU ETS cap approaching zero in 2050 results a steadily declining stock of allowances within the MSR as allowances in excess of the preceding year's auction volumes are invalidated, leaving behind a small number of allowances in the MSR. MSR1 also follows this invalidation mechanism, resulting in a similar downward trend in the stock of allowances held in the MSR. Meanwhile, MSR2 invalidates allowances in excess of the intake threshold. Since the thresholds under MSR2 are held constant after 2030, invalidations will not completely remove the MSR stock. As a result, the residual MSR stock under MSR2 remains at around 400 million allowances, which are available for injections in the case of supply shortages. Across all MSR options, releases only take place in the 2030s with a cumulative size of 400 to 500 million allowances. This is relatively small when compared to the cumulative MSR invalidations in Phase 4, which range from 2.7 billion under MSR0 to 3.1 billion under MSR2.

The precise design of the invalidation mechanism is not consequential to market outcomes in 2021-30, given that almost all allowances placed in the MSR are invalidated. Given the constrained foresight of market actors, as long as there are no significant volumes of release from the MSR in the 2020s or 2030s, the market's forecast of the future supply of allowances is independent of the timing in which allowances get invalidated within the MSR. What matters to market participants is the supply of allowances in the medium term, which is more influenced by MSR intakes rather than releases. However, the existence of an invalidation mechanism remains important as a guarantee that allowances stored in the MSR will not be released back into future auctions in large volumes.

Figure 31 MSR stock under alternative MSR designs



Note: MSR stock displayed represents the number of allowances at the start of the year, i.e. prior to invalidations and intakes that take place in the given year

Source: Vivid Economics

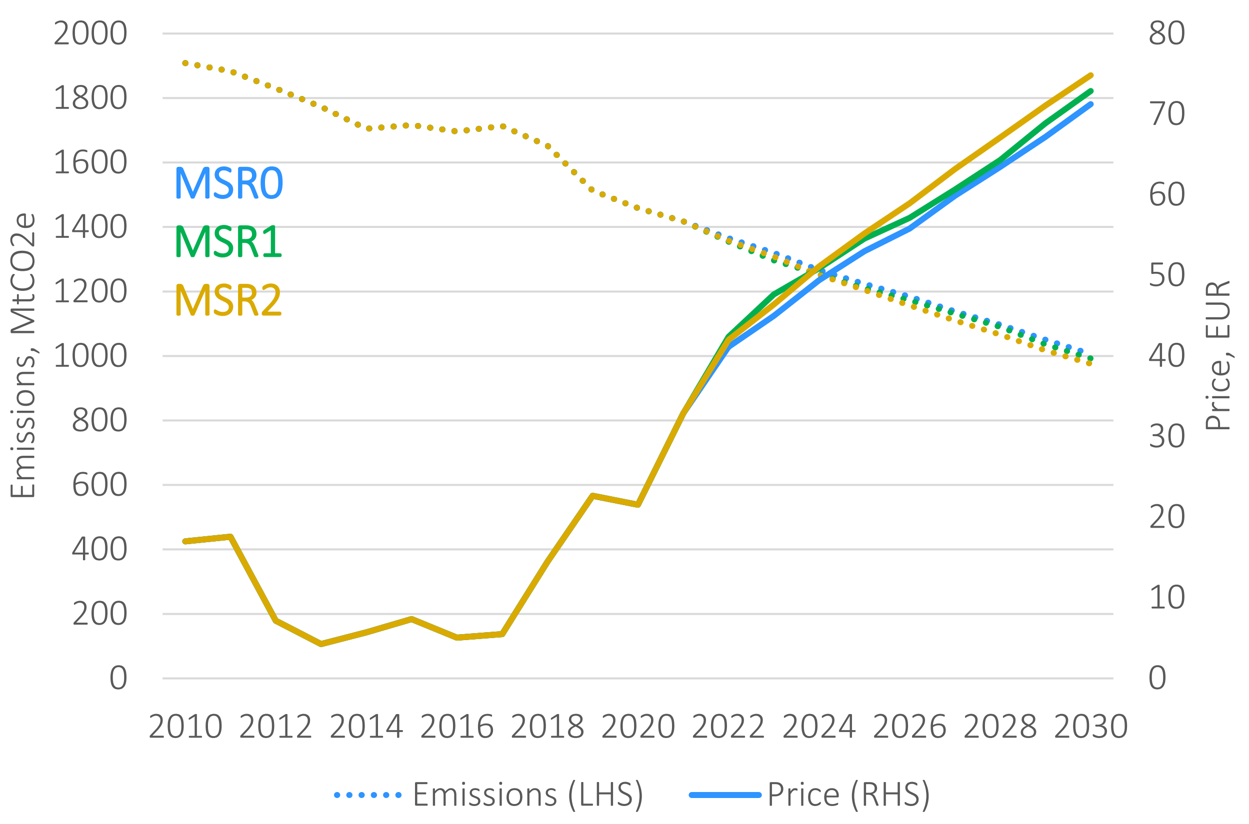
6.3.2 Allowance prices and emissions

MSR options that reduce cumulative allowance supply further have a larger impact on allowance prices and emissions. With forward-looking market participants, price is an indicator of the perceived scarcity of emissions allowances in the short and medium term. The impact of MSR on prices depends on the extent it reduces auction volumes over the time horizon relevant to market participants. Similarly, the level of emissions in the market equilibrium is determined by the scarcity of allowances. A tighter supply increases abatement and reduces emissions, with elevated prices reflecting the more emissions abatement, and hence high marginal abatement costs from firms regulated under the EU ETS. It is important to note that these modelled prices are indicative of the differences between the options. The overall price trajectory is significantly influenced by the cap, and that the MSR has limited impact on prices.

Prices are the highest under MSR2 due to larger intakes, reaching €75 in 2030. Prices are lowest under MSR0, reaching €71 in 2030. MSR1 sees higher prices than MSR0 in the first half of this decade driven by larger intakes and therefore tighter supply. However, as intakes under MSR1 come to an end earlier than MSR0, their price paths converge towards 2030, with the price reaching €73 under MSR1. Finally, MSR2 results in the tightest supply across all the options, resulting in a sharply higher price path that is about €4 above that of MSR0.

Similarly, emissions under MSR2 are lower relative to MSR0 and MSR1. Under the MSR0 and MSR1, 2030 emissions reach 1,010 $MtCO_2e$ and 990 $MtCO_2e$ respectively. This compares to 2030 emissions of 975 $MtCO_2e$ under MSR2. It should be noted that these emissions projections are not directly comparable to those from energy system models which optimise for the entire energy system. The key insight from these numerical projections is that MSR intakes play a minor but positive role in reducing emissions further under the EU ETS.

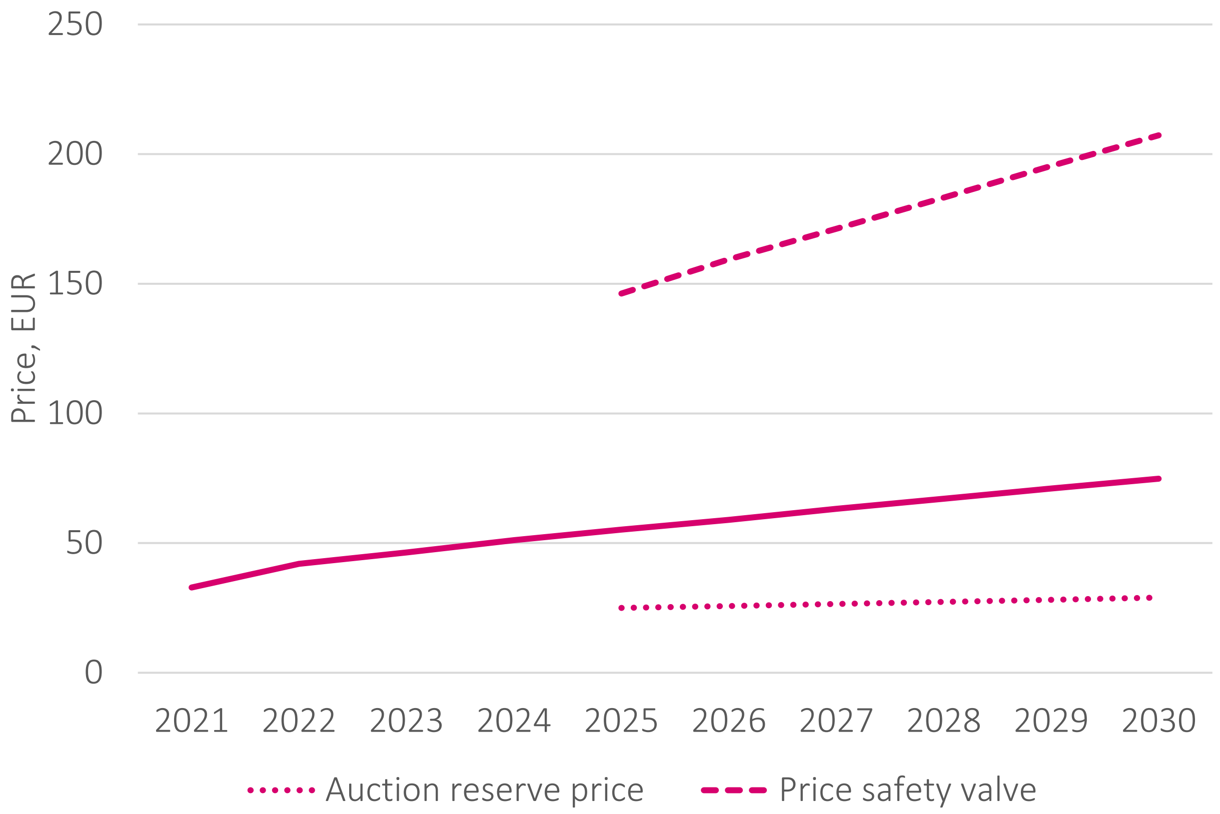
Figure 32 Prices and emissions under alternative MSR designs



Note: Prices are presented in constant 2015 prices.
Source: Vivid Economics

Modelling outcomes under MSR3 are the same as MSR2, though the inclusion of short term responses should mitigate short run price volatility. The modelling outcomes are the same as MSR3 is designed in the same way as MSR2 in terms of intake, releases, and thresholds. The inclusion of an auction reserve price and a 'safety valve' auction cost containment price under MSR3 simply introduces lower and upper bounds to the range of prices in the market, as illustrated in Figure 33. In the assumed policy environment, these lower and upper bounds are not breached throughout the time horizon in the absence of large shocks. Given current and expected prices, the value of the safety valve auction ceiling far exceeds any price level likely except in extreme circumstances. Note the modelling framework used is not able to test short term (less than a year) price variations and as such cannot fully explore potential differences between MSR3 and MSR2. In practice, the addition of short term response measures may curb speculation and prevent extreme price swings that cannot be captured by this model.

Figure 33 Prices under MSR3



Note: Prices are presented in constant 2015 prices.
Source: Vivid Economics

Modelling indicates that the increase in EU ETS ambition through changes to the cap is a much more significant driver of the price trajectory. The central case used in the modelling analysis for this impact review assumes the case of a 5.04% LRF taking effect in 2024, without a rebase of the cap. The increase in long term ambition from a LRF of 2.2% has a much larger impact on prices than variations in the MSR design, as it implies much greater changes in the long term supply of EU allowances to the ETS.

6.3.3 Price volatility

The smooth price paths depicted in the graphs above is a result of modelling assumptions and the annual reporting period in the model. In practice, shocks will introduce short term volatility within time spans of weeks or months. These short term shocks are not captured through the quantitative model deployed for this study. This section examines how the MSR can influence price stability in the short term, while the next sections (6.4) will discuss the MSR in response to longer term, structural shocks.

Price volatility is caused by shocks to market expectations or changes in market behaviour that alter the demand or supply of allowances. The EU ETS is similar to other commodity markets that unanticipated news can cause EU allowance prices to fluctuate, while market fundamentals determine the longer-term price path. For the EU ETS, these fundamentals are related to factors such as the stringency of the cap or the level of abatement costs in the covered sectors. Short term volatility can be introduced by both the demand and supply side of the market. On the demand side, a range of factors can affect demand for emissions allowances, ranging from the weather to speculative behaviour from financial entities. On the supply side, volatility may arise from policy uncertainty. Unanticipated changes to the stringency of the cap or sudden increases in voluntary cancellations could also introduce price volatility.

In the context of MSR design, clear and predictable intakes will help reduce supply side uncertainty. As noted in the previous section, both the MSR baseline (currently legislated) and option 1 has a discontinuous response to the level of TNAC: if TNAC is just above the intake threshold, the MSR will remove over 100 million allowances from subsequent auctions, compared to zero intakes if TNAC is just below the intake threshold. This represents a major source of uncertainty to market participants as TNAC approaches the upper threshold, a very plausible case for the decade 2021-30. Prices may become volatile as market expectations regarding the level of TNAC swings back and forth depending on forecasted emissions, as the precise number of TNAC will be influential to allowance supply.

Predictability is one of the main advantages for the intake design proposed for MSR2. Intakes under MSR2 is proportional to the difference between TNAC and the intake threshold, resulting in a smooth response function. This will prevent the price volatility associated with the threshold effect as in the case of the baseline and MSR1.

Both MSR1 and MSR2 can contribute to price stability by providing sufficient market liquidity. For the market to operate effectively, the TNAC needs to be high enough to allow for hedging as well as efficient banking to spread out intertemporal abatement costs. Therefore, the MSR thresholds play an important role in ensuring that the TNAC stays at a reasonable range. The intake threshold proposed in MSR1 and MSR2, starting at 700 million in 2024, sits within the upper range of the estimated amount of market surplus required for hedging between 2025 and 2030.

Both MSR1 and MSR2 should continue to signal political commitment in the EU ETS, in itself providing stability to the system. An important driver for the EU allowance price increase over the past two years has been the escalating political ambition within the EU in reducing its emissions. This also serves as an anchor for longer term (e.g., 2030) price expectations for the market, thereby preventing sharp drops away from this broadly increasing trajectory. By removing allowances from circulation, the MSR reinforces this market expectation and provide price stability even in the shorter term. To this end, both MSR1 and MSR2 will continue to trend through higher intakes compared to the baseline and greater responsiveness to shocks.

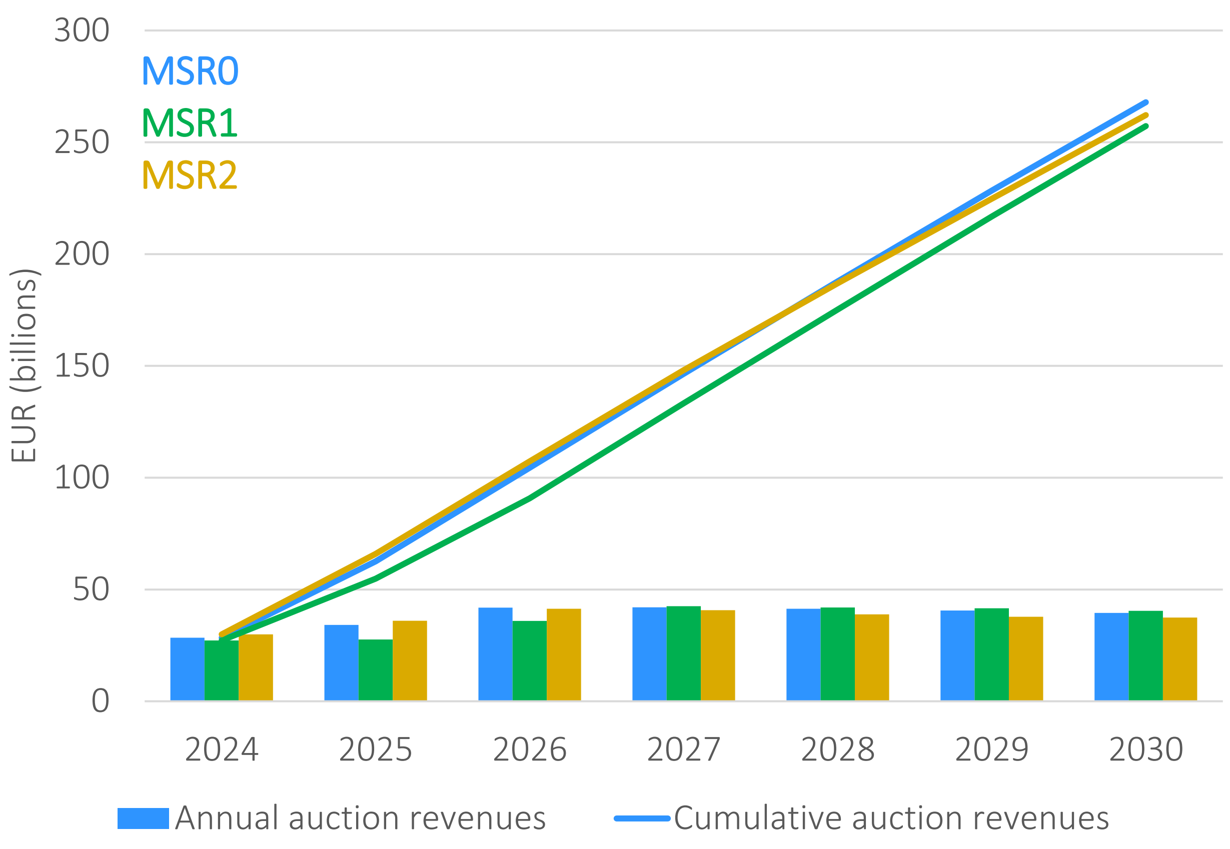
MSR3 may provide additional stability by constraining market expectations regarding potential extreme price outcomes. The introduction of an auction reserve price would create a floor on market price expectations, which would reduce uncertainty in the event of downside shocks, such as a negative demand shock. Meanwhile, the introduction of a price safety-valve would provide further certainty that excessive price spikes could be avoided in the event of positive demand shocks or excessive speculative holdings.

6.3.4 Other considerations

Auction Revenues

Auction revenues under MSR1 and MSR2 are about 2-4% lower than the baseline due to larger reductions in auction volume. The size of auction revenues is jointly determined by the volume of auctions and the EU allowance price. Due to larger intakes under MSR1 and MSR2 as compared to the baseline, cumulative auction volumes are about 4-5% lower relative to the baseline between 2024-2030. Meanwhile, prices under MSR1 and MSR2 are marginally higher than the baseline. As a result, compared against the baseline, auction revenues are 4% lower in option 1 and 2% lower in option 2. The cumulative and annual auction revenues under all MSR options between 2024-2030 are shown below.[135]

Figure 34 Annual auction revenues under different MSR options



Note: Prices are presented in constant 2015 prices.
Source: Vivid Economics

Competitiveness

The design of the MSR affects EU competitiveness mainly through two channels: impact on the EU ETS price level and stability. Overall, the literature has found little evidence of any negative impact that the EU ETS had on competitiveness. This may be explained by the relatively low EU allowance prices to date, and the relatively large share of free allocations in the annual cap. Yet, it remains possible that competitiveness impacts will emerge as EU allowance prices continue to rise and free allocations get phased out for some sectors.

[135] Free allocations are set constant at 43% of the cap across all options for the modelling analysis.

Given their limited impact on price levels in this modelling, the different MSR design options will have minimal differences in terms of carbon leakage and competitiveness. As mentioned in Section 6.3.2, the different MSR design options displayed limited price impacts in the modelling analysis – the difference between MSR0 and MSR2 were about €4 only. Given the lack of adverse impacts on competitiveness and leakage so far from the EU ETS price in general (see Section 9), this limited price increase driven by the MSR is unlikely to bring significant negative competitiveness impacts. With regards to carbon leakage and competitiveness, the stringency of cap is much more consequential than the MSR design.

The design of MSR2 and MSR3 is able to improve the predictability of intakes as compared to the baseline and MSR1. As intakes are more predictable and continuous throughout the time horizon, MSR2 and MSR3 can reduce uncertainty on the supply side. The exact impact on competitiveness has not been quantified in the literature. However, the magnitude of such an impact is likely much smaller than that of the expected increase in prices and the phasing out of free allocations that may accompany the introduction of a CBAM.

Further detail on the competitiveness impacts of the MSR are presented in Section 9.

Social impacts

Other than the size of auction revenues, the various MSR designs will have limited differences in their social impact. The notable distinction across the MSR designs is the size of their auction revenues, which is redistributed across member states and industries to fund various projects. As described earlier in this section, cumulative auction revenues between 2024-30 are 2% - 4% lower in MSR1 and MSR2 when compared against the baseline option. MSR3 should be similar to MSR2 as well in this regard due to the same intake mechanism and thresholds. Therefore, adopting MSR options 1, 2, or 3 could forgo some opportunities to direct greater funding to achieve certain social objectives.

The social impact of MSR option 1 and 2 via prices will be limited. The type of social impact from the MSR via prices is similar to increasing ambition within the EU ETS, albeit at a smaller magnitude. Since MSR1 and MSR2 have just 1% to 5% impact on market prices by 2030 relative to the baseline, they constitute a very small share of the broader impact of the EU ETS. Based on the impact assessment conducted by the Climate Target Plan, which describes an upper estimate of 0.26% job losses from a 55% emissions target, the potential impact of the MSR likely sits within a negligible share of total employment within the EU.[136] While the aggregate statistic does conceal distributional consequences from greater climate ambition, the impact attributable to high prices *driven by* the MSR is much smaller in proportion.

6.4 Performance of each MSR design option given future shocks

This section provides stress tests to assess how different MSR designs interact with changes in external market conditions. The modelled performance of the MSR under different market and policy outcomes can be used to assess the resilience of the MSR. The results of these stress tests will inform the extent to which negative outcomes may be mitigated or accentuated by the MSR.

6.4.1 Anticipated decrease in EU allowance demand: coal phase out

The regulated phase out of coal power has the potential for a significant permanent reduction in EU allowance demand. The coal phase out is expected to reduce EU allowance demand by up to 277 million allowances by 2030. Half of this reduction is built into baseline emissions. The shock here simulates a scenario where the other half of emissions reductions are also realised, reducing EU allowance demand by 27 million allowances in 2021 and up to 138.5 million allowances by 2030. This shock is expected to be larger than other likely sources of anticipated demand reduction such as complementary policy measures or significant progress in industrial abatement technologies. It therefore represents the upper limits of a realistic shock.

[136] From JRC-GEM-E3 model, reported in the Impact Assessment accompanying the Climate Target Plan (SWD/2020/176)

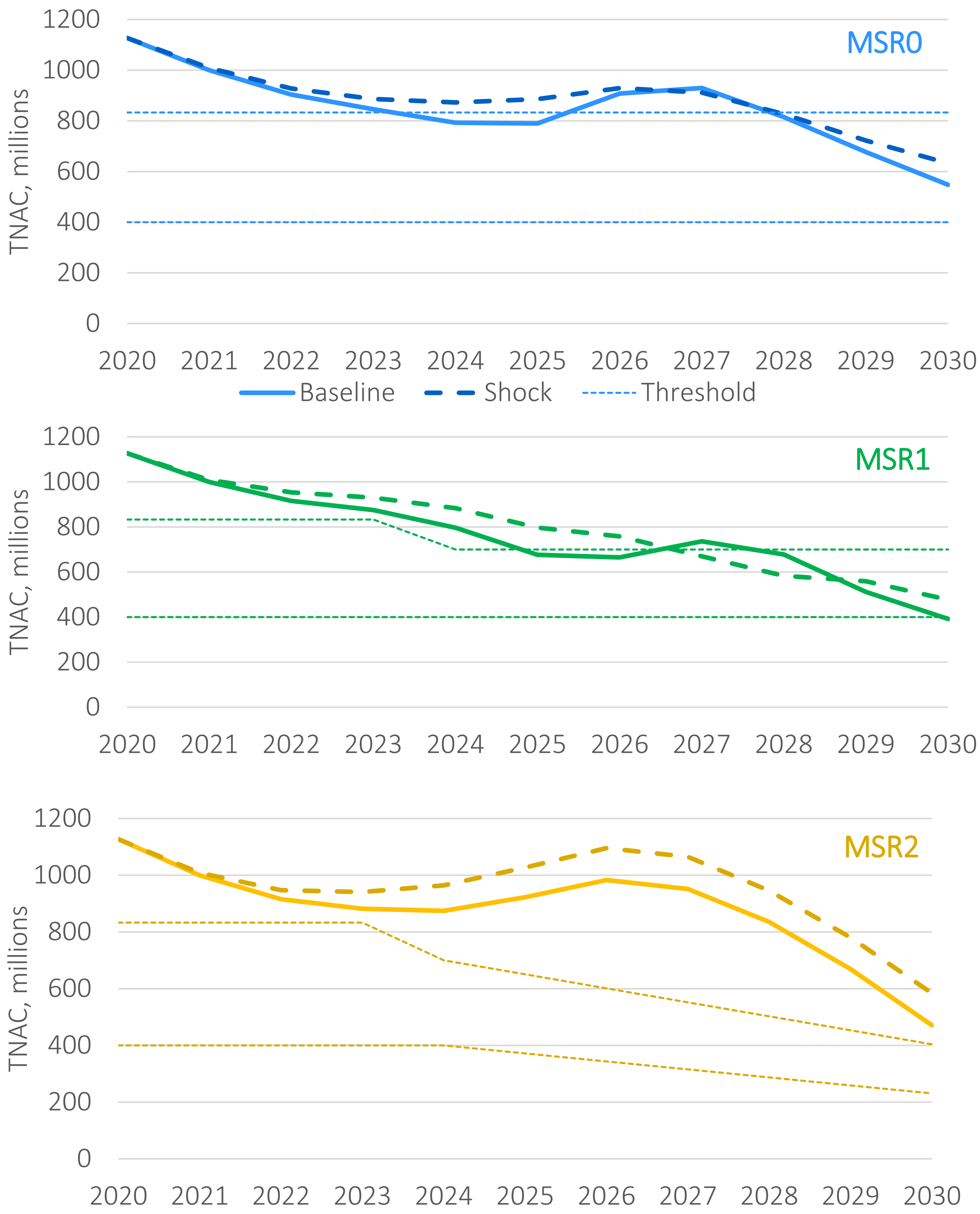
An anticipated reduction in EU allowance demand leads market participants to anticipate lower future prices, leading to a reduction in abatement. If prices fall, compliance entities would rather pay for emissions than invest in abatement. However, this only partially offsets the reduction in emissions from the closure of coal plants, such that total emissions are still lower in the coal phase out scenarios. In other words, the reduction in emissions pushes up TNAC (as there is an excess supply of allowances) while the *expectation* of future emissions reductions reduces TNAC.

Intakes increase under all MSR designs when faced with an anticipated reduction in EU allowance demand, but MSR1 and MSR2 generate a stronger response than MSR0 due to higher intake rates. Under MSR0, the shock results in cumulative intakes from 2021-2030 increasing by 0.22 billion (from 1.24 billion EU allowances to 1.46 billion). Under MSR1, there is an increase of 0.24 billion allowances (from 1.50 billion to 1.74 billion), reflecting the higher intake rate and lower thresholds for activation of the MSR. MSR2 results in an increased cumulative intake of 0.22 billion, similar to MSR0.

The shock bumps TNAC up further, extending intakes till 2028 for MSR 0 and MSR1, and resulting in prolonged intakes into the MSR throughout the 2020s for MSR2. Additional intakes to the MSR under MSR0 and MSR1 are concentrated between 2025 and 2028, as TNAC remains above the upper threshold for more periods under the shock. Conversely, MSR2 has a more drawn-out response, taking longer to neutralise the shock as intakes continue till 2030. This is due to the changed intake rule compared to MSR0 and MSR1. MSR2 gradually ramps up intakes as the impact of the shock gets bigger compared with the unshocked case.

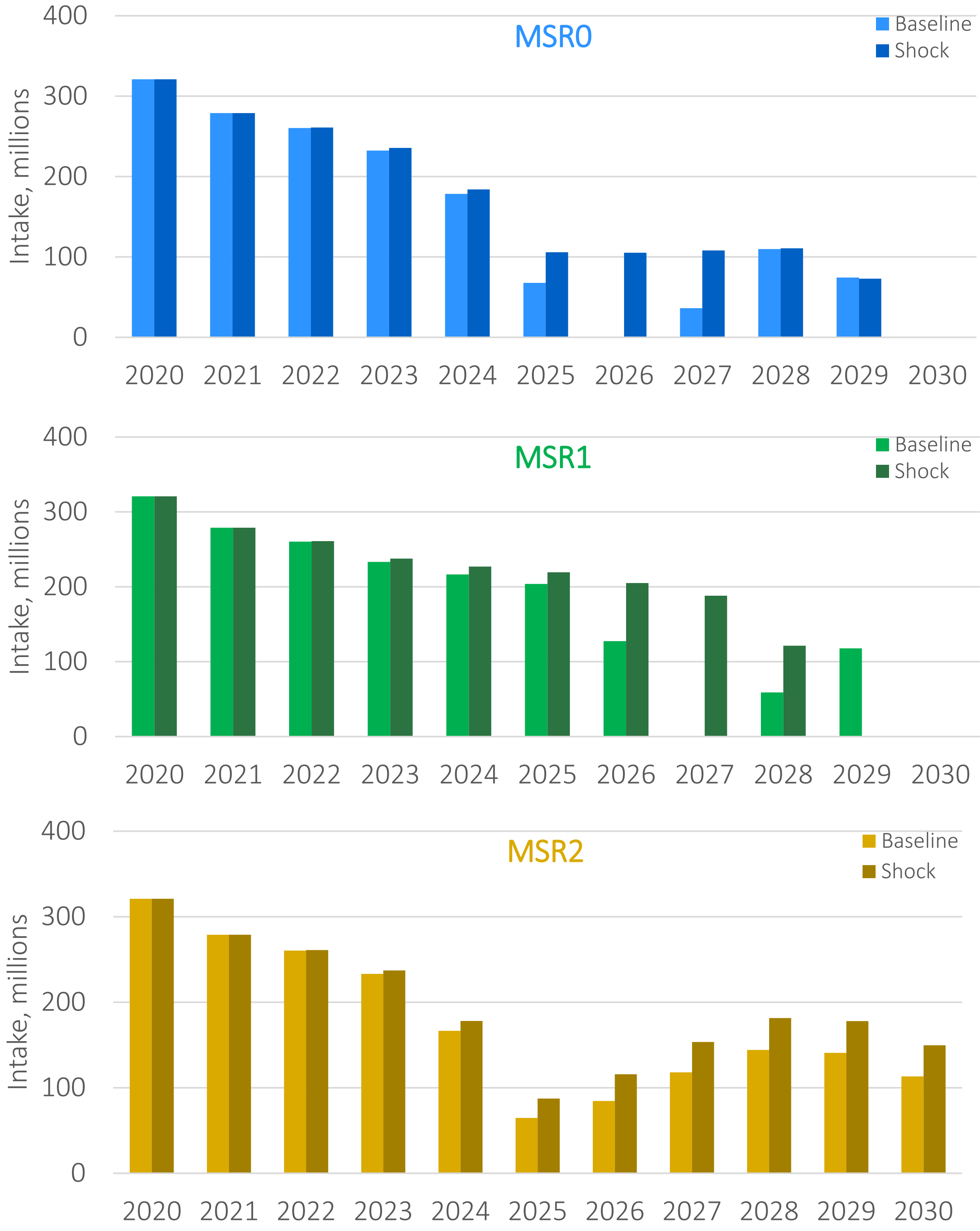
The 2030 TNAC is lowest under MSR1, followed by MSR2 and finally MSR0. Under MSR0 and MSR1, TNAC in 2030 is 85 million higher with coal phase out compared with the baseline scenario. This compares to 113 million under MSR2.

Figure 35 TNAC under an anticipated reduction in EU allowance demand



Source: Vivid Economics

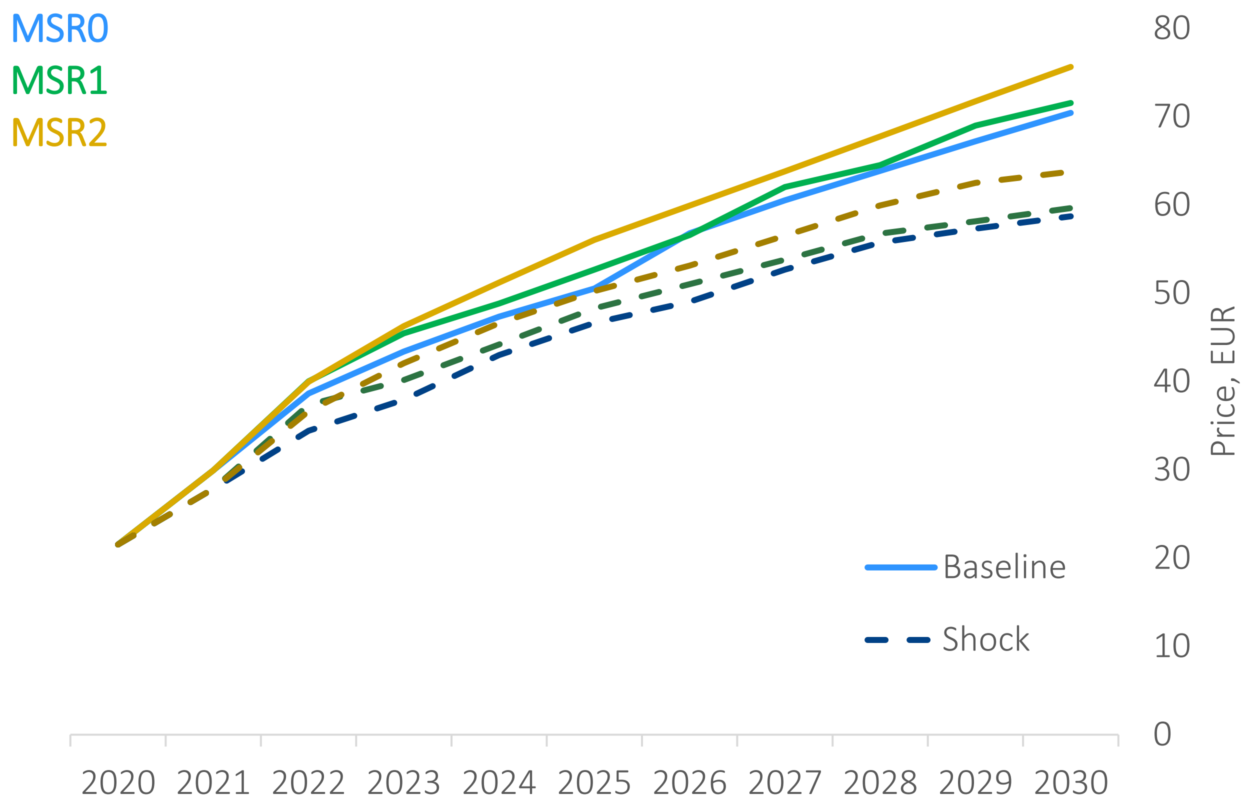
Figure 36 MSR intakes under an anticipated reduction in EU allowance demand



Source: Vivid Economics

A long term reduction in EU allowance demand leads to a consistent decrease in price across MSR designs. As the reduction in emissions is assumed to be permanent, firms have a lower demand for allowances. Prices therefore remain lower to 2030, despite the higher cumulative intakes across all design options. The reduction in prices cause by the shock (measured against the respective reference case) is fairly consistent, at around €10 in all MSR designs. This indicates that the MSR is not well suited to maintaining a particular price level in the event of an anticipated long term shock, which permanently alters the available allowances and firm behaviour.

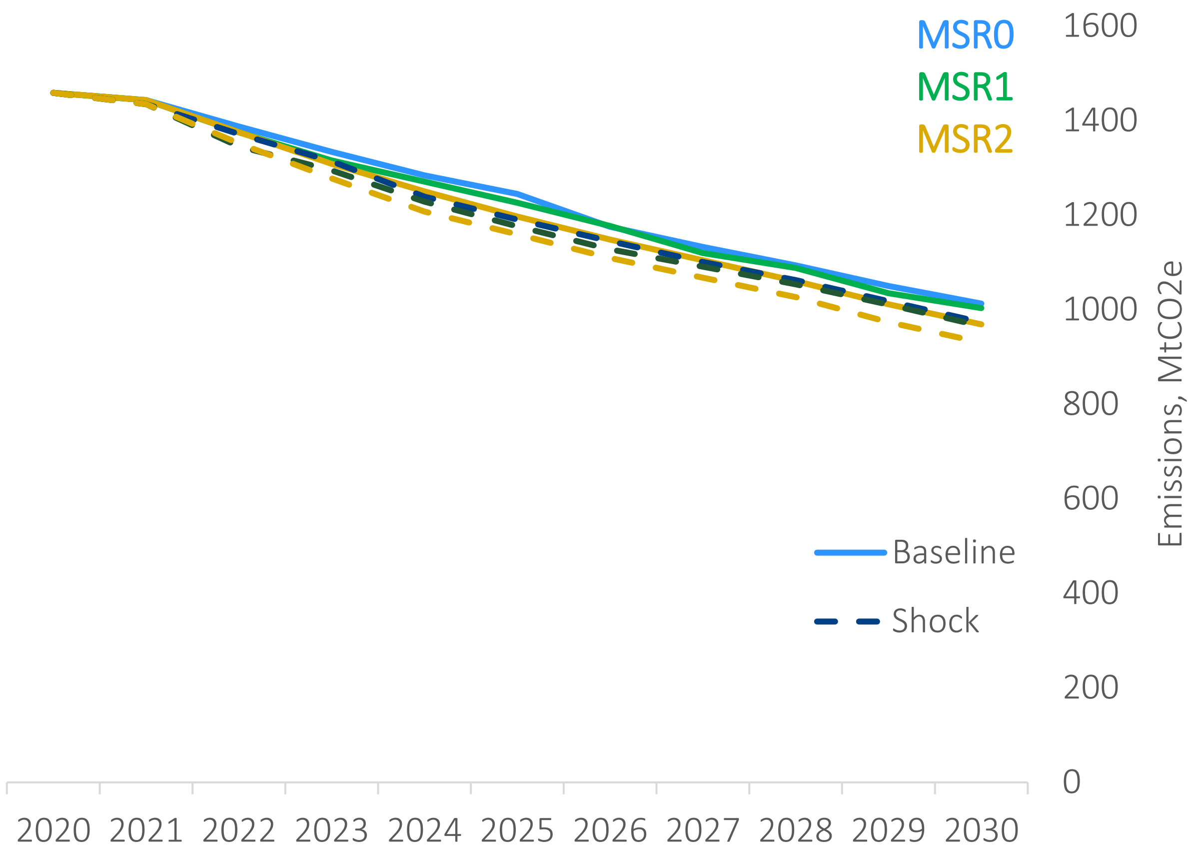
Figure 37 EU allowance prices under an anticipated reduction in EU allowance demand



Note: Prices are shown in constant 2015 Euros.
Source: Vivid Economics

Emissions reductions from the coal phase out persist across all MSR designs. These results do not support the 'green paradox' theory, whereby anticipated emissions reductions lead to entities reducing abatement behaviour. This is due to the fact that the impact of the coal phase out on emissions is realised gradually, with additional reductions occurring each year from 2021-30. The emissions reductions realised from 2021 offset the reduction in abatement due to lower anticipated emissions levels in future years, leading to a consistent reduction in emissions relative to the baseline.

Figure 38 Emissions under an anticipated reduction in EU allowance demand



Note: Prices are shown in constant 2015 Euros.
Source: Vivid Economics

6.4.2 Unanticipated change in EU allowance demand: economic shock

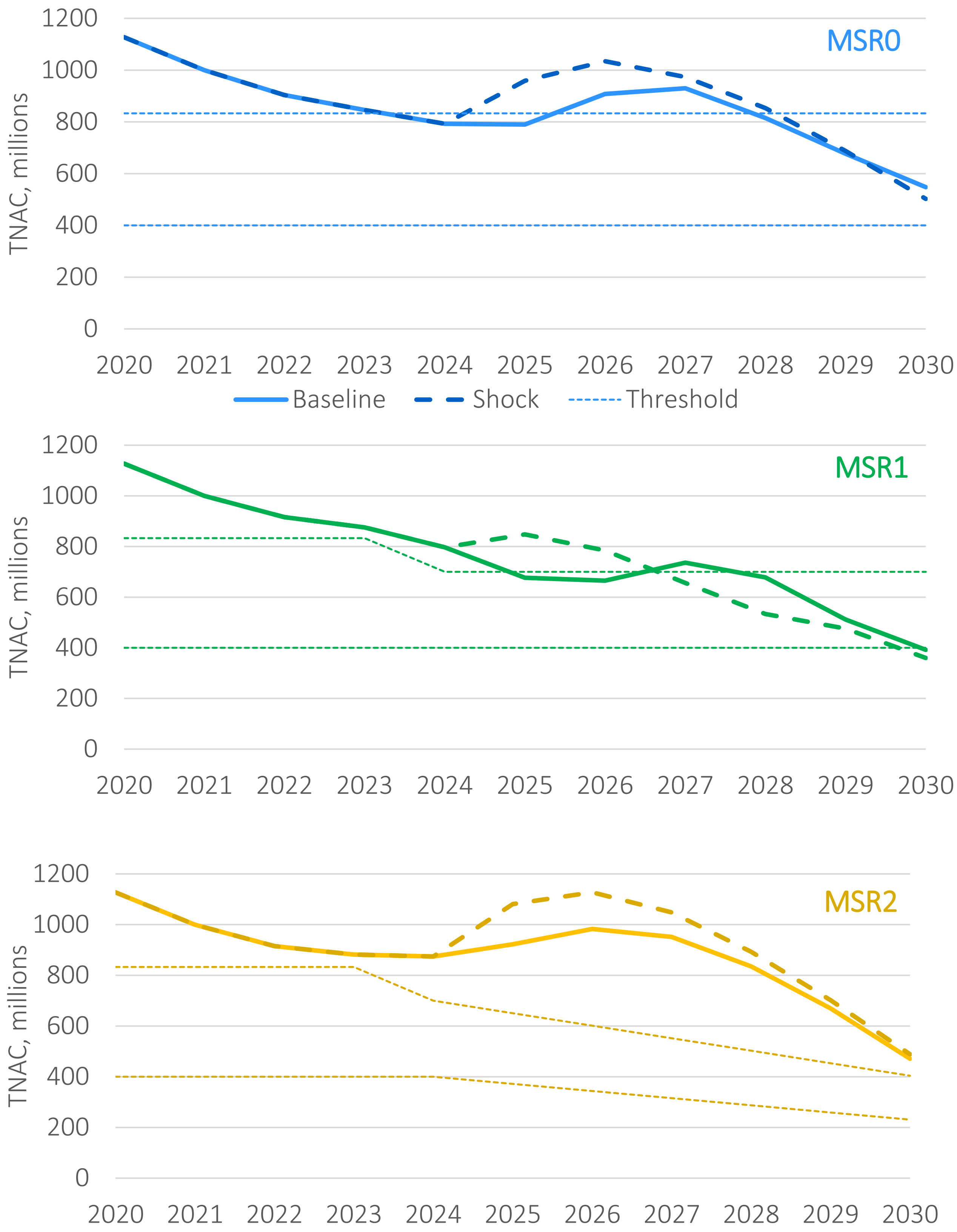
A sudden economic downturn can result in reduced emissions and an unanticipated decrease in EU allowance demand. Conversely, an economic boom could result in higher demand for EU allowances. In this section we explore four different variations of an economic shock:

- **A temporary economic recession**. This tests the impact of a 155 Mt shock occurs in 2025, lasting for one period before economic production and baseline emissions bounce back to previous levels. The magnitude of the shock is based on the 2020 emissions impact of COVID-19, which represents an unprecedented reduction in emissions.
- **A temporary economic recession with a shorter anticipation horizon for the firm**. This scenario tests the impact of a temporary shock (as outlined above) when firms have a shorter time horizon (3 years instead of 10 years).
- **A persistent economic recession**. This tests the impact of a 155 Mt shock in 2025, which halves in 2026 (78 Mt), and halves again in 2027 (39 Mt). The 39 Mt reduction is considered structural and remains persistent to the end of 2050.
- **A persistent economic boom**. Finally, we consider a scenario where there is an unanticipated increase in EU allowance demand rather than a decrease.

Temporary reduction in EU allowance demand

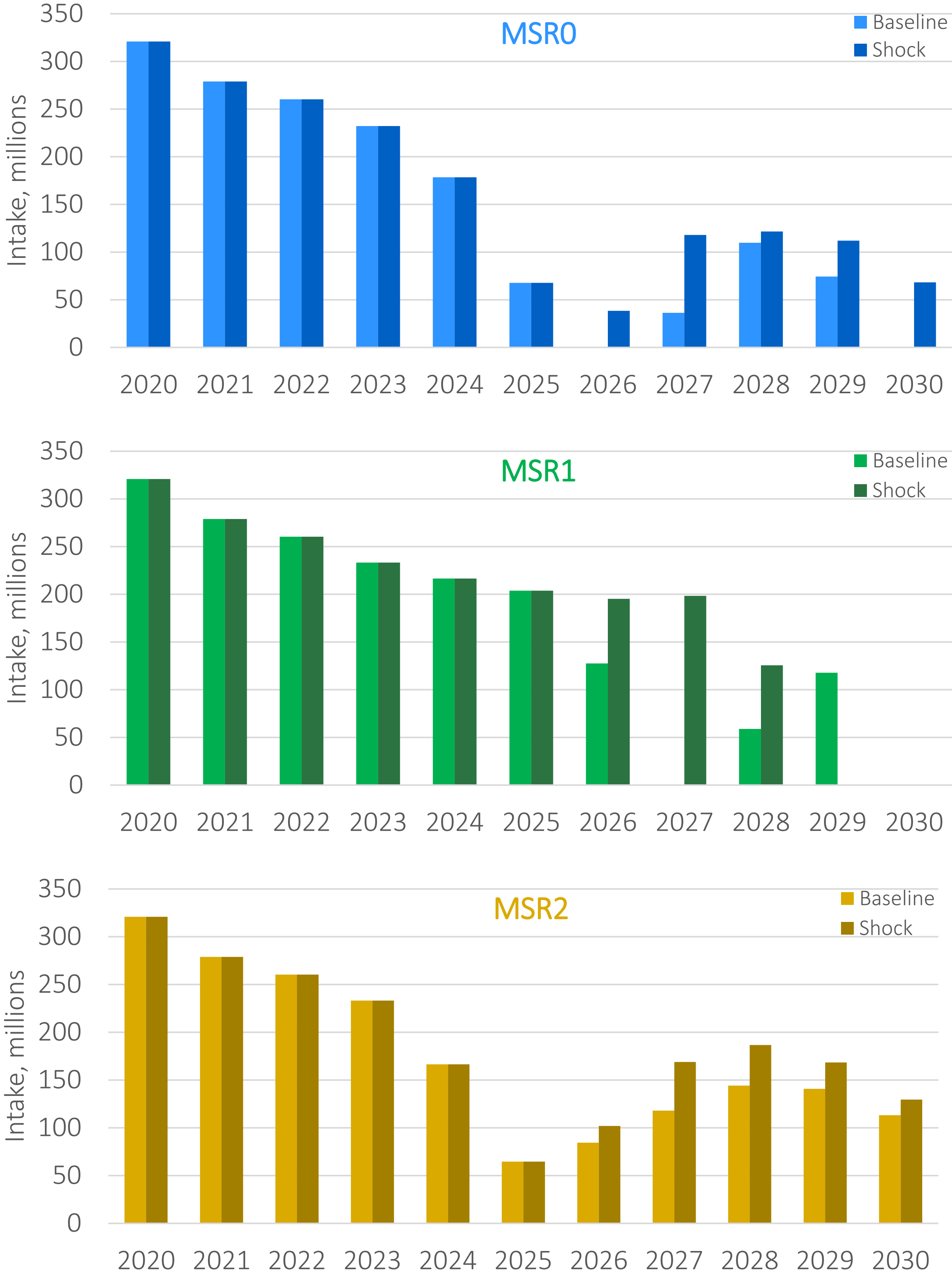
An unanticipated reduction in EU allowance demand leads to an increase in TNAC across MSR designs as firms bank excess allowances, but different intake rules lead to varied reactions. The initial change in TNAC is fairly similar across different MSR designs, with TNAC increasing in 2025 in response to a negative economic shock. However, subsequent reaction to the shock is dependent on the MSR design. MSR0 is not able to bring the TNAC back in line with the baseline by 2030, five years after the shock occurs. MSR1 reduces the surplus quicker due to the higher intake rate. The larger intakes as a result of the shock even result in TNAC dipping below what it would have been without a shock. This result is due to threshold effects. MSR2 is able to reduce most of the surplus by 2030. Under MSR0 and MSR1 intakes stop by the end of the decade. However, declining thresholds mean that intakes continue under MSR2.

Figure 39 TNAC under a temporary reduction in EU allowance demand



Source: Vivid Economics

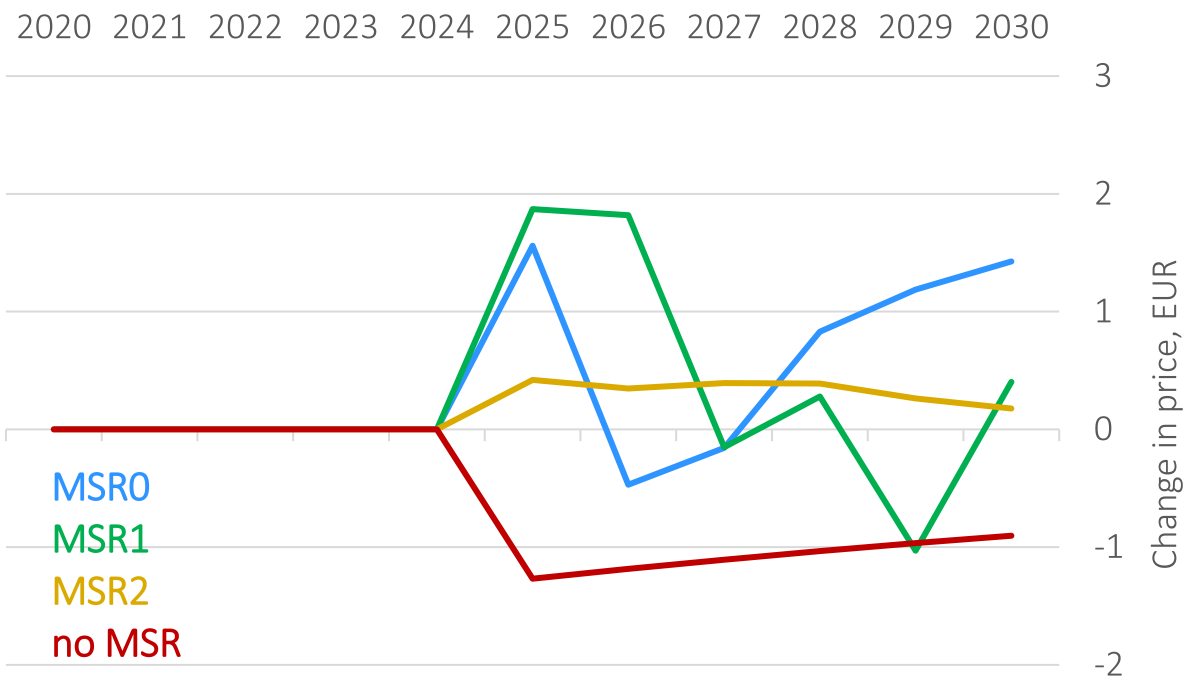
Figure 40 Intakes under the baseline and temporary reduction in EU allowance demand



Source: Vivid Economics

The price response to an unanticipated shock is limited and equivalent across MSR designs, in part due to an assumption of 10-year foresight for firms. In the years following the initial demand shock, prices relative to the reference case without the shock are broadly the same, with some small deviations for MSR0 and MSR1 due to threshold effects. The variation between designs is in the range of 1.5 euros. This is due to the temporary nature of the shock and the MSR's delayed time scale of action. By the time the intakes kick in, economic activity has returned to normal. The price trajectory is unstable for MSR0 and MSR1 due to changing expectations of the size of intakes in future periods. This contrasts with a relatively stable price path under MSR2. This is also due to modelling assumptions, as firms anticipate that the long term emissions trajectory is relatively unaffected.

Figure 41 EU allowance prices relative to baseline under a one period unanticipated reduction in EU allowance demand

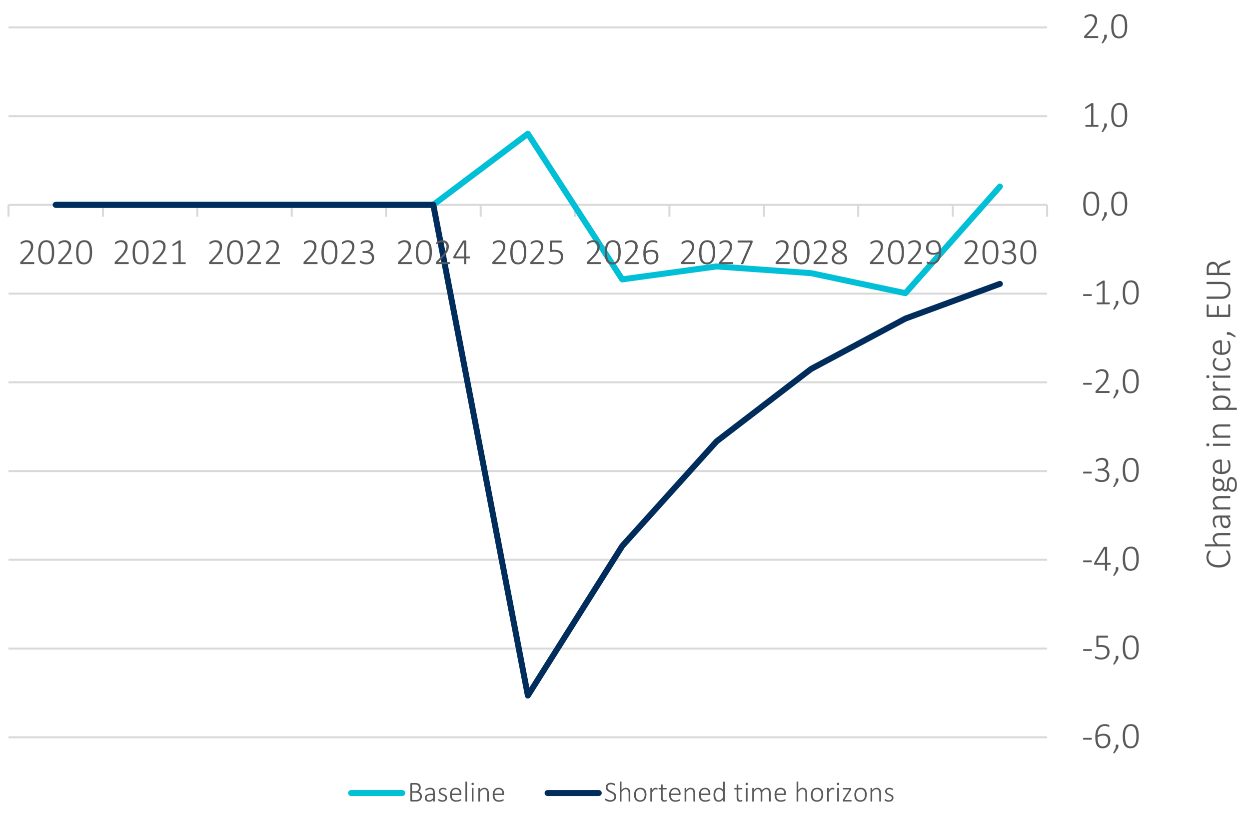


Note: Prices are shown in constant 2015 Euros.
Source: Vivid Economics

Temporary unanticipated reduction in EU allowance demand with shortened time horizons

The relatively muted price response in the previous section is partially a result of the modelling assumption that firms have a 10 year forward looking horizon. While this horizon is likely appropriate for the medium term without any economic disturbances, firms typically behave in a more short-sighted fashion in times of crises. We therefore tested this reduction in EU allowance demand with a 3-year time horizon. Results show that there is a more dramatic decrease in price when firms have a shorter time horizon.

Figure 42 EU allowance prices relative to baseline (MSR0)

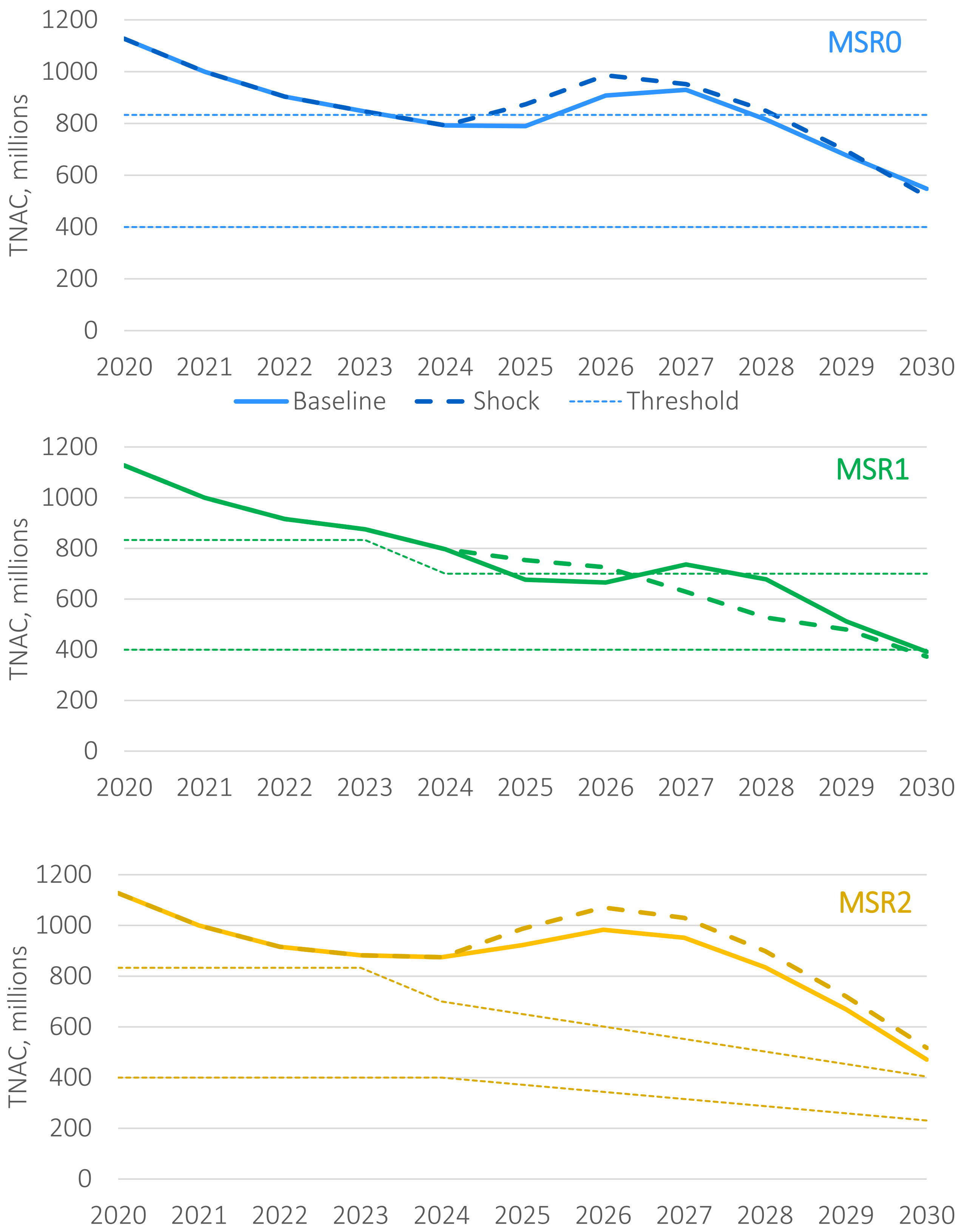


Note: Prices are shown in constant 2015 Euros.
Source: Vivid Economics

Persistent and unanticipated reduction in EU allowance demand

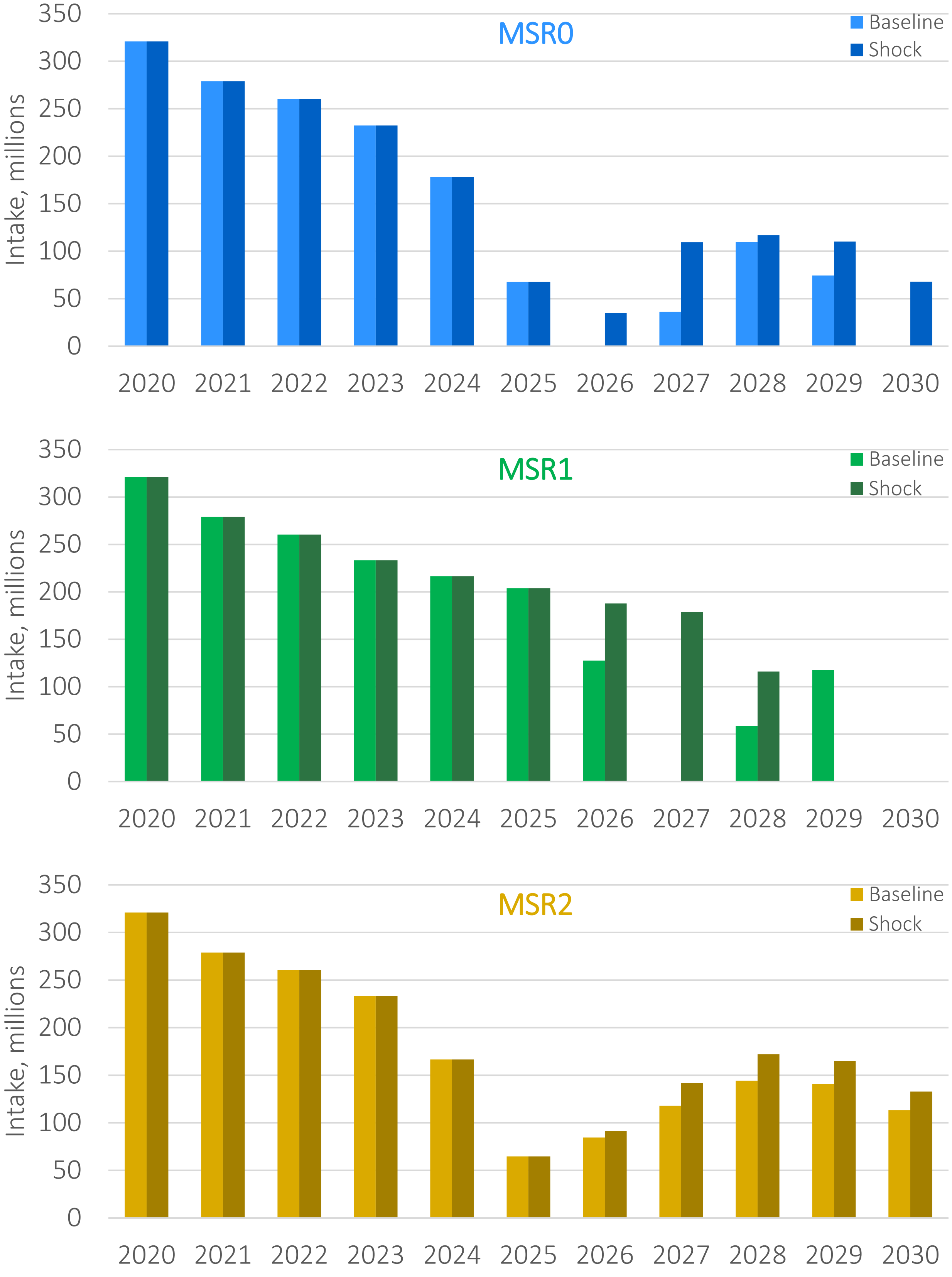
The key difference between a temporary and persistent reduction in EU allowance demand is the effect on prices, which fall more significantly and remain slightly lower than the baseline through to 2030. Prices fall by around 10 EUR in 2025 when the shock occurs and remain about €4 lower than the counterfactual without the shock across all MSR designs in 2027. This price impact persists to 2030 due to the long term persistence assumed in this case. The price impacts vary slightly by MSR design, with MSR1 making the quickest recovery due to the higher intake rate. However, differences of this small size (approx. €2) should be interpreted with caution.

Figure 43 TNAC under a persistent unanticipated reduction in EU allowance demand



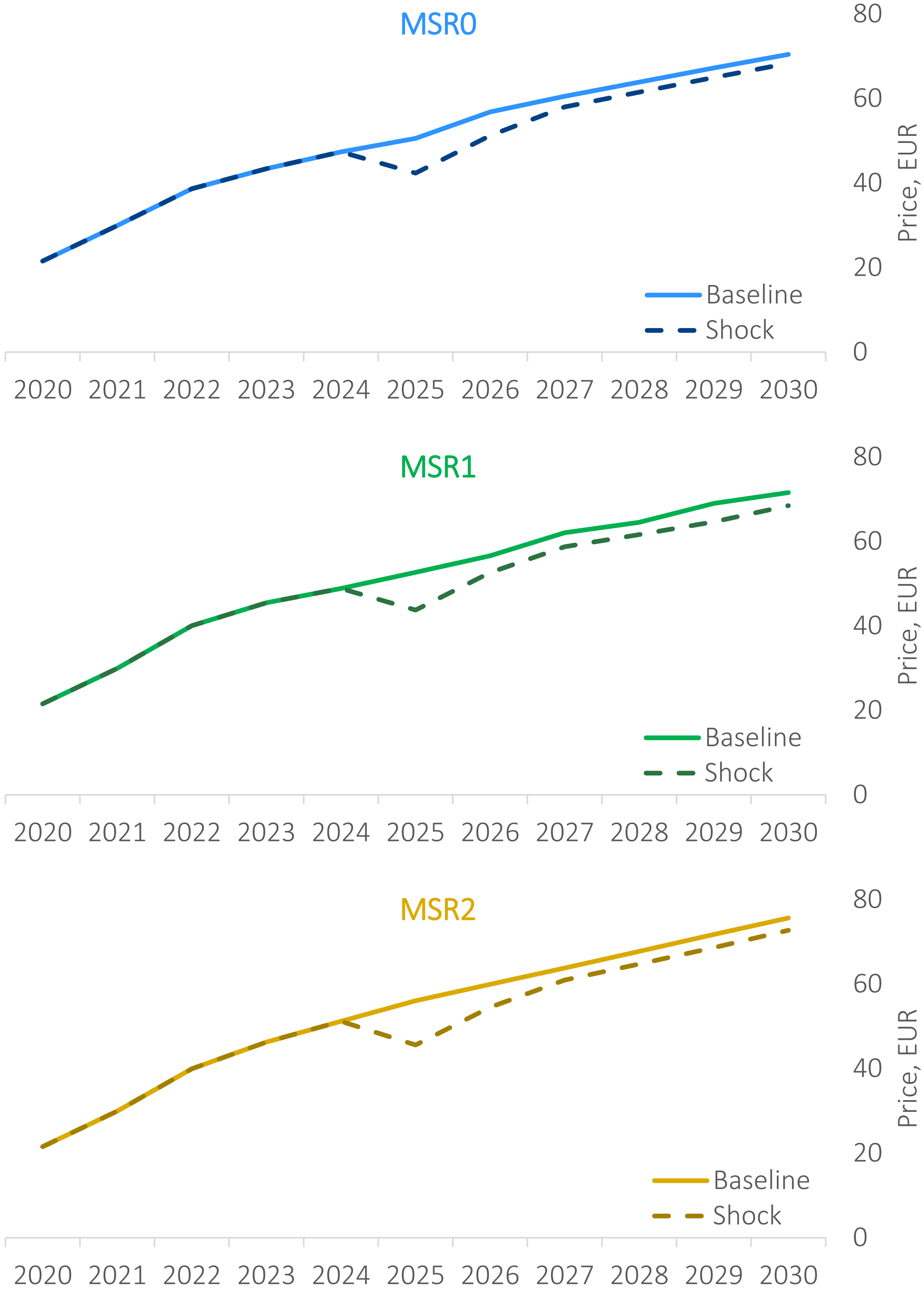
Source: Vivid Economics

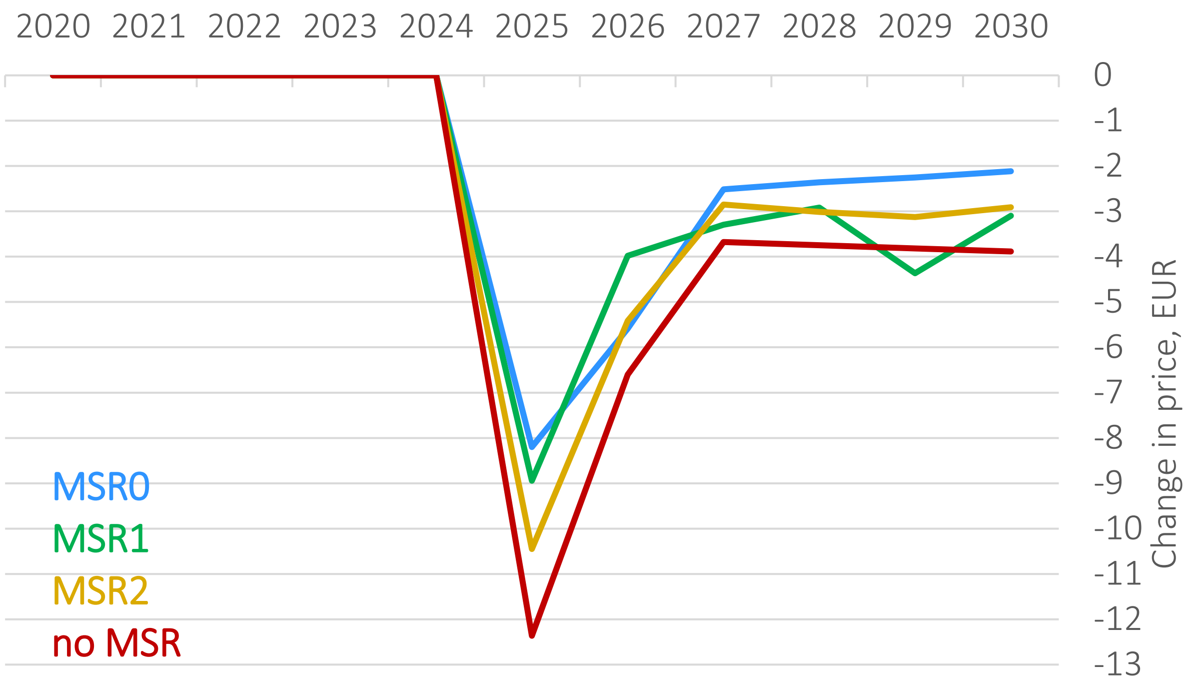
Figure 44 Intakes under a persistent unanticipated reduction in EU allowance demand



Source: Vivid Economics

Figure 45 EU allowance prices under a persistent unanticipated reduction in EU allowance demand

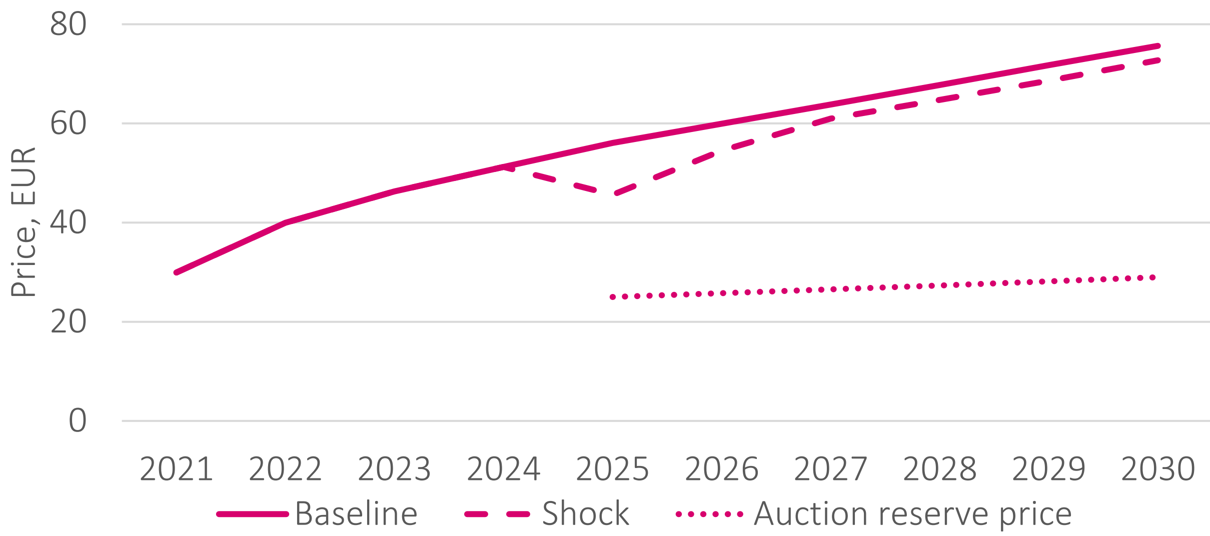




Note: Prices are shown in constant 2015 Euros.
Source: Vivid Economics

An auction reserve price, which is part of MSR3, could provide a faster and more effective response to negative demand shocks. The MSR3 design outlines an auction reserve price that starts at €25 in 2025 and increases by a real rate of 3% each year, reaching €29 in 2030 if unadjusted. While this price floor does not bind in the scenarios tested, it could serve to bolster market participants' confidence in the system in case of a larger demand shock. A minimum price also unlocks investment in abatement options below the price floor by removing uncertainty around future prices and market evolution. Alternative projections of price impacts should also be considered, as these results reflect outputs of one model and do not constitute a definitive forecast of prices.

Figure 46 EU allowance prices under a persistent unanticipated reduction in EU allowance demand (MSR3)

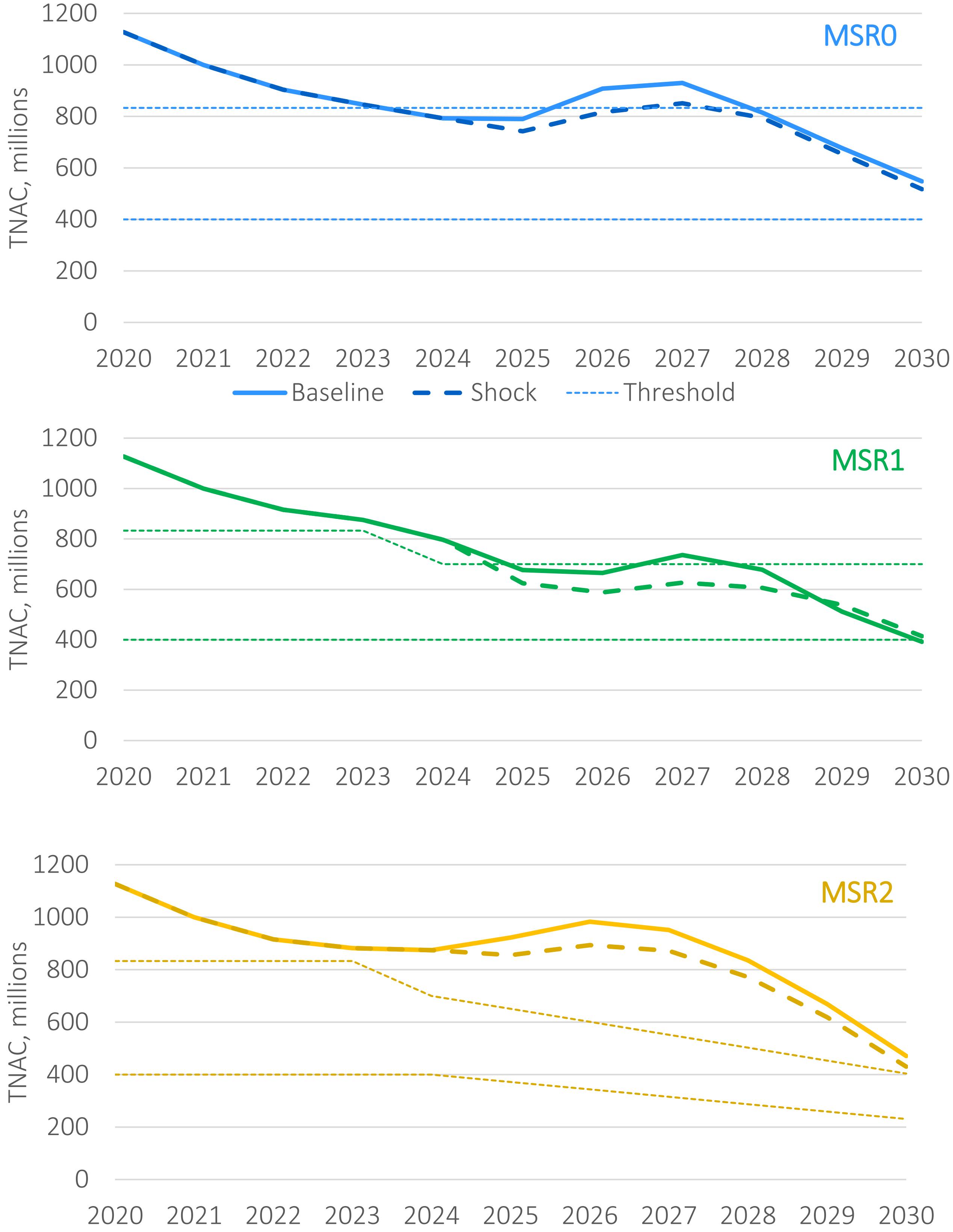


Note: Gray line indicates the level of price floor in the case of MSR3
Source: Vivid Economics

Persistent unanticipated increase in EU allowance demand

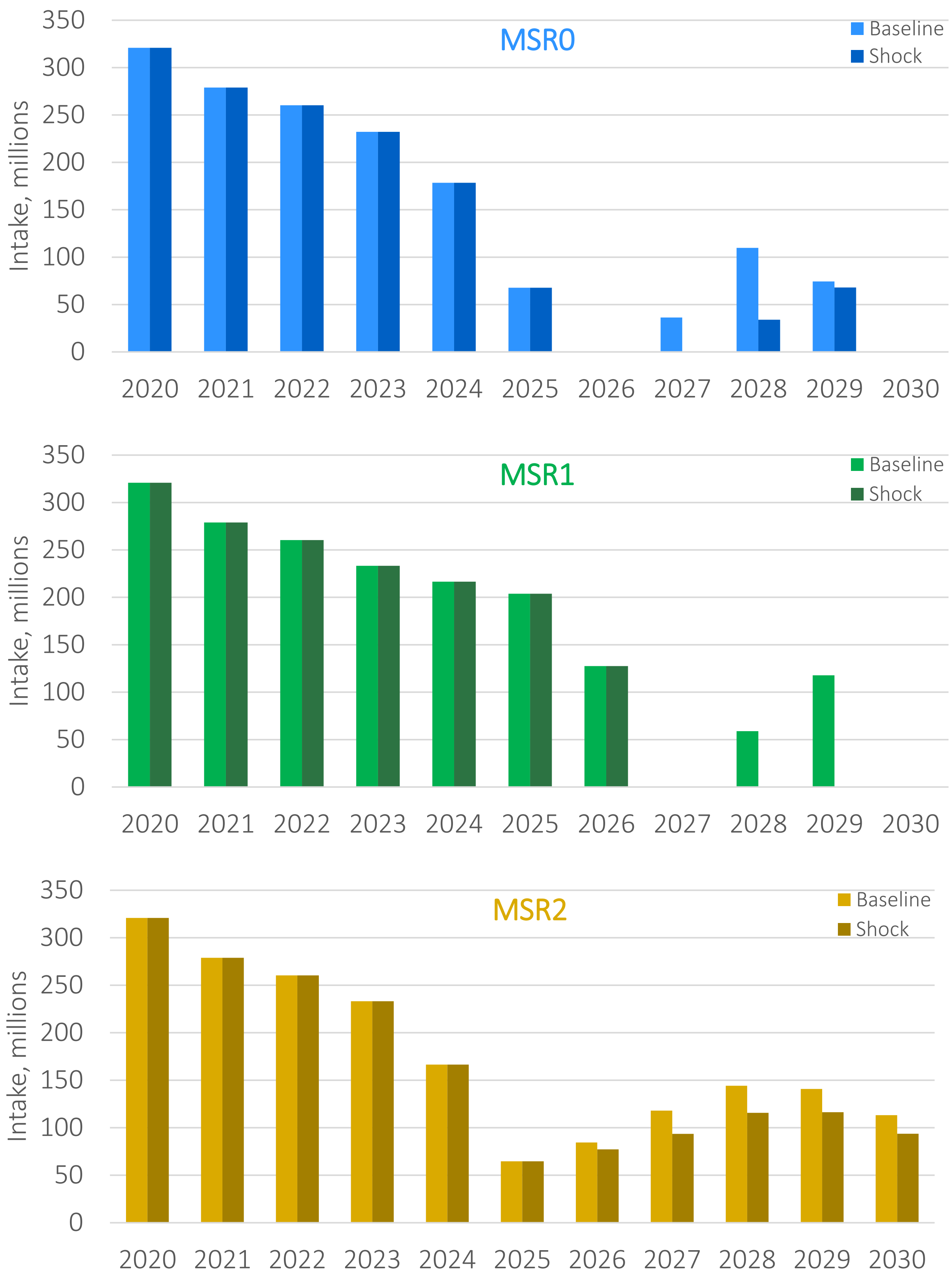
A persistent increase in EU allowance demand mirrors the results presented for a persistent decrease in demand and has been included for completeness. Prices increase by around €12 in the initial period of the shock, with this differential reduced to around €4 across all MSR designs by 2027. This price impact continues to 2030 due to the long term persistence assumed in this case.

Figure 47 TNAC under a persistent unanticipated increase in demand for EU allowances



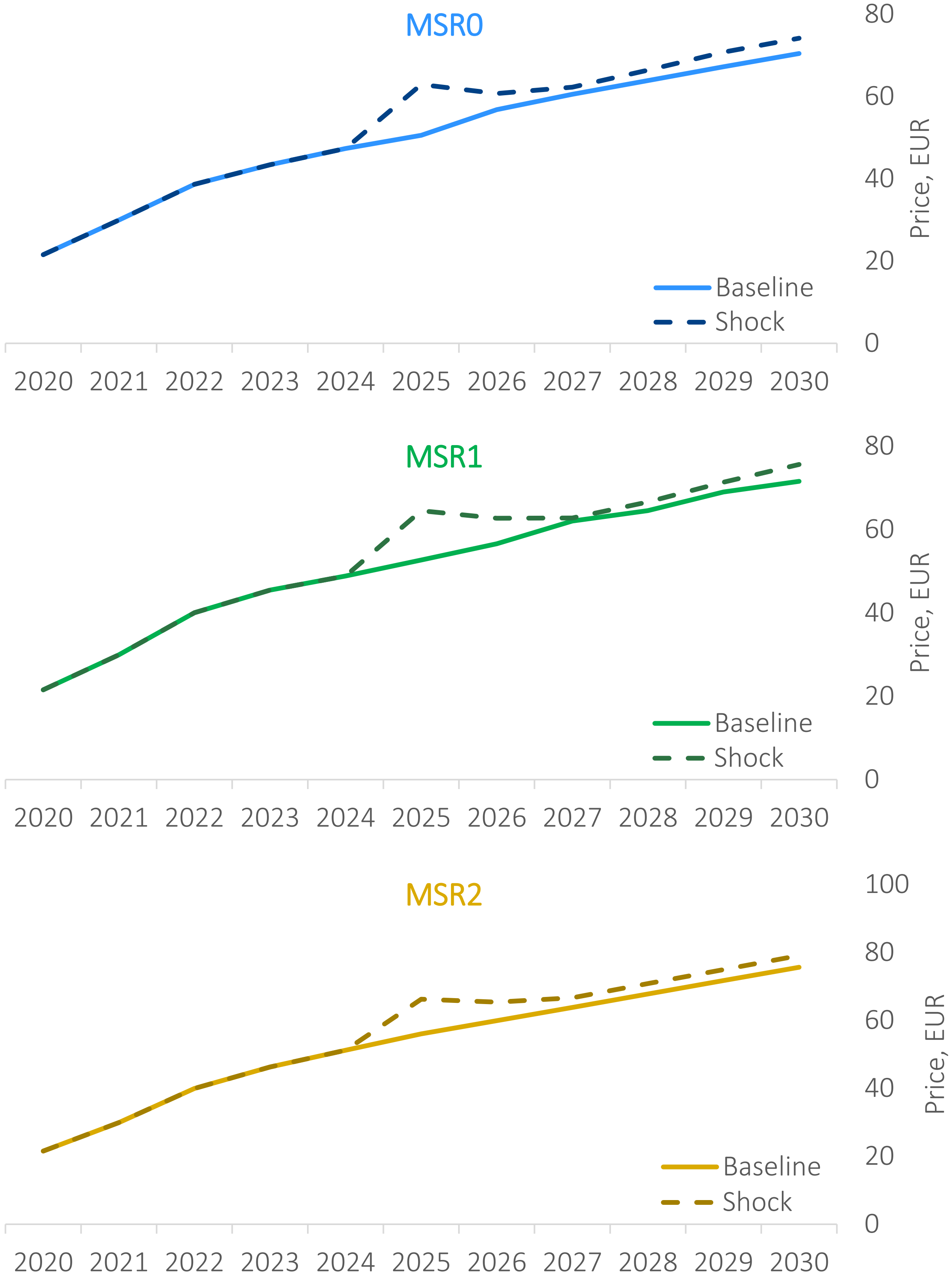
Source: Vivid Economics

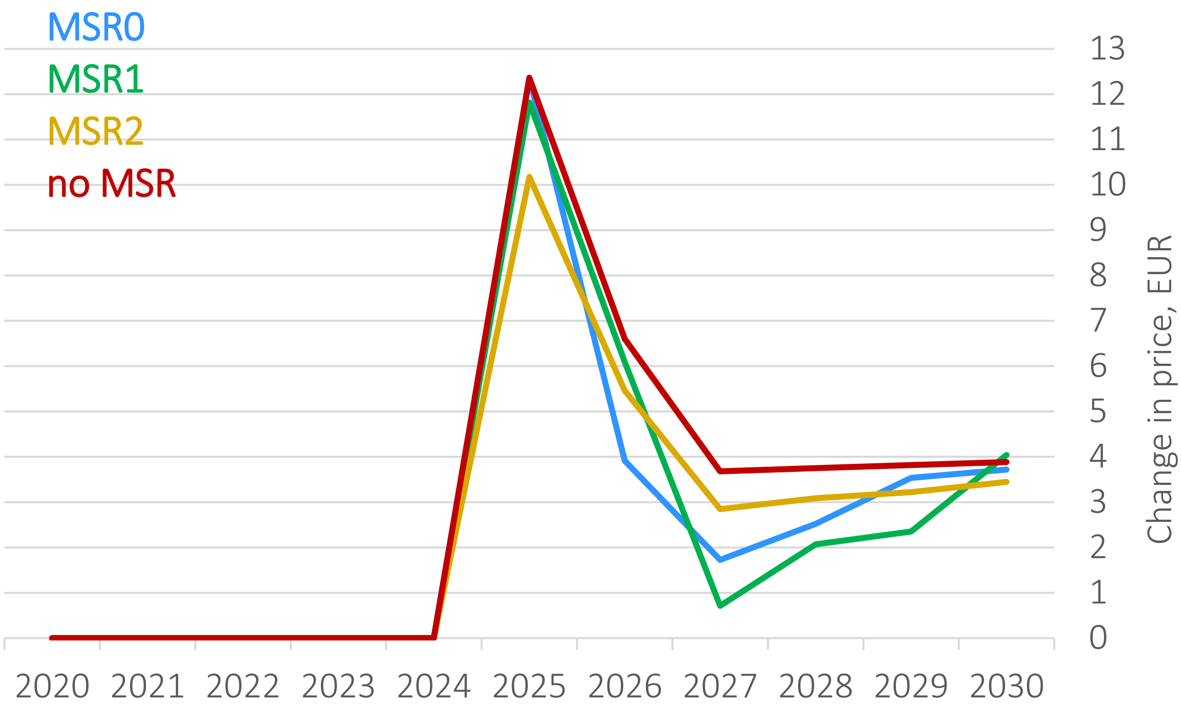
Figure 48 Intake under a persistent unanticipated increase in demand for EU allowances



Source: Vivid Economics

Figure 49 EU allowance prices under a persistent unanticipated increase in EU allowance demand





Note: Prices are shown in constant 2015 €.
Source: Vivid Economics

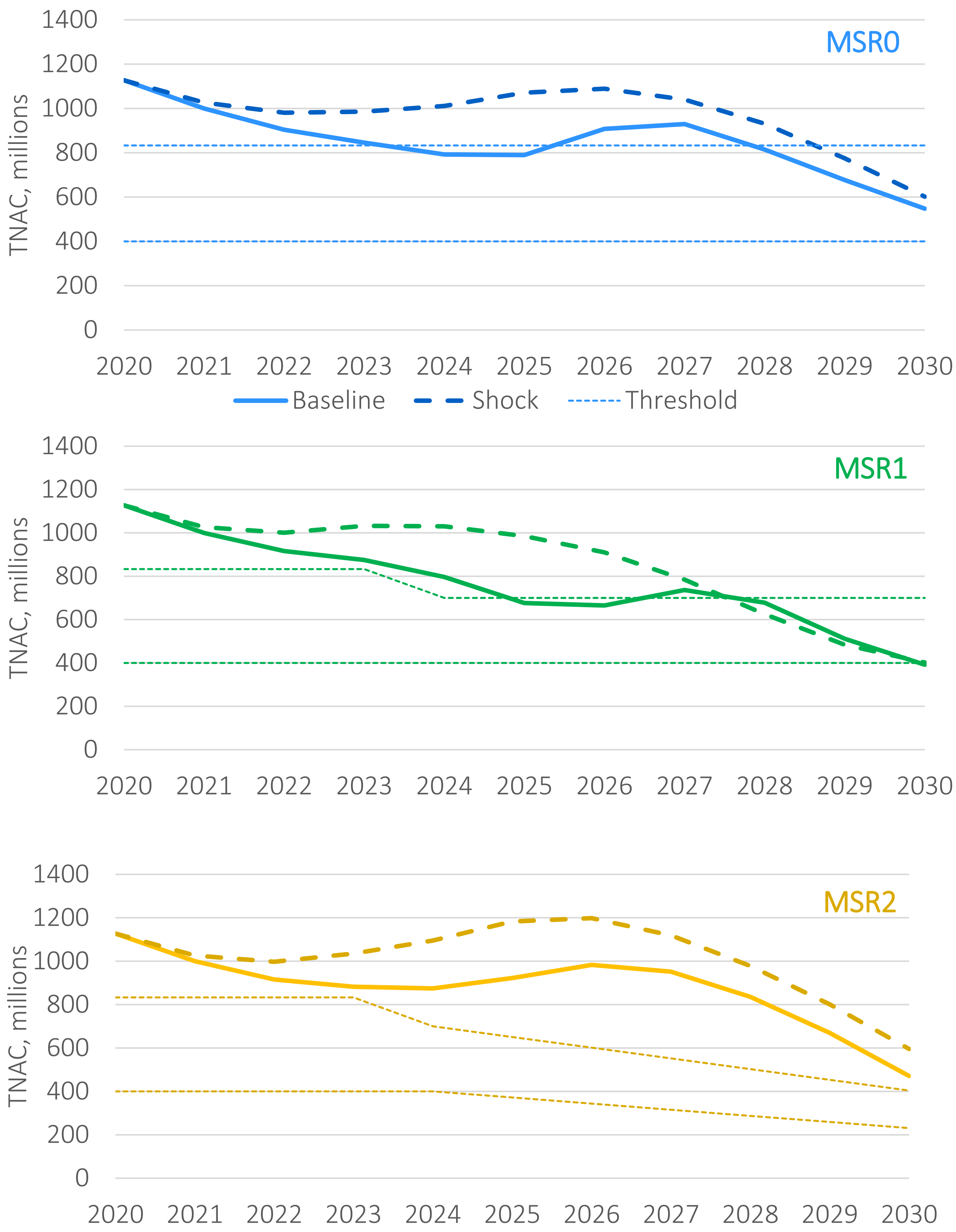
6.4.3 Induced holdings to stimulate tightening

In some cases, actors may seek to leverage the MSR's design to deliberately drive prices up. For instance, environmental organisations could 'buy and bank' allowances and hold them indefinitely, thereby restricting the supply of allowances and increasing prices.[137] Similarly, long term investors may hold a large share of allowances to increase prices and gain a return on investment. In both cases, the TNAC would overestimate the number of allowances that are actually available to the market. The results in larger MSR intakes and contributes to higher prices. The shock modelled assumes around 240 million allowances being held by non-compliance entities from 2025, driving up TNAC and prices in the ETS.

MSR1 results in the largest intakes due to induced holdings. An induced holdings shock increases EU allowance demand, leading to an increase in TNAC and intakes across all designs. Due to the way the intakes are structured, MSR2 intakes allowances more slowly and avoids sharp threshold effects. Note that if these induced holdings remain inaccessible to market participants, the higher intake rates will also have negative impacts on liquidity for compliance entities.

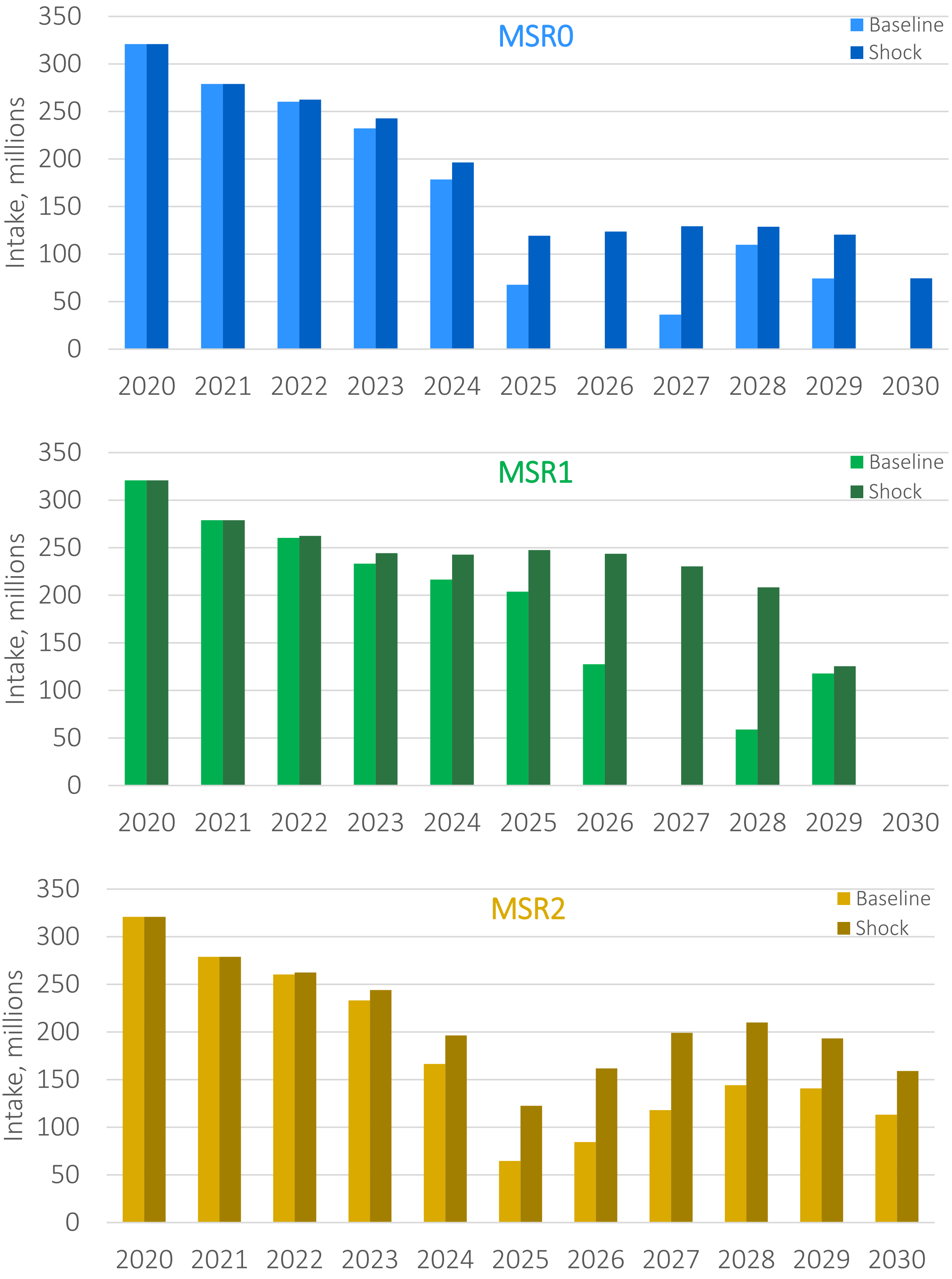
[137] Gerlagh and Heijmans (2019), "Climate-conscious consumers and the buy, bank, burn program"

Figure 50 TNAC under an induced holdings shock



Source: Vivid Economics

Figure 51 MSR intakes under an induced holdings shock

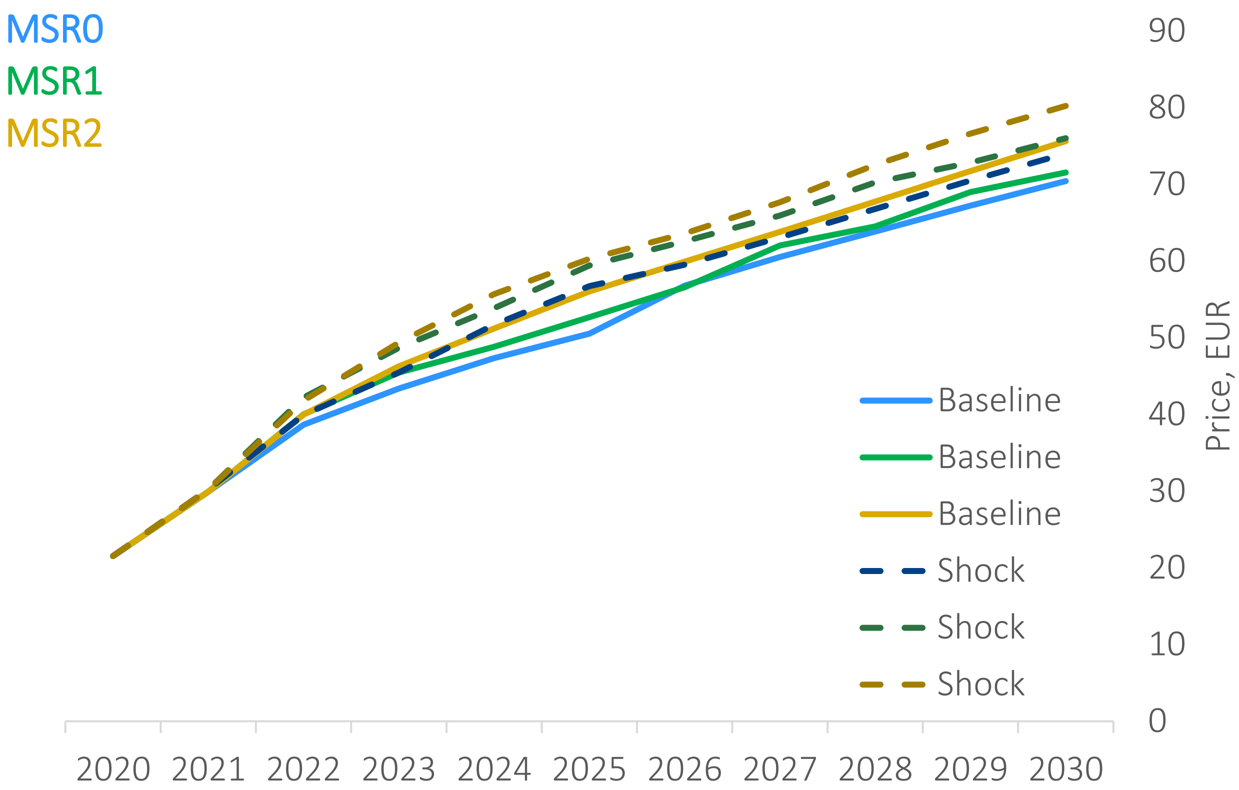


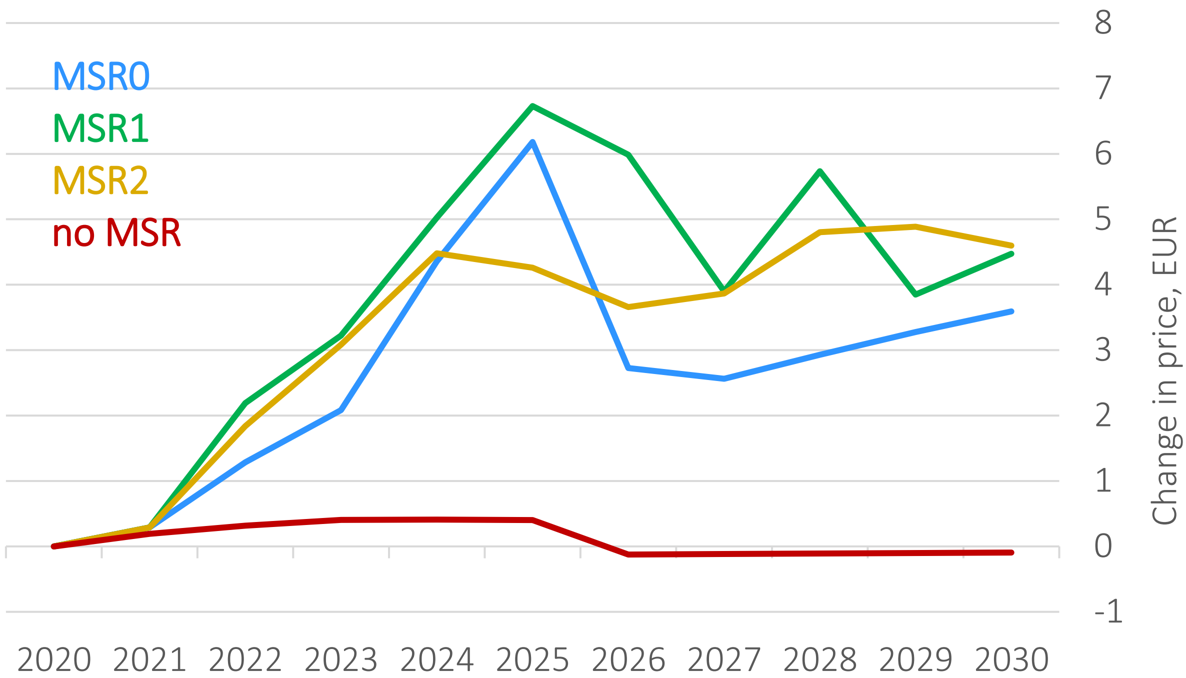
Source: Vivid Economics

An induced holdings shock increases prices in all MSR designs but is exacerbated by higher intake rates and lower thresholds. As expected, the holding shock instigates prices increases as supply of allowances falls short of demand. Prices are driven up by further reductions in auctioned allowances, as the higher TNAC leads to increased intakes to the MSR. In the interim period, prices are stabilised, as firms benefit from the early abatement activity undertaken when allowance supply was tighter. However, prices increase again relative to the case without induced holdings as TNAC approaches zero, as firms have been unable to bank as many allowances as desired, and the MSR continues to reduce supply relative to the case without the shock. Prices are increased most under MSR1 followed by MSR2, where higher intake rates cause the induced shock to reduce cumulative allowance supply most.

MSR1 results in sharper price increases than MSR2 due to threshold effects. The graph below shows the change in price between the 'shock' scenario and the respective baseline case for each MSR design. MSR1 results in the highest increase in prices, but also the most volatile ones because of the large intakes when the threshold is crossed. In practice, this volatility may be more pronounced than modelling shows. This is because the model is only able to represent an annual time period (which abstracts away from within-year volatility), and assumes firms have a 10-year anticipation horizon (which may not hold in practice, resulting in more myopic and erratic behaviour of short term prices).

Figure 52 EU allowance prices under induced holdings



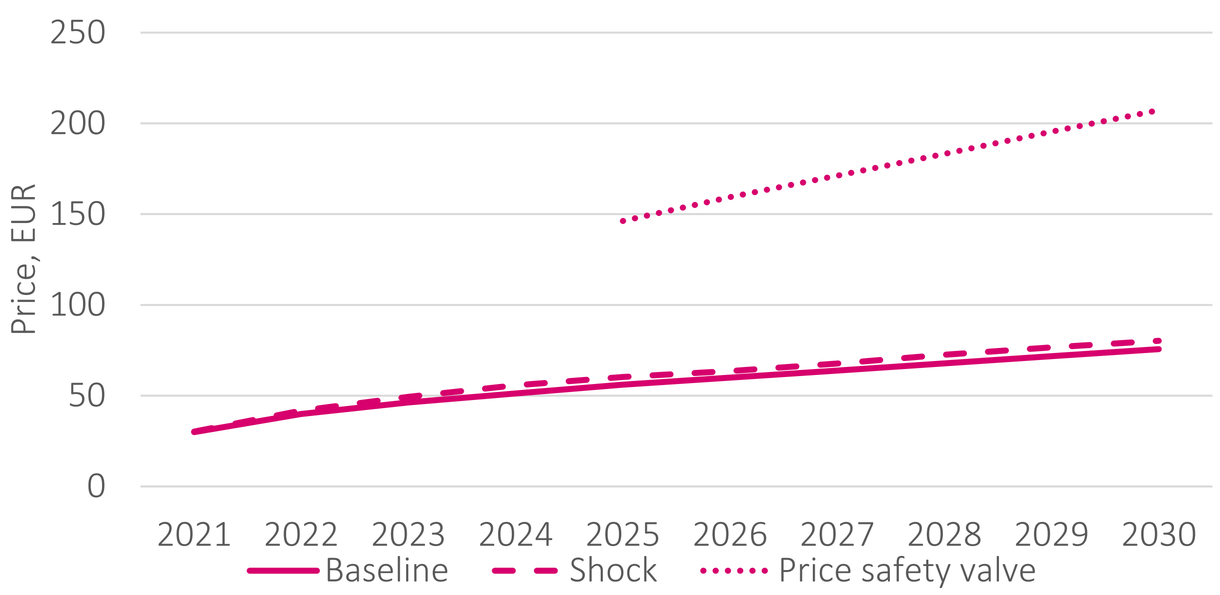


Note: Prices are shown in constant 2015 €.
Source: Vivid Economics

MSR3 which includes a price safety valve could protect against short term price spikes, and anchor expectations to avoid a price spiral. Induced price spikes could occur because entities holding on to allowances believe the price can be increased significantly in the short run before facing any corrections as a result of the current provisions in Article 29a, which can act only once excessive prices have been maintained for a six-month timeframe.[138] MSR intakes as a result of the inflated TNAC put further upward pressure on prices, potentially contributing to a price spiral. The safety valve has a twofold objective: to reduce the risk of a price spiral by pausing MSR intakes and to reduce reaction times by releasing allowances at auctions at the next available opportunity. This could act to discourage speculation as it reduces the ability of speculators to driver price increases. This may also help to ensure the MSR acts in a way that is consistent with its objective of reducing market imbalances.

The safety valve proposed as part of MSR3 is not triggered by the induced imbalance shock in this particular modelling exercise. Under the design of the safety valve in MSR3, interventions are only likely to occur at very high prices. This could suggest the need for an alteration to safety valve provisions, such that it applies at a lower price than the proposed design. However, the results of this modelling should be interpreted with caution given the model's limited functionality in assessing short term price dynamics.

Figure 53 The price safety valve is anticipated to apply only at very high prices



Source: Vivid Economics

Insights from interviews and discussions with market participants suggest that the current likelihood of speculation triggering a price spiral is low. This is primarily due to the relatively small size of the speculative market. Short term speculators do not tend to hold large positions and would be more likely to sell in the event of a larger-than-expected price increase. Long term investors represent a small part of the market (less than 100 million allowances) so are unlikely to be a significant driver of a price spiral. Speculative activity may also serve to reduce prices as investors may be incentivised to sell off a portion of holdings if the EU allowance price exceeds internal price targets. However, this market is changing rapidly and high-profile investment in EU allowances may cause the size of speculative holdings to expand rapidly.

[138] Article 29a provides for measures in the event of excessive price fluctuations, if, for more than six consecutive months, the allowance price is more than three times the average price of allowances during the two preceding years on the European carbon market.

6.5 Policy variation sensitivities

6.5.1 Cap and LRF variations

We consider four cap scenarios from the EC's wider EU ETS impact assessment, which represents differing levels of stringency over the 2021-2030 period. All cap variations lead to an equal level of allowance supply in 2030, with variations in the annual allowance supply from 2024-2030. AMB2b involves rebasing the cap and an increase in the LRF from 2024, providing the lowest level of cumulative allowance supply to 2030 and reflecting the most stringent of the policy variations. AMB2a involves increasing the LRF to 5.04% in 2024, but no rebasing. AMB1 involves increasing the LRF to 6.17% from 2026 and no rebasing, reflecting the least stringent of the policy variations considered. Table 14 provides a summary of the key differences across these scenarios.

Table 14 Summary of policy variations

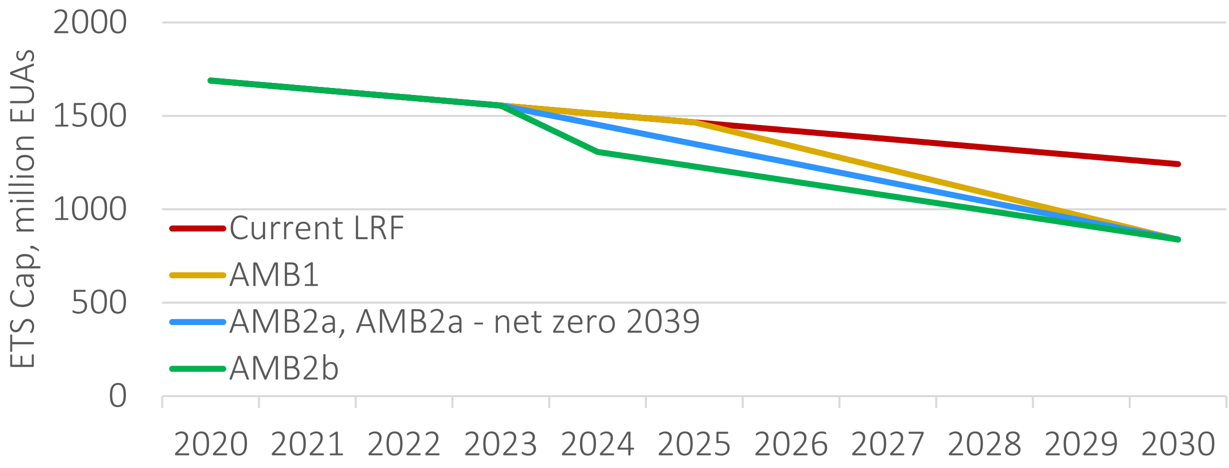
Cap scenario	AMB1	AMB2a	AMB2b	AMB2a – 2039 net zero
LRF	Adjusted to 6.17% in 2026	Adjusted to 5.04% in 2024	Adjusted to 3.85% in 2024	Adjusted to 5.04% in 2024
Cap rebased	No	No	Supply rebased by 163 Mt in 2024	No
Cumulative allowance supply (2021-30)	13.2 billion EU allowances	12.8 billion EU allowances	12.3 billion EU allowances	12.8 billion EU allowances
Net zero	2050	2050	2050	2039

Note: In line with the modelling approach, the cumulative allowance supply shown above were adjusted to include domestic and intra-EEA aviation and maritime navigation, together less than 10% of the cap.

Source: Vivid Economics

The four cap options represent a significant increase in ambition compared to the current LRF. The supply trajectories of each of these caps is presented in Figure 54, along with the cap trajectory when the LRF remains unchanged at 2.2%. The new options differ in the supply offered in the short term, but their trajectories converge by 2030. However, the AMB2a option that extends the 5.02% LRF beyond 2030 is more stringent than all the others and reaches net zero emissions 11 years earlier.

Figure 54 The ETS cap under different cap options

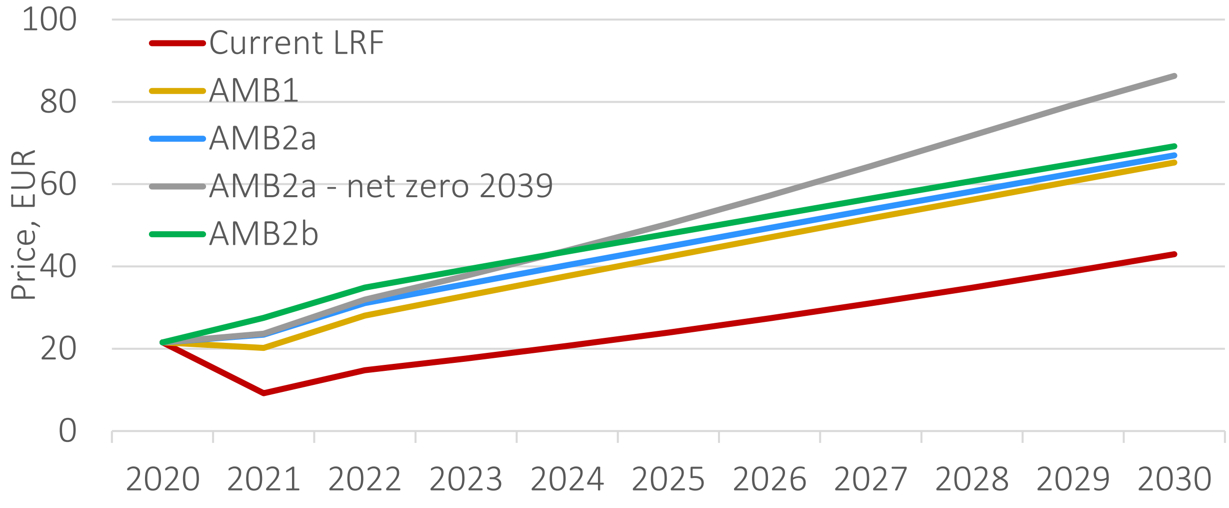


Source: Vivid Economics

Modelling indicates that in a scenario without the MSR, the long run ambition or cap trajectory drives prices (see Figure 55). Prices in the high ambition cap scenarios are significantly higher compared to the current trajectory with a 2.2% LRF, but there is little price variation amongst the three high ambition scenarios themselves. The average price under AMB2b, AMB2a and AMB1 reaches €67 in 2030 compared to just €43 if the LRF remains unchanged at 2.2%. Prices under AMB2b, the most ambitious scenario, are on average €6 higher across the 2021-2030 period than under AMB1, the least ambitious of the options analysed. The price differences are the greatest early in the period, due to anticipation of tighter supply. As a moderately ambitious scenario, prices in AMB2a are between AMB2b and AMB1 across the period, in line with the relative change in cumulative supply. This indicates that that near-term variations in supply are less important in determining prices than expectations of long term ambition. To some extent, this is a function of the 10-year anticipation horizon assumed by the model; firms are forward looking and optimise based on future supply. In practice, there may be more variation in price due to firm myopia. If the LRF in AMB2a is unchanged at 5.04% after 2030, the cap will hit zero in 2039. The resulting price will be much higher than the other cap scenarios, with the 2030 price estimated at €89 because firms expect a tighter supply of allowances after 2030.

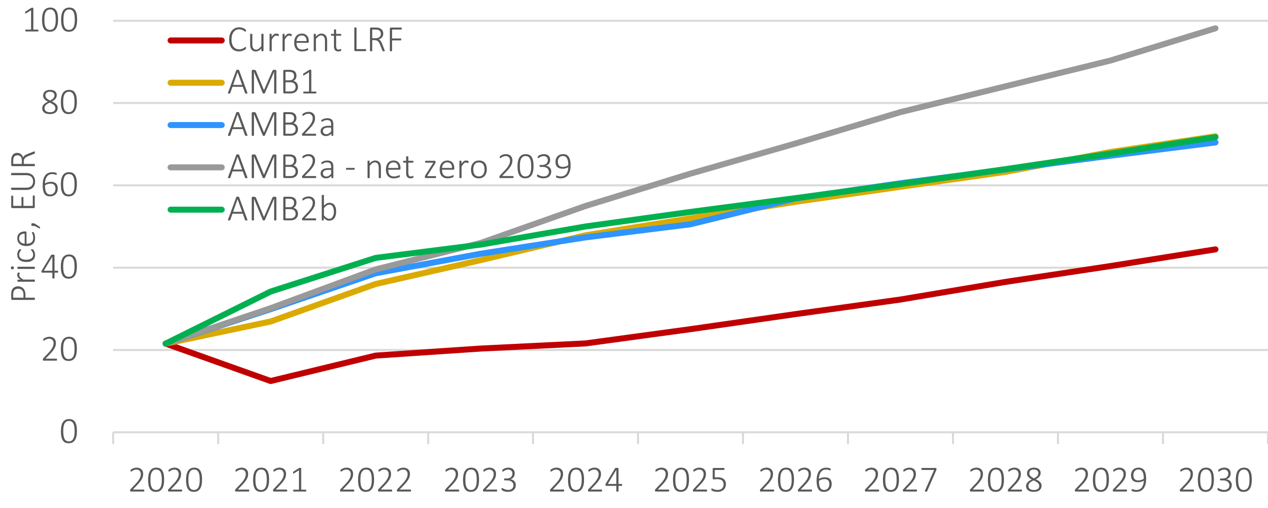
With an MSR in place, differences in prices across different cap scenarios are smaller because supply under a less stringent cap would be tightened by larger intakes to the MSR (see Figure 56). Caps which are initially less stringent, such as AMB1, have a higher surplus of allowances in earlier periods due to greater annual supply. This increases the TNAC during 2021-2030, which subsequently increases intakes into the MSR, reducing auctioned allowances and the effective cap. This leads to similar price outcomes across the different caps, which range between €69 to €71 in 2030. Meanwhile, if the cap in AMB2a is extended to hit net zero in 2039, the price can reach €96 in 2030.

Figure 55 Prices under cap variations are relatively similar without an MSR in place



Source: Vivid Economics

Figure 56 Prices under cap variations are even more similar with an MSR in place



Source: Vivid Economics

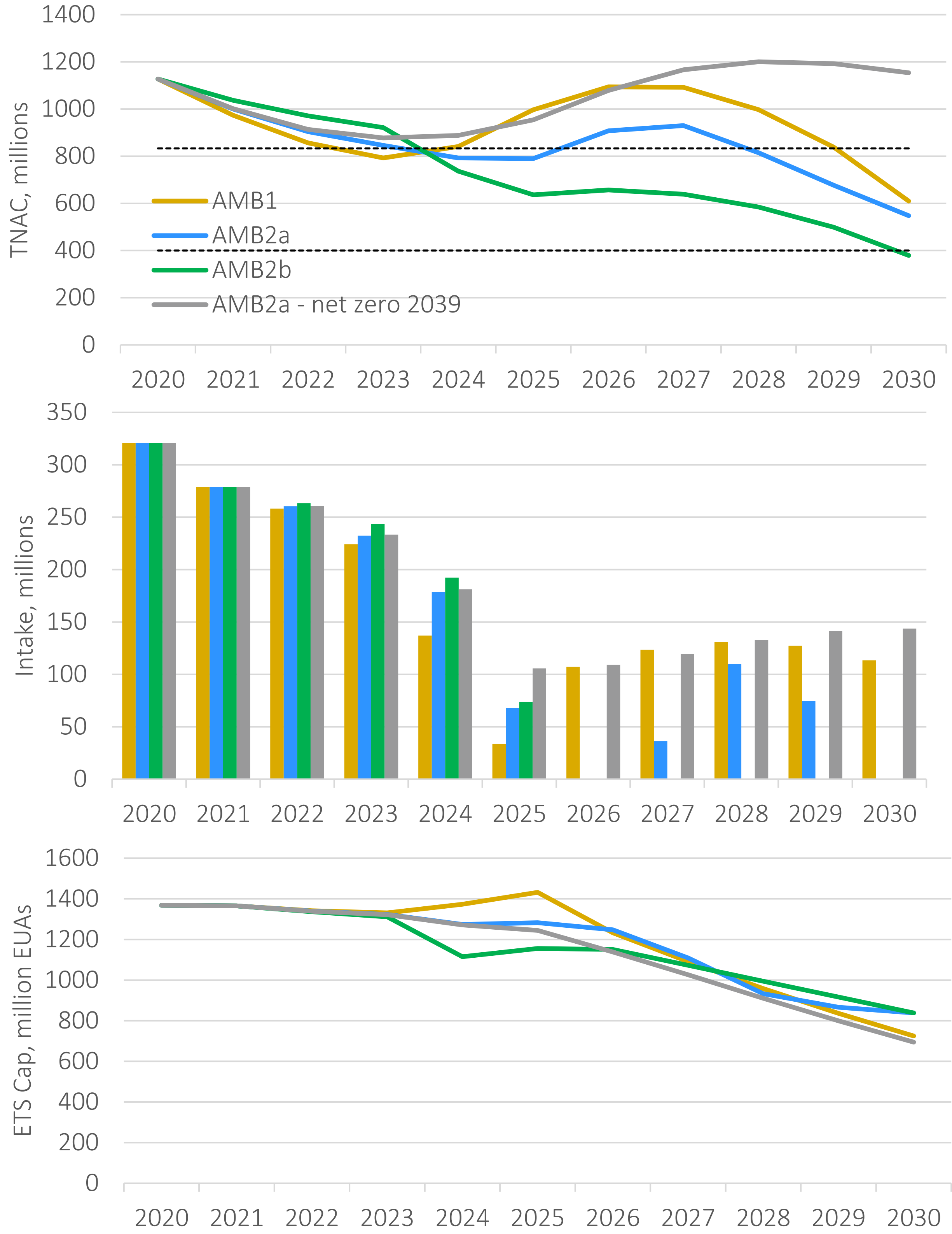
Detailed modelling results for each MSR option under the different cap variations are presented in Figures Figure 57, Figure 58, and Figure 59. The qualitative insights regarding the MSR designs discussed in Section 6.3 remain unchanged in these cap variations, although there are some important differences in the numerical results driven by the adjusted cap trajectories. The key observations are summarised below:

- **A tighter Phase 4 cap (e.g. AMB2b) results in a lower TNAC between 2024 and 2030.** This is a result of a reduced supply of allowances available to market participants. The resulting differences in the level of TNAC across the cap variations is more pronounced between 2025 to 2027, after which the impact of MSR intakes become observable from the narrowing differences across the cap variations. By 2030, the difference in TNAC between AMB1 and AMB2a typically lies within 100 million. The same is true when comparing 2030 TNAC between AMB2a and AMB2b under the different MSR options.
- **A tighter Phase 4 cap has two immediate implications for the MSR: (a) fewer MSR intakes, and (b) shorter intake period and potentially earlier releases.** For instance, under MSR1, the MSR intakes become zero by 2027 under AMB2b with MSR1, three years earlier than AMB1. In the example of

AMB2b with MSR1, TNAC in 2028 falls just below the lower threshold of 400 million, resulting in releases from the MSR by 2029. The extent to which (b) occurs is sensitive to model parameters. This creates uncertainty for market participants under MSR0 and MSR1, as intakes are discontinuous at the upper threshold, from over 100 million in a particular year to zero in the next year. Depending on whether market expectations are met, this ‘threshold effect’ can produce kinks in the price path. Meanwhile, this is not the case for MSR2, as intakes are continuous at the upper threshold.

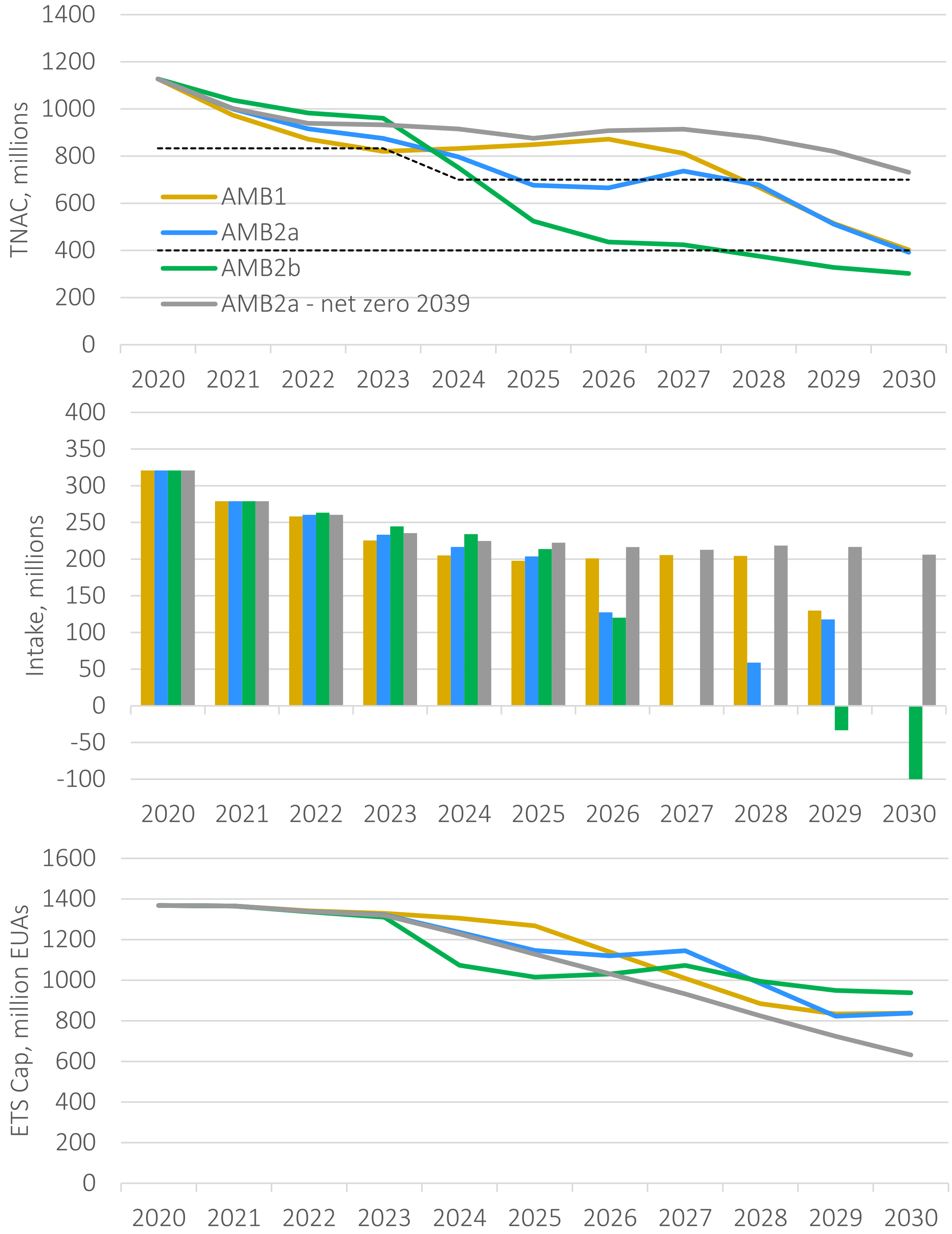
- **Across all MSR options, the main analytical statistics under AMB2a are nested between AMB1 and AMB2b.** For this reason, the discussion in Sections 6.3 and 6.4, which is based on AMB2a (LRF of 5.04% without rebase in 2024), can be interpreted as the midpoint of EU ETS cap ambition.
- **The expectation of a tighter cap beyond 2030 increases TNAC between 2024 and 2030, resulting in larger MSR intakes.** This is most obvious when comparing the extreme scenario of “AMB2a with net zero in 2039” (grey line) against the other scenarios. In anticipation of a very tight supply of allowances, banking of allowances will be significantly higher during Phase IV, resulting in a TNAC that says above 1 billion throughout the period. Correspondingly, MSR intakes are much higher, reducing the cumulative supply of allowances further. All of this contributes to explain the much higher price trajectory shown in Figure 56.

Figure 57 TNAC, intake and cap post-MSR adjustments under cap scenarios under the baseline design



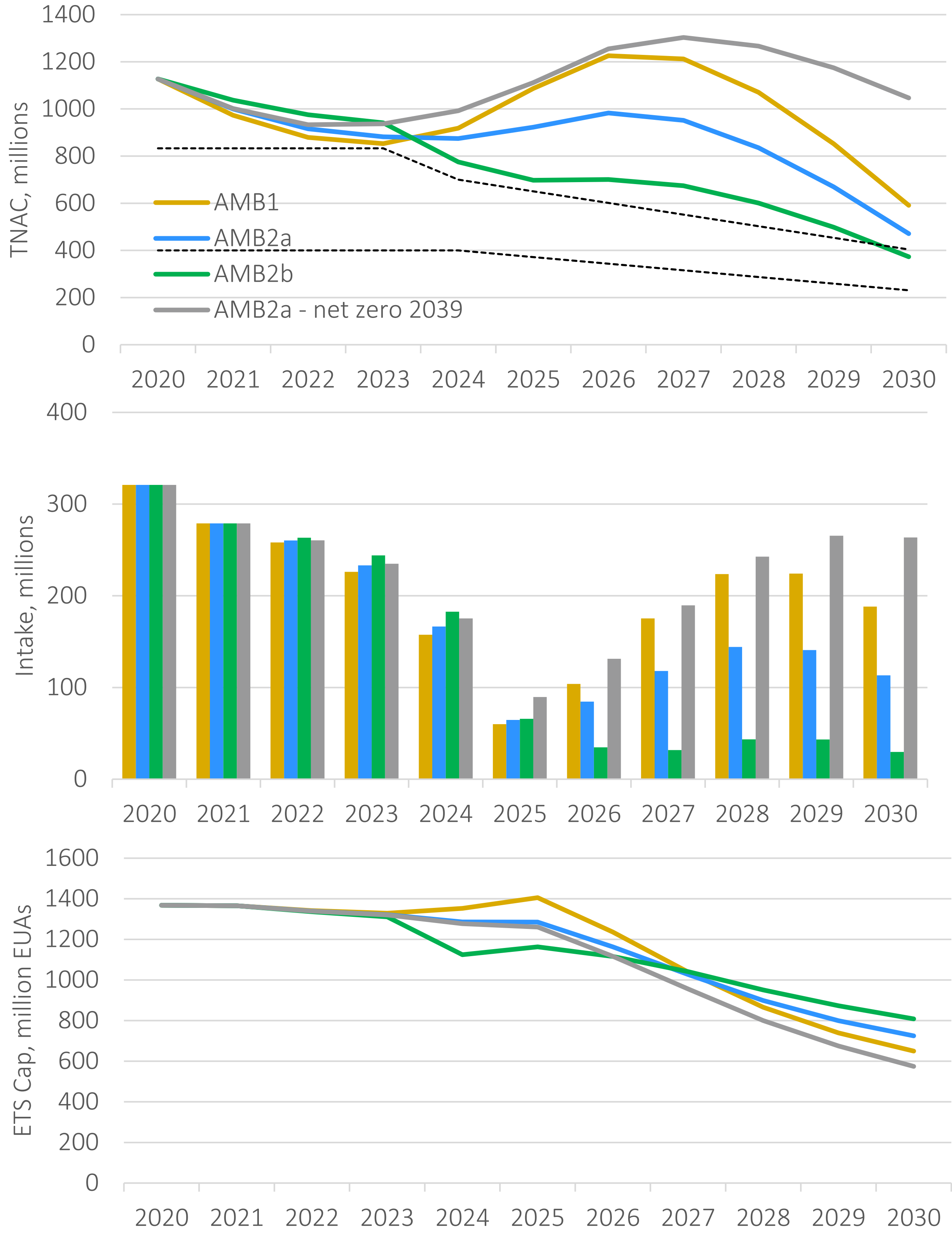
Source: Vivid Economics

Figure 58 TNAC, intake and cap post-MSR adjustments under cap scenarios under MSR1



Source: Vivid Economics

Figure 59 TNAC, intake and cap post-MSR adjustments under cap scenarios under MSR2



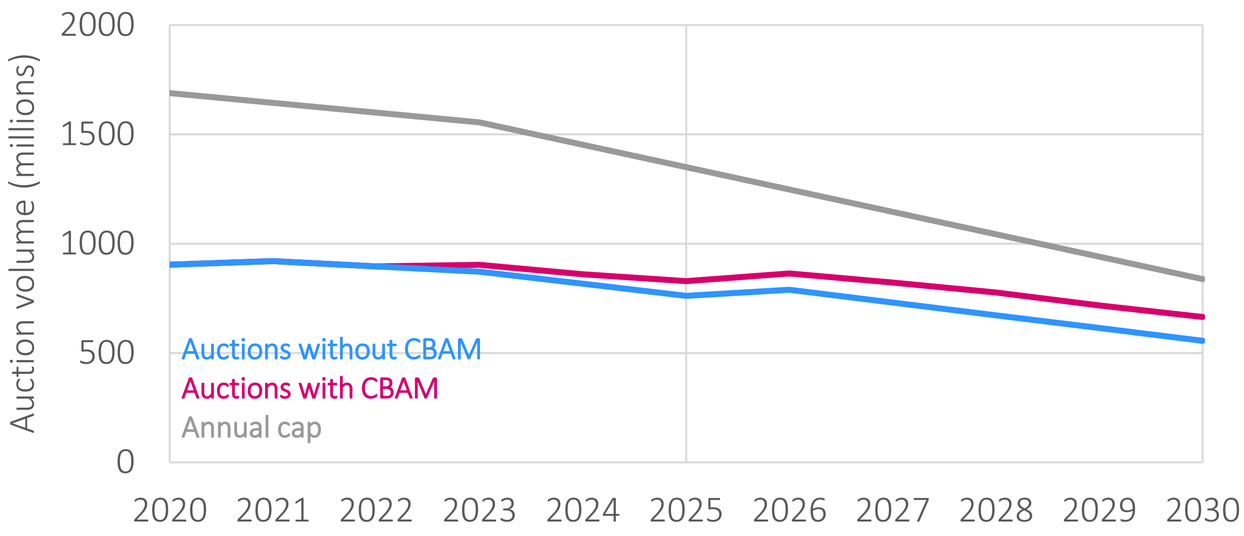
Source: Vivid Economics

6.5.2 Introduction of Carbon Border Adjustment Mechanism

The introduction of a carbon border adjustment mechanism (CBAM) is being considered as an alternative to free allocations to prevent carbon leakage. A CBAM prevents carbon leakage and safeguards competitiveness by imposing a tariff-like adjustment to emissions-intensive imports and/or exports to account for differences in carbon prices between the EU and its trading partners. Free allocations could be phased out for some sectors if a CBAM is introduced, forcing them to participate in the market. This is likely to increase the number of allowances required for banking and hedging, resulting in a higher TNAC.

The analysis in this section investigates the impact of different MSR designs with a hypothetical CBAM. Since the precise design and scope of a CBAM is not yet available, the analysis makes the simplifying assumption that firms in the steel and cement sectors will be subject to a CBAM in 2023, and see their free allocations phased out gradually between 2023 and 2030. In this scenario, free allocations within the EU ETS each year drop from 43% of the cap towards 30% of the cap in 2030, remaining constant post-2030. The share of auctions under the cap increases correspondingly, as shown in Figure 60 below.

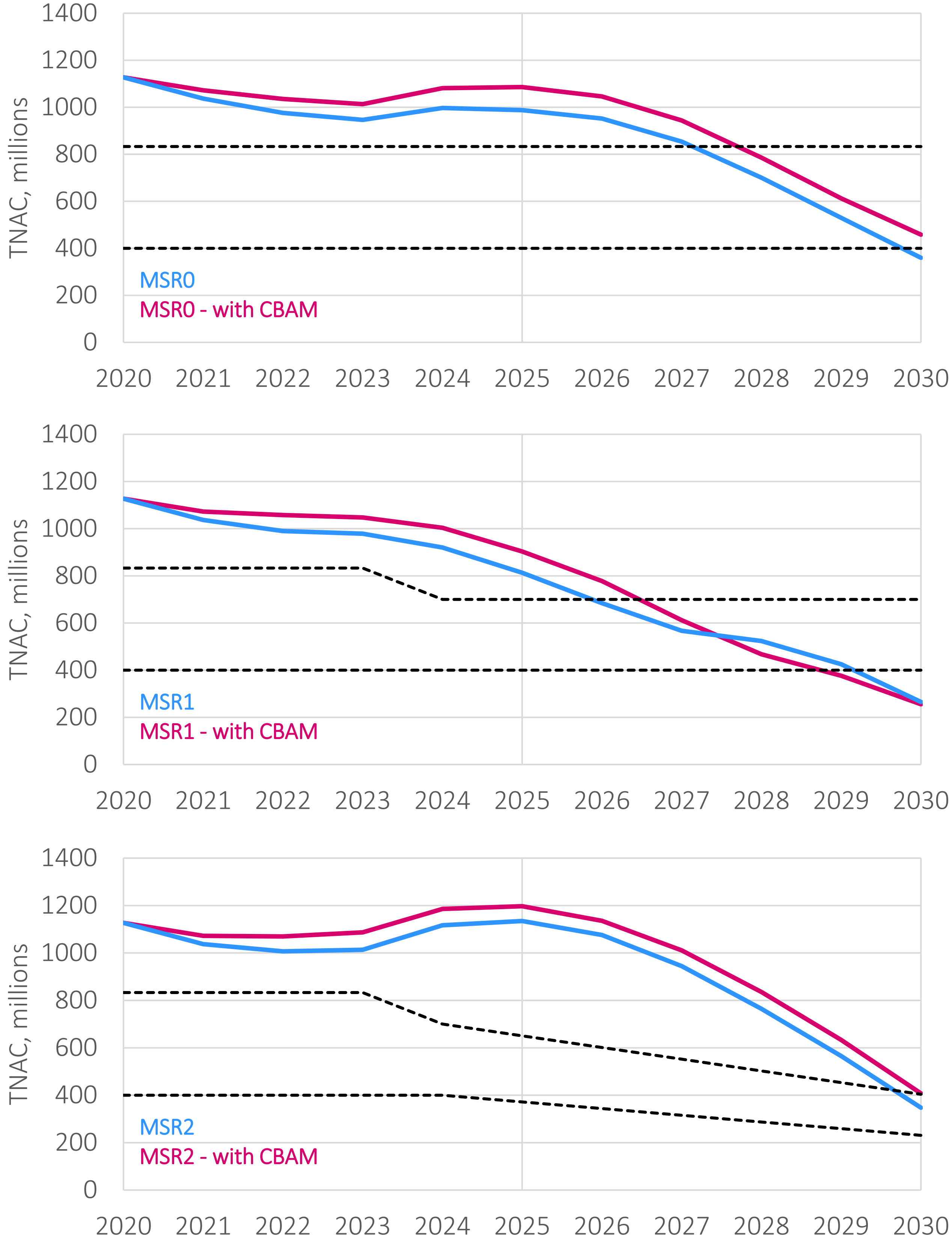
Figure 60 Auction volumes with and without a CBAM (prior to MSR adjustment), under cap AMB2a



Note: Auction volumes shown include the 3% flexibility buffer.
Source: Vivid Economics

The inclusion of a CBAM increases TNAC (and MSR intakes), but do not change the conclusions made in previous sections comparing the different MSR options. Across all the MSR options, the introduction of the hypothetical CBAM specified above results in a level increase in TNAC by 50 to 100 million for most of the 2020s. In some cases, such as MSR1, the inclusion of a CBAM shifts the point in which TNAC goes below the upper threshold back by a year. This has the direct consequence of prolonging intakes for an extra year. However, whether this 1-year shift occurs is sensitive to the particular cap and model parameters, regardless of the MSR design.

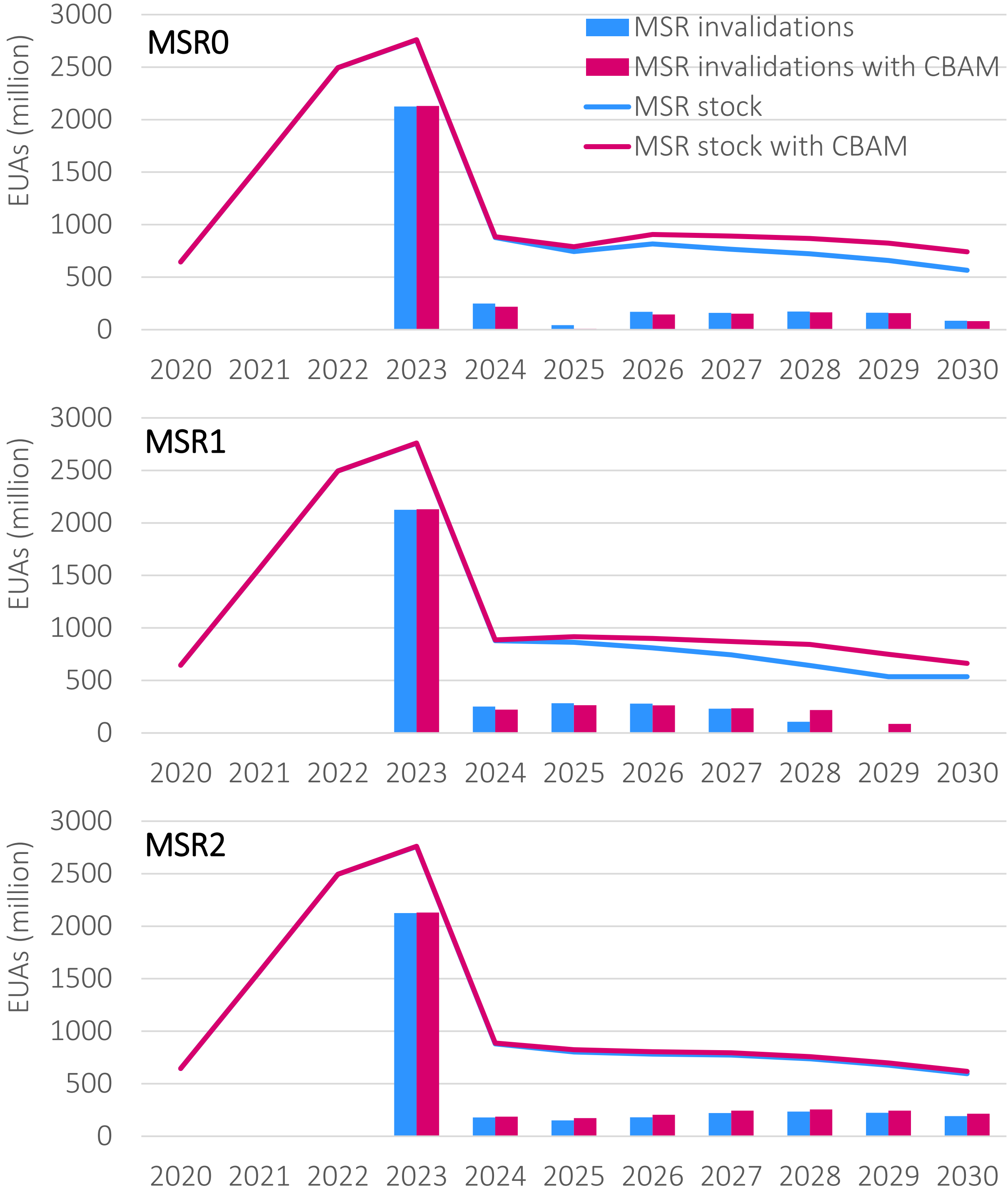
Figure 61 TNAC with and without a CBAM under the three MSR options (with cap setting of AMB2a)



Source: Vivid Economics

The introduction of a CBAM reduces the rate at which allowances are invalidated within the MSR. Under MSR0 and MSR1, allowances within the MSR that exceed the auction volume in the previous year is invalidated. As there are more auctioned allowances under the CBAM scenario, the MSR stock declines slower. By contrast, there is no such distinction under MSR2, under which allowances that exceed the upper threshold are invalidated. It should be noted that the MSR stock is influenced by both the invalidation threshold (e.g. prior year auction for MSR0 and MSR1, upper threshold for MSR2) and the size of MSR intakes. This directly affects the number of allowances in the MSR available for release beyond 2030 but lies outside of the scope of this review.

Figure 62 TNAC with and without a CBAM under the three MSR options (with cap setting of AMB2a)



Source: Vivid Economics

6.5.3 Expanded scope

Expanding the ETS scope to include emissions from the heating of buildings and road transport, in addition to inter-EEA maritime, would have significant implications for MSR design. These implications arise primarily through three impact channels: an increase in the size of emissions covered by the ETS, a change in hedging behaviour as new entities fall under ETS regulation, and a change in abatement costs. These factors can have complex and interrelated effects on the aggregate system. As such, substantial adjustments to MSR parameters would be needed, with further analysis required in order to establish appropriate parameters.

The inclusion of new sectors would increase the total emissions covered by the ETS, necessitating changes to thresholds to provide enough liquidity for the increased number of participants. Current emissions from these sectors stands at a total of 1190 Mt in 2020, which would constitute more than 73% of the 2020 ETS cap. Of these, the largest share comes from transport (690 Mt), followed by buildings (430 Mt), and finally international maritime navigation (70 Mt).[139] ETS expansion would necessitate an upwards revision of the cap, and further consideration of thresholds to determine the appropriate range to support market balance under this new scope.

Hedging demand from these sectors is another factor that will affect the choice of appropriate threshold values. It is uncertain how hedging demand in the new sectors would evolve and will depend largely on the sophistication of entities regulated, their familiarity with hedging input prices, and the scale of liabilities. Assuming the point of regulation is upstream, entities regulated will likely include fuel suppliers and tax warehouses. These will likely include a range of sophisticated market participants such as international oil and gas companies and energy companies that are likely to engage in the hedging of a large proportion of their liabilities.

These sectors are likely to require a high carbon price to motivate emissions reductions due to high costs of abatement and low price responsiveness from end consumers. Emissions reductions in these sectors tend to have a high marginal abatement cost. Additionally, heating in buildings and road transport are both characterised by inelastic demand from users: an increase in price does not elicit a strong decrease in the use of heating or road transport. This means that fuel suppliers may be more likely to buy allowances and pass on carbon costs to downstream consumers rather than invest directly in abatement technology. Such a scenario could see other sectors to shoulder a larger share of the emissions reduction burden in the near term. Depending on decisions regarding effort sharing with uncovered sectors, this could also potentially result in higher prices for the ETS overall. The desirability and ability of the MSR to stabilise prices would need to be considered, particularly if it is revised to include the addition of short term response measures.

[139] PRIMES reference scenario, covid-adjusted, retrieved in January 2021

7 Annex 2: Evaluation of hedging and speculation

7.1 Efficient threshold setting

Generally, the band implied by the upper and lower thresholds of the MSR is considered as representing the required 'space' for current emitters to hedge future emissions liabilities. Absolute hedging is expected to reduce over time as renewable generation increases and emissions fall. However, behaviour in the market is changing, with some utilities hedging more than five years in advance and increased hedging activity from industrial participants. Further, changes in hedging demand are not the only driver of secondary market activity, with financial sector participants taking more active positions in the market. The outlook for long term prices in the market is positive based on the EU's tightening targets and economic fundamentals, which is the main driver of increased interest in the market. That said, the nature of financial sector participation opens up some questions about the impacts of price speculation, the potential size of financial sector holdings, and the role of the financial sector in the EU allowance market.

Future consideration of threshold levels may need to account for both reasonable levels of hedging and efficient levels of banking to leave room for participants to plan abatement effectively. With these dynamics in play, it may be appropriate for thresholds to be changed in absolute levels, or for their calculation to be altered to allow flexibility over time.

Historically, the surplus band of 400 to 833 million reflects the lower end of estimates of hedging volumes at the time.[140] However, this was deemed pragmatic given some level of consensus that hedging demand was likely to reduce over time, as renewable generation increases, and emissions reduces.

In order to inform threshold decisions, we will provide an overview of the ranges of hedging and speculative demand.

7.2 Determinants of hedging

Company hedging is determined by various factors that are difficult to predict. Historically, hedging of EU allowances has been conducted almost exclusively by electric utilities, who have the ability to predict emissions with a high degree of certainty in markets where long term power purchase agreements mean they can predict electricity production several years in advance. Utilities also tend to hedge other exposures, such as fossil fuel inputs, so often have internal capacity for trading derivatives, or relationships with traders who execute trades on their behalf. Most industrial sectors do not have the same type of visibility into future production, nor the in-house experience with hedging other commodities. For this reason, predicting industrial hedging behaviour carries with it significant uncertainty.

Sectors with existing significant commodities exposures (such as metals and oil) are more likely to hedge. One reason why utilities have a high propensity to hedge is because they regularly hedge other inputs into their costs. In liberalised markets, they can also set their prices several years out through contracting arrangements. This means hedging their carbon exposure is not significantly different for how they manage other costs, and for large utilities does not represent a significant additional cost. Using the experience of utilities, an analysis of likely hedging in industrials assumes that sectors for whom raw materials are not commonly hedged using derivatives are less likely to hedge their carbon exposure.

[140] Department of Energy and Climate Change UK (2014) https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/391793/Assessing_design_options_for_a_market_stability_reserve_in_the_EU_ETS_Final_report.pdf

Industrials may not hedge as much or as long as utilities. Industrials do not have as much visibility into the prices for their goods as utilities in liberalised markets do. If they implement hedging programmes, they are more likely to be shorter-term, with less of their exposure hedged.

Implementing a hedging programme in-house requires modelling expertise. To effectively hedge, companies must be able to understand their exposure to risk and the market dynamics that can be used to hedge that risk. Industrial companies often manage their carbon exposure through their treasury departments without the capacity for in-depth risk modelling. Companies are more likely to hedge EU allowances if they hedge other price risks, such as commodities exposure, and already have the capabilities to perform risk modelling. Because of this need, it is more likely to be implemented in-house in larger companies.

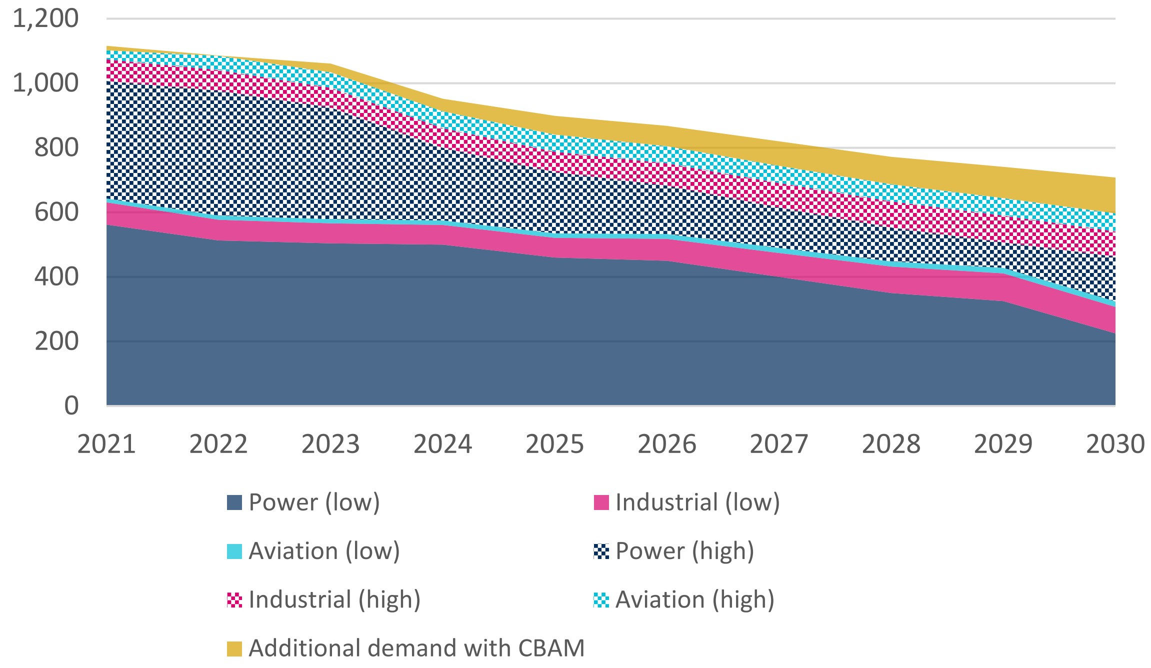
A company's propensity to hedge also depends on its location, the size of its carbon costs, and its history of banking allowances. Utilities are likely to hedge more of their exposure and farther into the future in liberalised markets, such as Central Europe, and are less likely to hedge as much if they are publicly owned or heavily regulated. For these regions, there may not be a large market for carbon derivatives that industrial companies would use to hedge. Companies with large amounts of banked allowances are unlikely to hedge in the near-term as they use up their banked allowances.

As expectations for future prices increase, companies are more likely to hedge and are more likely to hedge farther ahead of time. For short term changes in price expectations, companies may choose to strategically over hedge or under hedge, which is considered a form of speculation. For longer-term changes in price expectations, companies may change their hedging strategies. Short term price volatility is unlikely to have an impact on hedging strategies.

7.3 Estimates

Utility hedging is expected to decrease significantly by 2030 as emissions decrease, which will be partially offset by increases in industrial hedging. Figure 63 shows our estimates for hedging demand from various sources to 2030. Our estimates excluding the impact of a possible Carbon Border Adjustment Mechanism (CBAM) range from 500-850 million allowances in 2025, falling to 300-600 million allowances in 2030. These estimates are in line with ICIS estimates which decreased from approximately 650 in 2025 to 550 million allowances in 2030. If CBAM were to be implemented, we estimate that additional demand in 2025 would be approximately 50 million allowances, increasing to over 100 million in 2030.

Figure 63 Estimated sources of hedging behaviour to 2030



Source: Vivid Economics

Increased demand due to industrial hedging ranges from 75 to 300 million allowances in 2030. The fate of free allowances is the key determinant of industrial hedging demand, representing an increase in hedging of up to 100 million allowances in 2030 in a scenario where some free allocations are phased out. Figure 64 shows a broad range of estimates for industrial hedging in 2030.

Figure 64 Range of industrial hedging estimates

2030 Industrial hedging demand ranges ($MtCO_2e$)		
	Free allocations (no CBAM)	Phase out some free allocations (CBAM)
More companies hedge (all sizes)	150	300
Less companies hedge (> 750 ktCO2e)	75	150

Note: Assumes only certain sectors will hedge (metals, chemicals, oil & gas)
Source: Vivid Economics

Based on these dynamics, the extent to which overall hedging demand decreases depends on both the behaviour of industrials and policy decisions such the level of free allocations.

7.4 Key uncertainties

It is not known how many banked allowances are held by industrials – the total is estimated to be about 400 million, but the sectoral and company breakdown is unknown. Estimates used for this analysis depend on assumptions, including a modelling assumption that a proportion (54%) of excess allowances held by companies are sold each year. That proportion was set to result in a 400 million banked allowance result but does not differentiate between sectors or companies.

If the carbon border adjustment mechanism (CBAM) were implemented and free allocations were replaced for some sectors, companies' carbon exposure would increase and hedging activity would also be expected to increase. This analysis assumes that free allocations for the cement and metals sectors would be phased out by 2030 in the event of a CBAM implementation. The timing of such a mechanism would affect the hedging estimates.

The hedging strategies of sectors or companies is highly uncertain and the analysis of industrial hedging is based on previous experience and behavioural assumptions. Forward-looking analysis assumes certain sectors are more likely to hedge than others, based on observations gathered from market participants and exposure to other hedgeable commodities. In addition to utilities, these sectors are aviation (due to the prevalence of fuel hedging programmes), chemicals (based on information gathered from traders), metals (due to exposure to hedgeable commodities such as aluminium, iron ore, and non-ferrous metals), and oil & gas (due to exposure to crude oil). Analysis uses the absolute size of emissions as a proxy for carbon costs, though the carbon cost relative to other costs is a better measure of impact. For conservative estimates, the emissions threshold was set at 0.75 $MtCO_2e$ based on the emissions levels for utilities with sophisticated hedging programmes. The top-end estimates include all companies in sectors that are likely to hedge regardless of size.

The behaviour of new sectors is highly uncertain but is expected to be similar to existing industrial participants. Forward-looking analysis assumes some new sectors are more likely to hedge based on exposure to other hedgeable commodities and incidence of EU allowance regulation. These sectors include maritime, due to existing fuel hedging programmes. The buildings and transport sectors are expected to depend on whether upstream companies, which tend to be larger and are used to hedging fuel exposure, or downstream entities, are required to surrender allowances. Results will hence depend on this assumption.

7.5 Implications for thresholds

There is significant regarding future hedging behaviour, which makes identifying appropriate thresholds challenging. The main sources of this uncertainty include changes to utility hedging behaviour as price expectations increase, new hedging by industrial participants as banked allowances run down, and the implications of new policies such as sector expansion and a CBAM. Upper and lower threshold recommendations of 700 and 400 million allowances respectively fall within a reasonable range of hedging expectations, but other design adjustments can also serve to reduce the MSR's reliance on hedging estimates to manage market balance.

The second implication of the hedging analysis is that by all estimates, hedging demand is expected to decrease overall as emissions decrease, implying that a mechanism to reduce thresholds over time may be appropriate. For instance, a gradual reduction in thresholds in line with the linear reduction factor will align the MSR's design with the overall ETS design.

Given the uncertainty of hedging requirements over time, designing the MSR to include a gradual intervention may be more appropriate than one with large threshold effects. One option analysed in section 5.3 includes a mechanism to reduce the threshold effect, which can reduce the MSR's exposure in case hedging amounts hit the upper edge of the range of estimates. Rather than calculating intakes to the MSR as a proportion of the TNAC, this option calculates intakes as a proportion of the TNAC in excess of the upper threshold. Using this design would allow for a more measured response, taking in fewer allowances for a small surplus and more allowances for a bigger surplus.

8 Annex 3: Survey of covered entities

8.1 Methodology

This review conducted a survey of EU ETS covered entities focusing on the impact of the MSR on price expectations, abatement and hedging behaviour. The survey consisted of 18 multiple-choice questions that helped provide an evidence base for some areas of the review, particularly on topics where there is a lack of quantitative data or qualitative evidence from the literature. For instance, it is difficult to identify future expectations of prices or abatement (and more specifically, the role of the MSR in influencing those expectations) from historical data. This survey is therefore useful in understanding how covered entities perceived and responded to the introduction of the MSR.

The survey received 934 responses spanning all major EU ETS sectors, countries, and installation sizes. The online survey was launched on February 8th, 2021. It was circulated to all covered entities via members states and received a total of 934 responses over four weeks. In terms of sectoral distribution, 25% of respondents come from the power and heat sector, followed by ceramics and glass (13%), chemicals (12%), pulp and paper (11%), metals (9%), cement/lime (6%), oil & gas (5%) aviation (1%) and some other sectors (18%). There is representation from all countries within the EU ETS, with most responses coming from covered entities with operations in Italy (19%), France (17%) and Spain (15%). There is a mix of both small and large emitters, with about half of the respondents representing entities with an annual emissions volume of under 1 $MtCO_2e$.

8.2 Results

There is a diverse range of opinions from survey respondents. Although the MSR increased price expectations for some covered entities, there is a lack of consensus over the impact of the MSR, particularly with regards to price volatility and predictability. There is a significant number of respondents who reported that they do not know the impact of the MSR both in the past and in the future. This is an indication of the complexity of the policy measure, making it difficult for firms to respond directly.

Table 15 summarises the distribution of responses to the 18 survey questions. The subsequent charts discuss the key findings from each survey question.

Table 15 Summary of survey responses

Question	Options	Responses
1. Did the introduction of the MSR increase or decrease your trust in the stability of the EU ETS?	Increase	19%
	No change	37%
	Decrease	21%
	Don't know	22%
2. Did the introduction of the MSR increase or decrease your expectations of future EU allowance prices?	Increase	38%
	No change	26%
	Decrease	14%
	Don't know	23%
3. From 2023, the MSR will invalidate allowances held above a certain threshold (currently equal to the previous year's auction volume). Did the introduction of this invalidation mechanism increase or decrease your expectations of long term prices?	Increase	42%
	No change	19%
	Decrease	15%

Question	Options	Responses
	Don't know	24%
4. Did the introduction of the MSR make long term EUA prices more or less predictable?	More predictable	20%
	No change	21%
	Less predictable	30%
	Don't know	29%
5. Did the introduction of the MSR increase or decrease price volatility (price fluctuations within 12 months)?	Increase	35%
	No change	19%
	Decrease	15%
	Don't know	32%
6. Did the introduction of the MSR increase or decrease your planned investment in emissions reduction projects?	Increase	22%
	No change	54%
	Decrease	7%
	Don't know	17%
7. What are your expectations for EUA prices in 2030?	Less than 30 EUR	11%
	Between 30 and 50 EUR	28%
	Between 50 and 70 EUR	23%
	Between 70 and 100 EUR	17%
	Over 100 EUR	6%
	Don't know	15%
8. Would a phase out of free allocations in the EU ETS increase or decrease your price expectations in 2030?	Large decrease (above 10 EUR)	3%
	Decrease (0-10 EUR)	3%
	No change	10%
	Increase (0-10 EUR)	18%
	Large increase (above 10 EUR)	49%
	Don't know	18%
9. Would a price floor on EU allowances increase or decrease your price expectations in 2030?	Large decrease (above 10 EUR)	2%
	Decrease (0-10 EUR)	5%
	No change	24%
	Increase (0-10 EUR)	19%
	Large increase (above 10 EUR)	19%
	Don't know	30%
10. Would the introduction of a price floor on EU allowances (preventing trading below a certain level) increase or decrease your expectations of price volatility (price fluctuations in a twelve-month period)?	Increase	22%
	No change	25%
	Decrease	24%
	Don't know	29%
11. Would the introduction of a price floor make you confident that extreme price fluctuations would be avoided?	No	56%
	Yes	44%

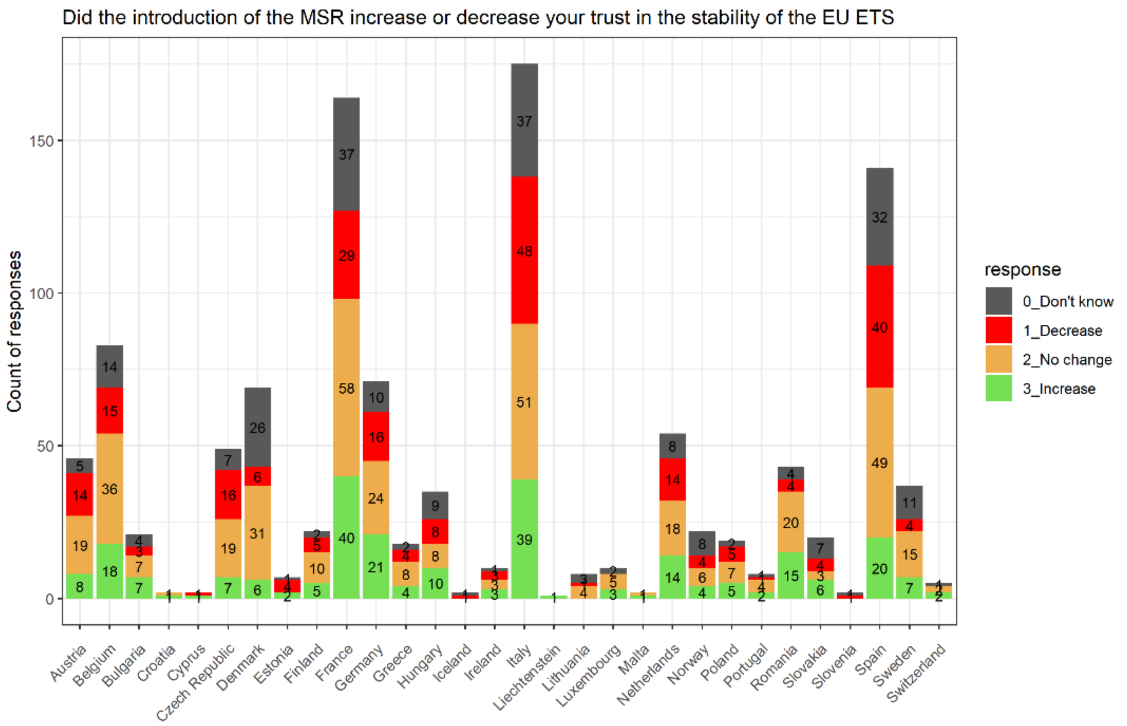
Question	Options	Responses
12. Has the recent increase in ETS ambition increased or decreased your planned emissions reductions activity?	Increase	36%
	No change	50%
	Decrease	7%
	Don't know	7%
13. Would a phase out of free allocations in the EU ETS increase or decrease your planned emissions reductions activity in the next few years?	Increase	34%
	No change	43%
	Decrease	11%
	Don't know	11%
14. What proportion of your annual EUA obligation do you currently carry into future compliance periods?	under 50% of annual obligations	45%
	50-100% of annual obligations	17%
	above 100% of annual obligations	5%
	Don't know	33%
15. Has the recent increase in ETS ambition increased or decreased your hedging behaviour?	Increase	24%
	No change	52%
	Decrease	5%
	Don't know	19%
16. Would a phase out of free allocations in the EU ETS increase or decrease the proportion of EU allowances you purchase for the next 2 years as part of a hedging strategy?	Increase	36%
	No change	35%
	Decrease	4%
	Don't know	25%
17. Would a price floor on EU ETS allowances increase or decrease the proportion of EU allowances you purchase for the next 2 years as part of a hedging strategy?	Increase	17%
	No change	48%
	Decrease	5%
	Don't know	30%
18. Would an increase in expected future EUA prices increase or decrease the proportion of EU allowances you purchase for the next 2 years as part of a hedging strategy?	Increase	32%
	No change	38%
	Decrease	3%
	Don't know	27%

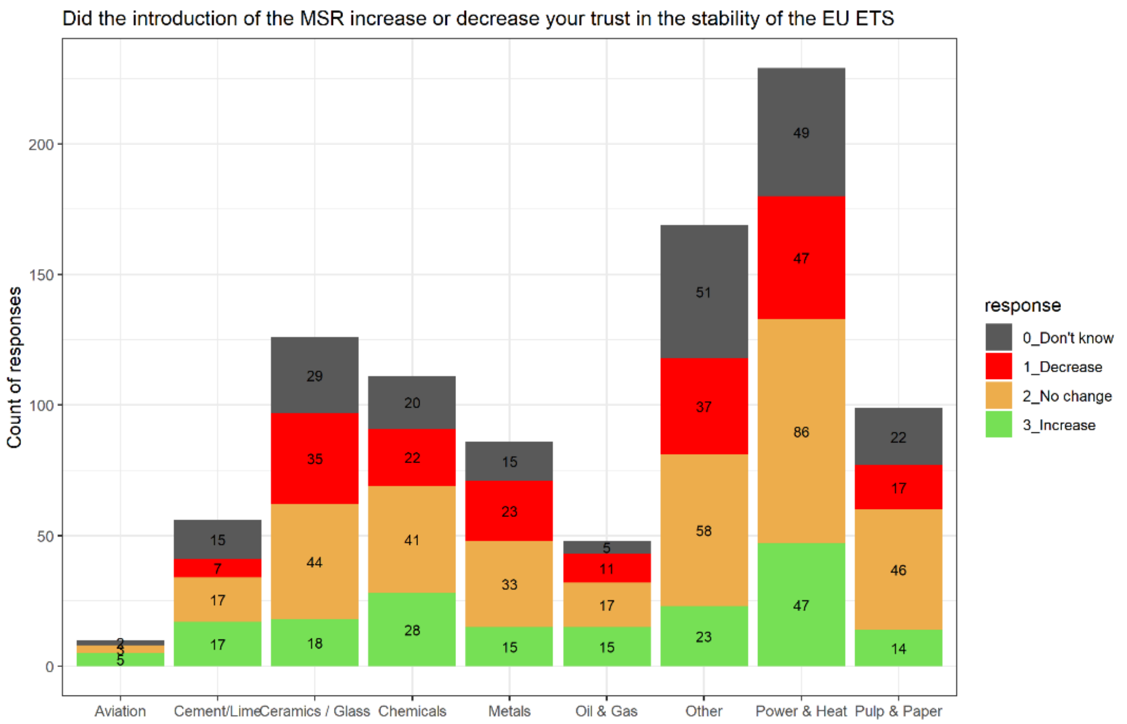
Source: Vivid Economics

8.2.1 Q1: Trust in the stability of the EU ETS

Q1: The MSR increased trust in the stability of the ETS only for 19% of respondents, compared to 37% who thought there was no change, and 21% who thought the MSR decreased their trust in the system. It is unclear from the survey why the MSR is perceived this way, although the complexity of the MSR is one reason for the mixed responses.

Figure 65 Survey response to Q1



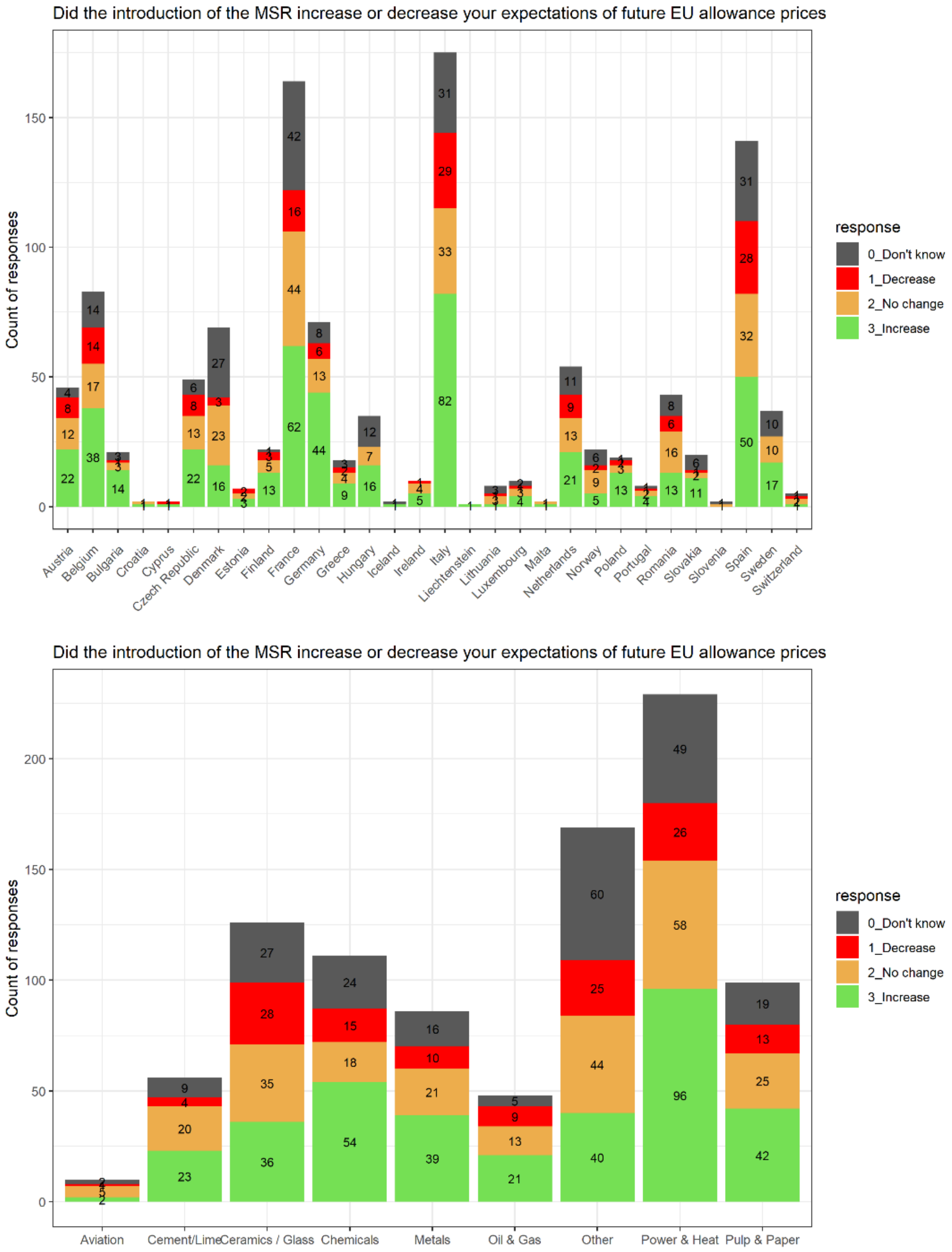


Source: Vivid Economics

8.2.2 Q2: Historical impact on price expectations – the MSR

Q2: The introduction of the MSR increased the price expectations of 38% of respondents, compared to 26% who thought it had no impact and 14% claiming the MSR decreased their price expectations. There is some evidence that larger covered entities (as measured by annual emissions) are more likely to say that the MSR increased their price expectations. Respondents from Denmark and France are less likely to report that MSR increased their price expectations.

Figure 66 Survey response to Q2

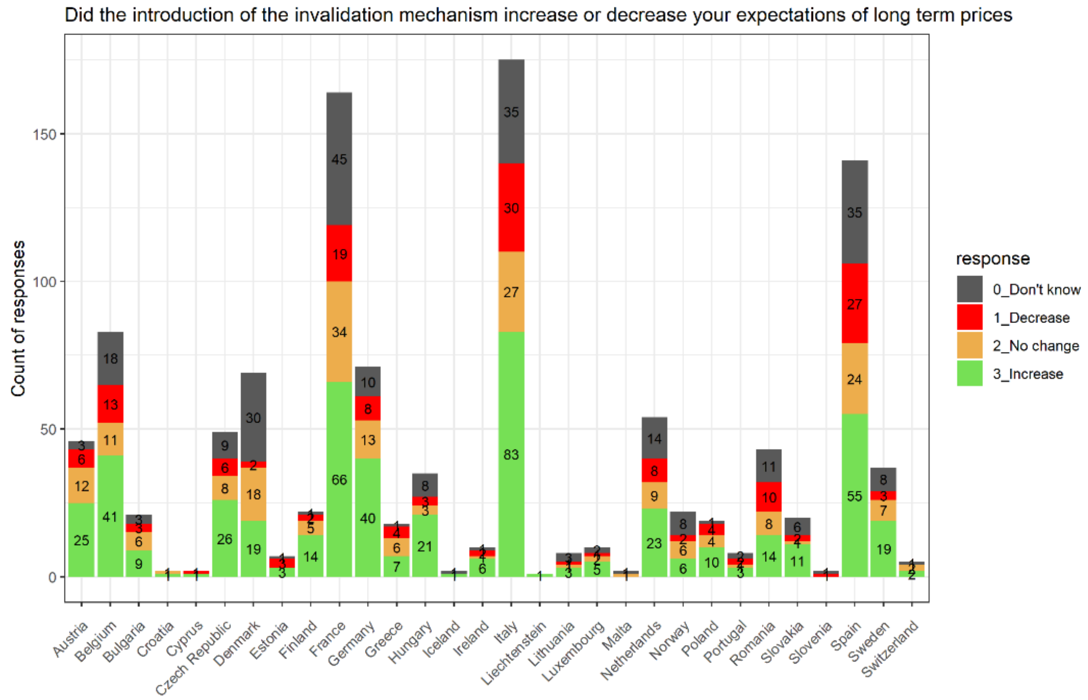


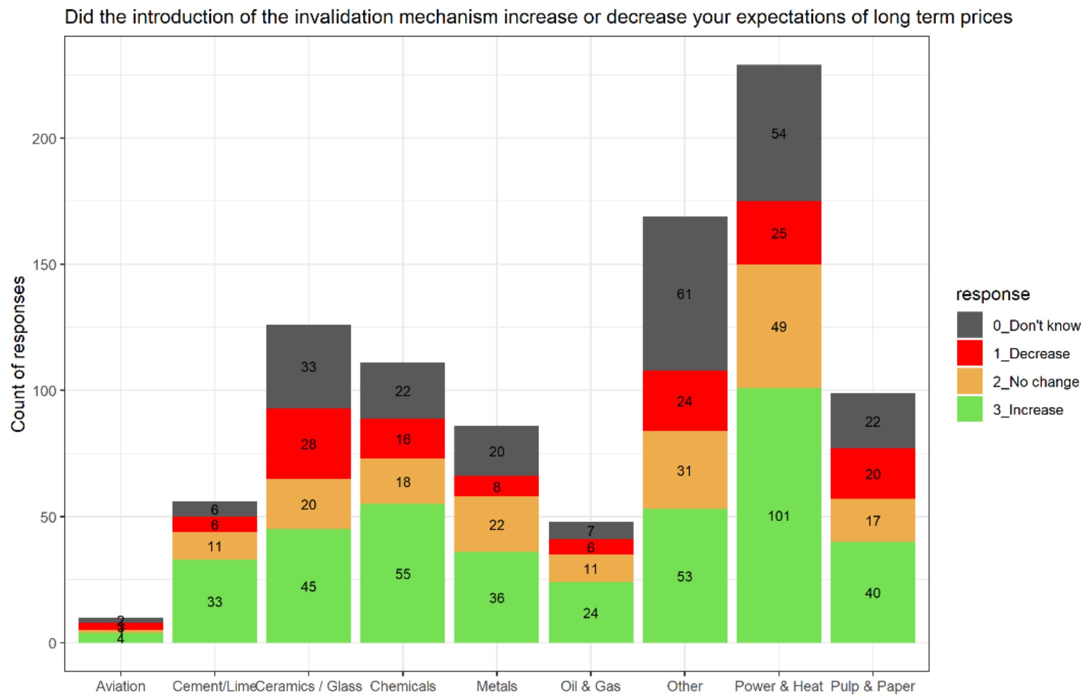
Source: Vivid Economics

8.2.3 Q3: Historical impact on price expectations – the invalidation mechanism

Q3: The introduction of the invalidation mechanism increased the price expectations of 42% of respondents, compared to 19% who thought it had no impact and 15% claiming that the invalidation mechanism lowered their price expectations. This indicates that the design of the invalidation mechanism is potentially a clearer signal of a tighter future allowance supply, relative to the MSR as a whole. The cement and lime sector is particularly bullish in response to the invalidation mechanism, with close to 60% claiming that it increased their price expectations.

Figure 67 Survey response to Q3



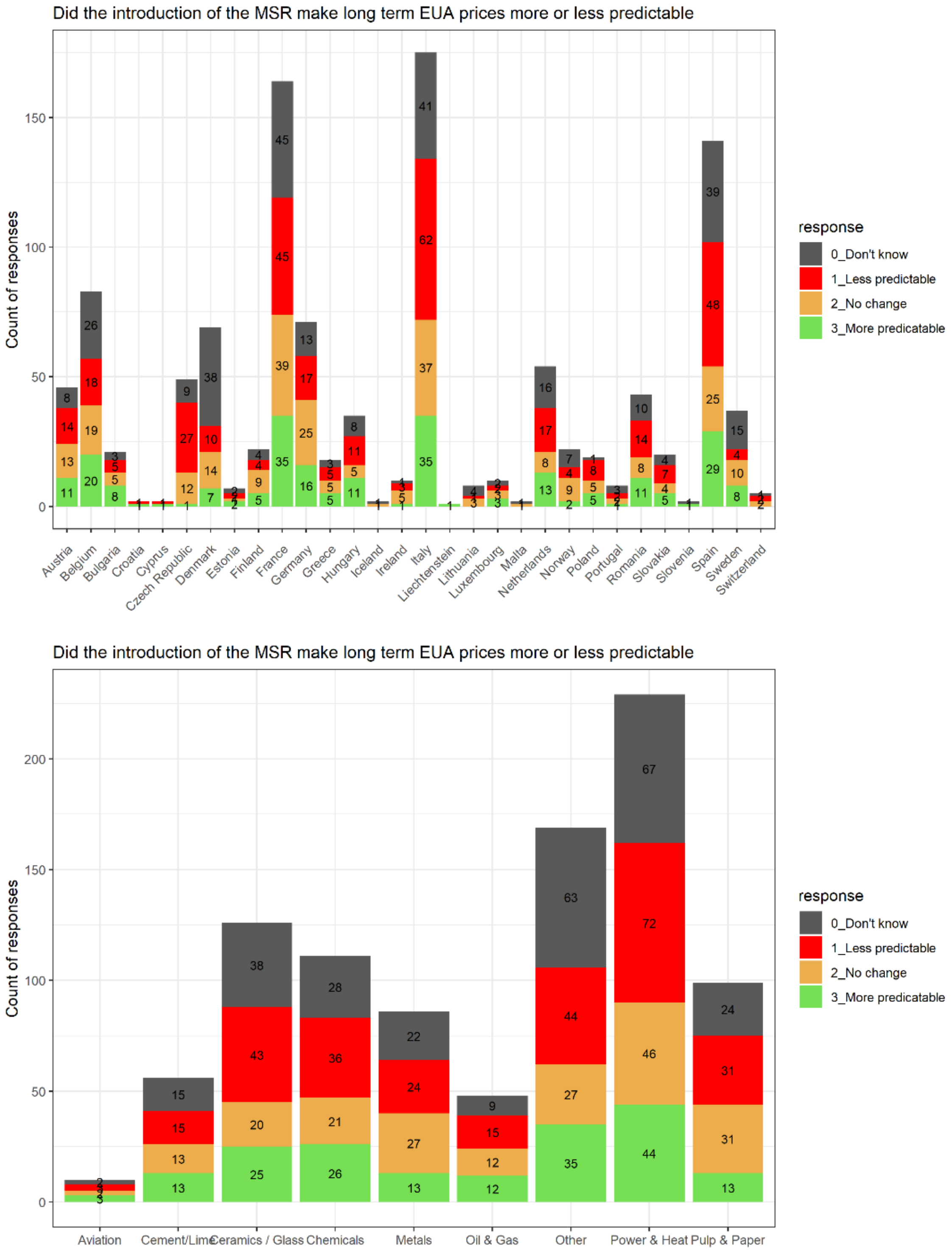


Source: Vivid Economics

8.2.4 Q4: Predictability of prices

Q4: The introduction of the MSR increased long term price predictability for just 20% of respondents, compared to 21% who thought it had no impact and 30% who thought it made long term prices less predictable. This finding is similar across sectors.

Figure 68 Survey response to Q4

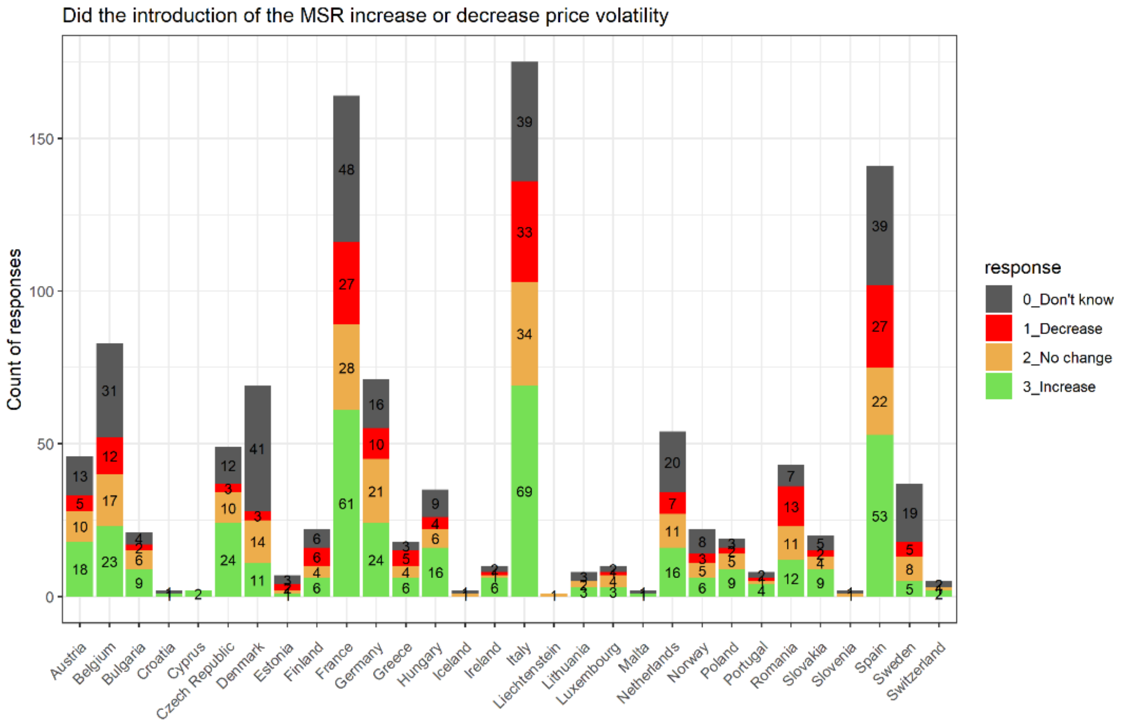


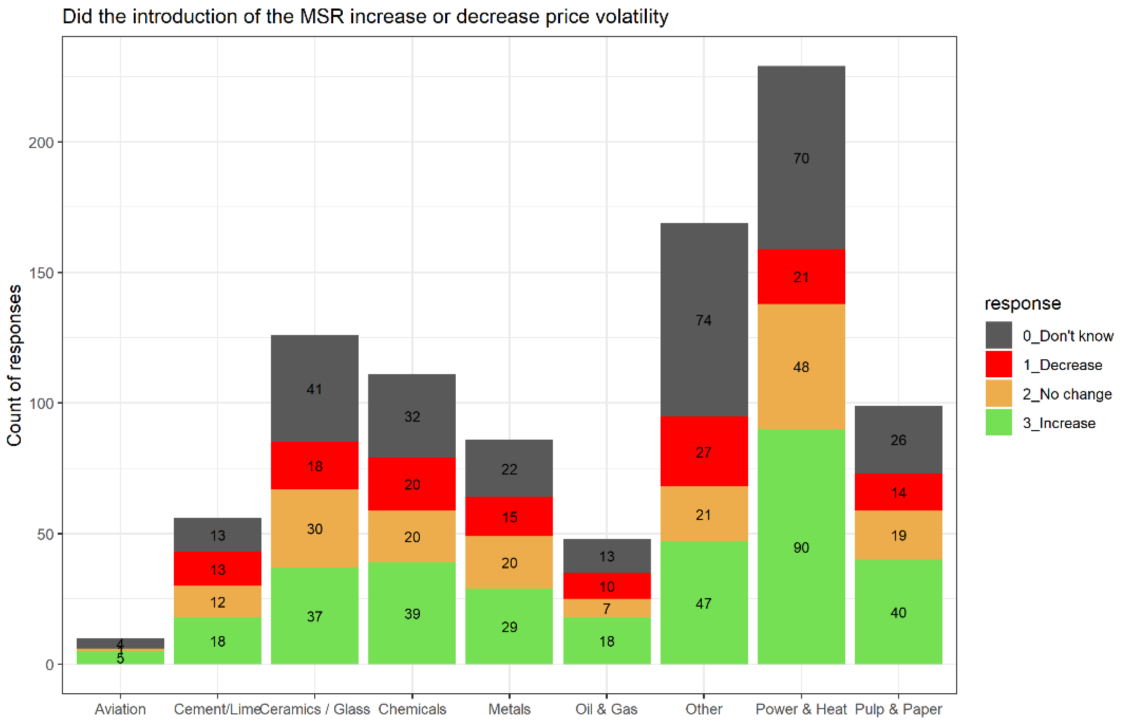
Source: Vivid Economics

8.2.5 Q5: Volatility of prices

Q5: Around 35% of respondents thought that the MSR increased short run (i.e. within 12 months) price volatility, compared to 19% who claimed that it had no impact and 15% who believed that it lowered price volatility. A significant minority of respondents are uncertain about the impact of MSR on price volatility. This exhibits the complexity of the instrument and how there is a lack of consensus on its impact.

Figure 69 Survey response to Q5



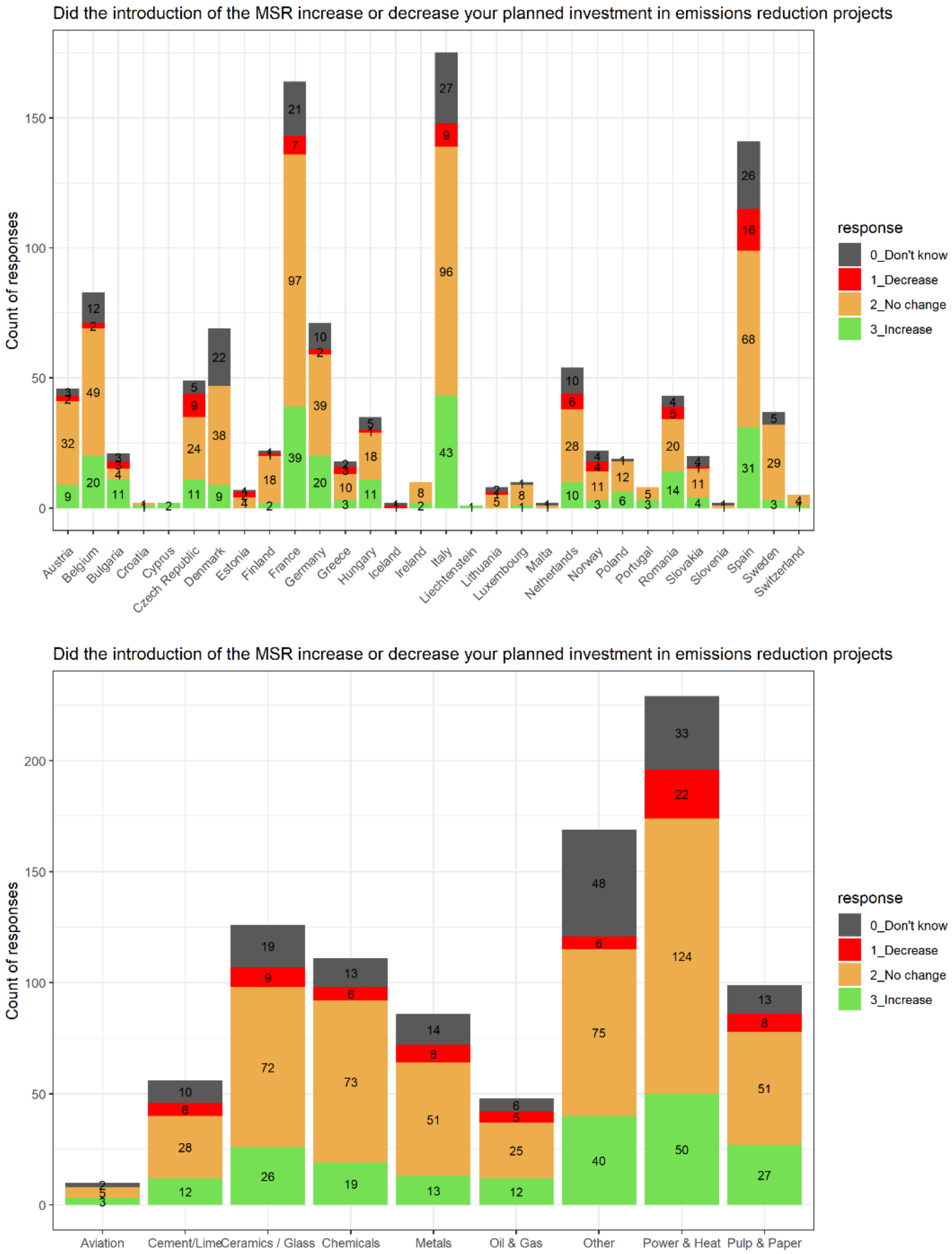


Source: Vivid Economics

8.2.6 Q6: Abatement investments

Q6: A majority of respondents (54%) claimed that the introduction of the MSR had no impact on their planned investment in abatement projects, compared to 22% who reported an increase and 7% who reported a decrease. There are no significant variations in the responses from different countries and sectors. As noted in Section 3.2.2, covered entities that claimed the MSR improved long term price predictability were more likely to have increased abatement investments.

Figure 70 Survey response to Q6

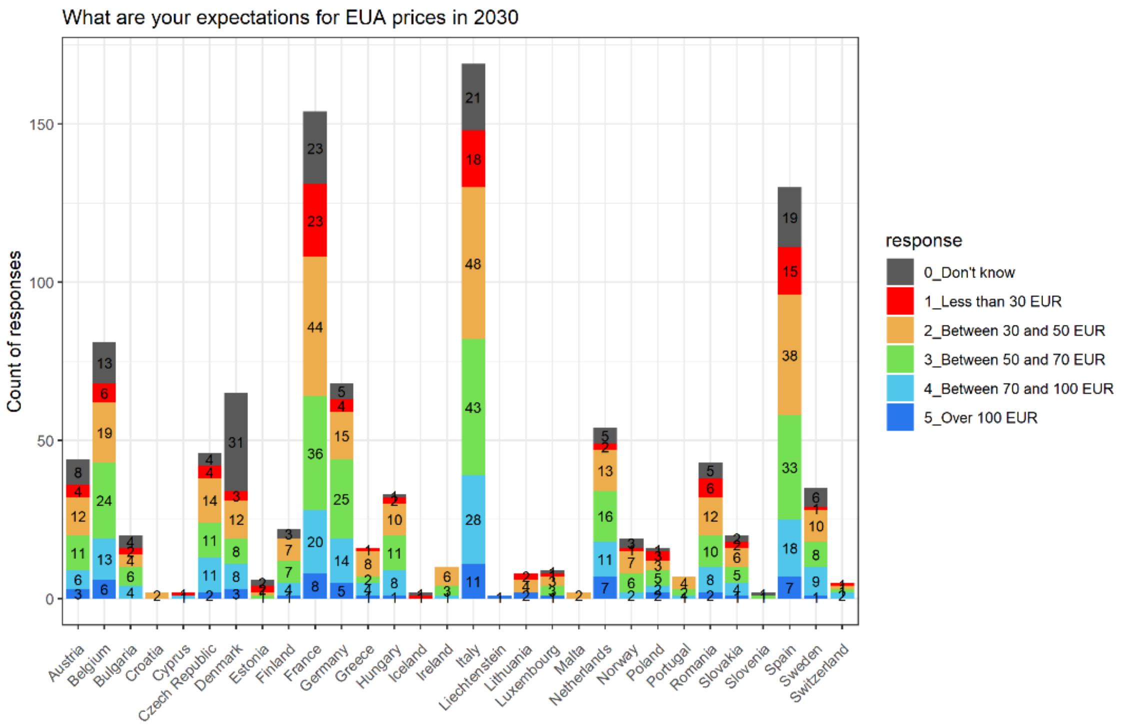


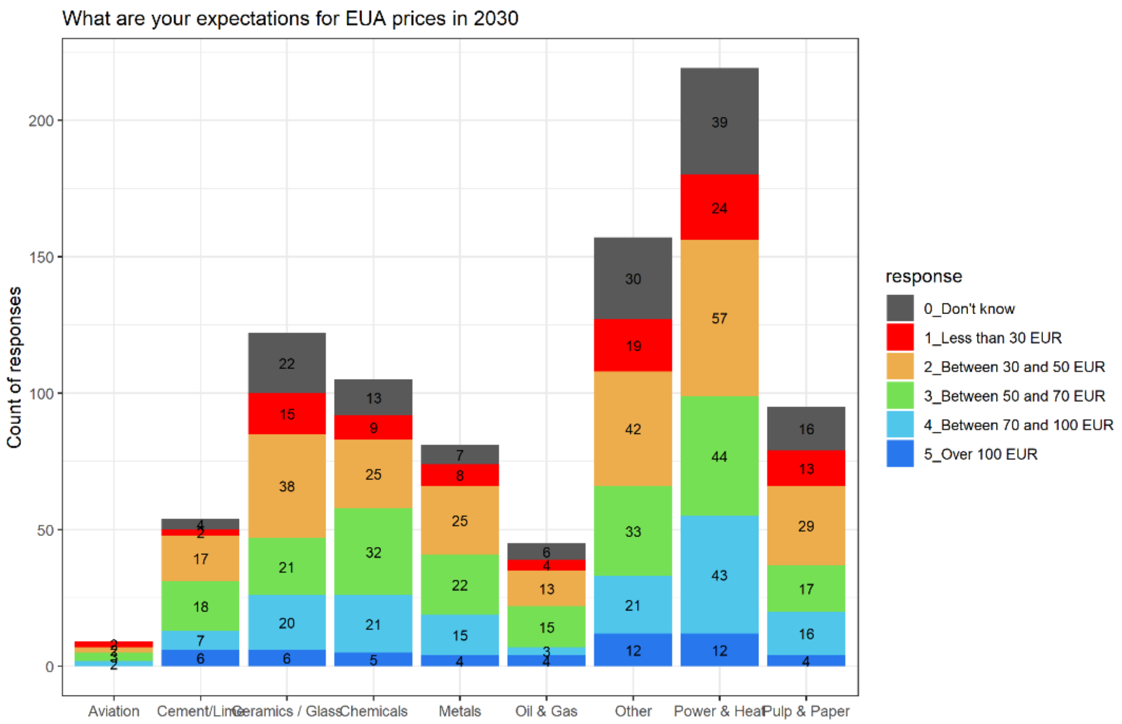
Source: Vivid Economics

8.2.7 Q7: 2030 price expectations

Q7: When asked about their price expectations for 2030, the median response suggests that the 2030 price would lie between 50 to 70 Euros. A significant minority of 28% believed that the price would remain below 50 Euros. Just 6% of respondents think that the 2030 price would exceed 100 Euros. There are no significant variations in the responses from different countries and sectors.

Figure 71 Survey response to Q7



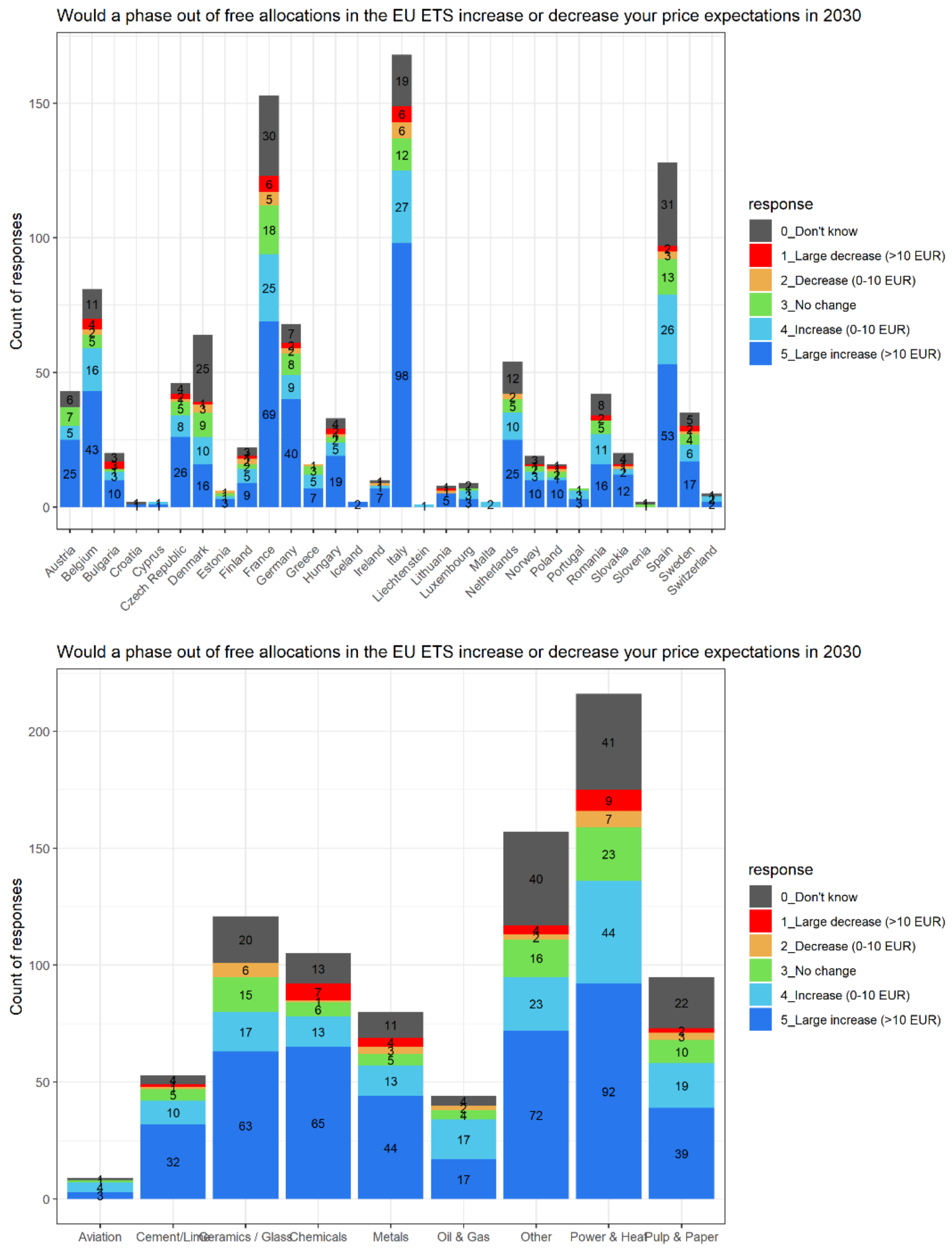


Source: Vivid Economics

8.2.8 Q8: Impact on price expectations – Phasing out free allocations

Q8: A phase out of free allocations in the EU ETSE would increase the 2030 price expectations from a clear majority of respondents, with 18% claiming that the increase would be smaller than 10 Euros and another 49% claiming the increase would be over 10 Euros. Relative to the aviation and power sectors, respondents from emissions intensive industries like cement and chemicals are more likely to think that the increase in their price expectations would exceed 10 Euros.

Figure 72 Survey response to Q8

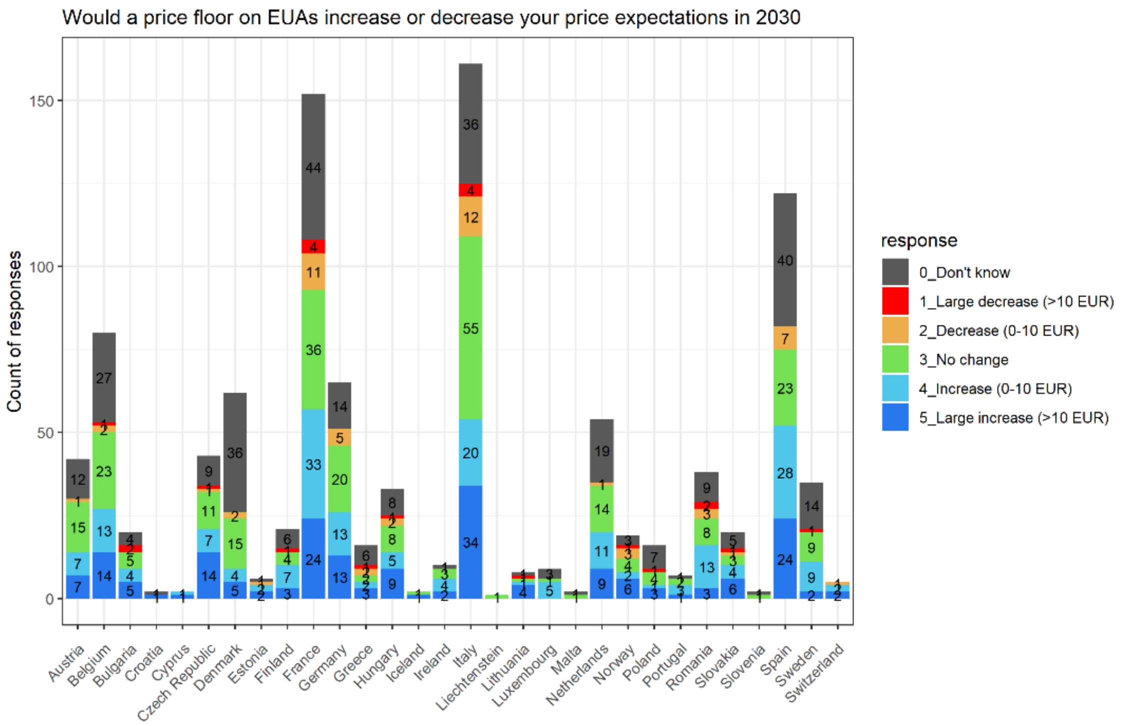


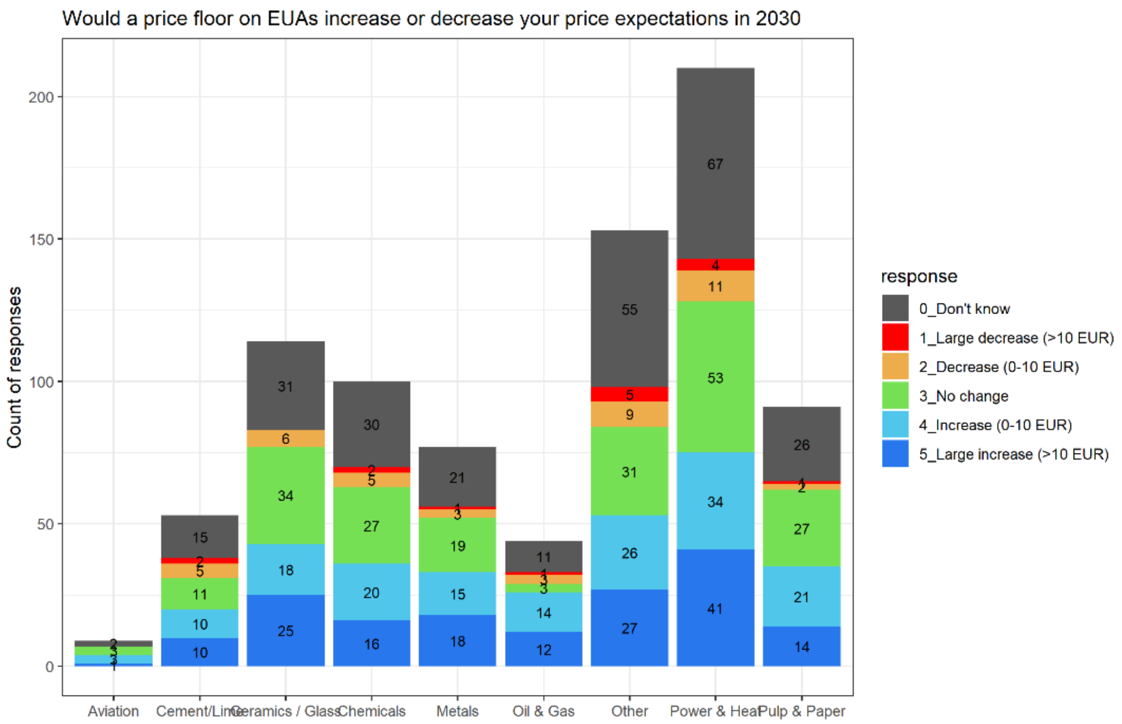
Source: Vivid Economics

8.2.9 Q9: Impact on price expectations – Price floor

Q9: If a price floor is introduced, 38% of respondents would increase their 2030 price expectations, compared to 24% of respondents who think it would have no impact on their price expectations. A lot of respondents are unsure about the potential impact of a price floor, potentially due to ambiguity over the stringency and design of this hypothetical price floor. The findings are similar across countries and sectors.

Figure 73 Survey response to Q9



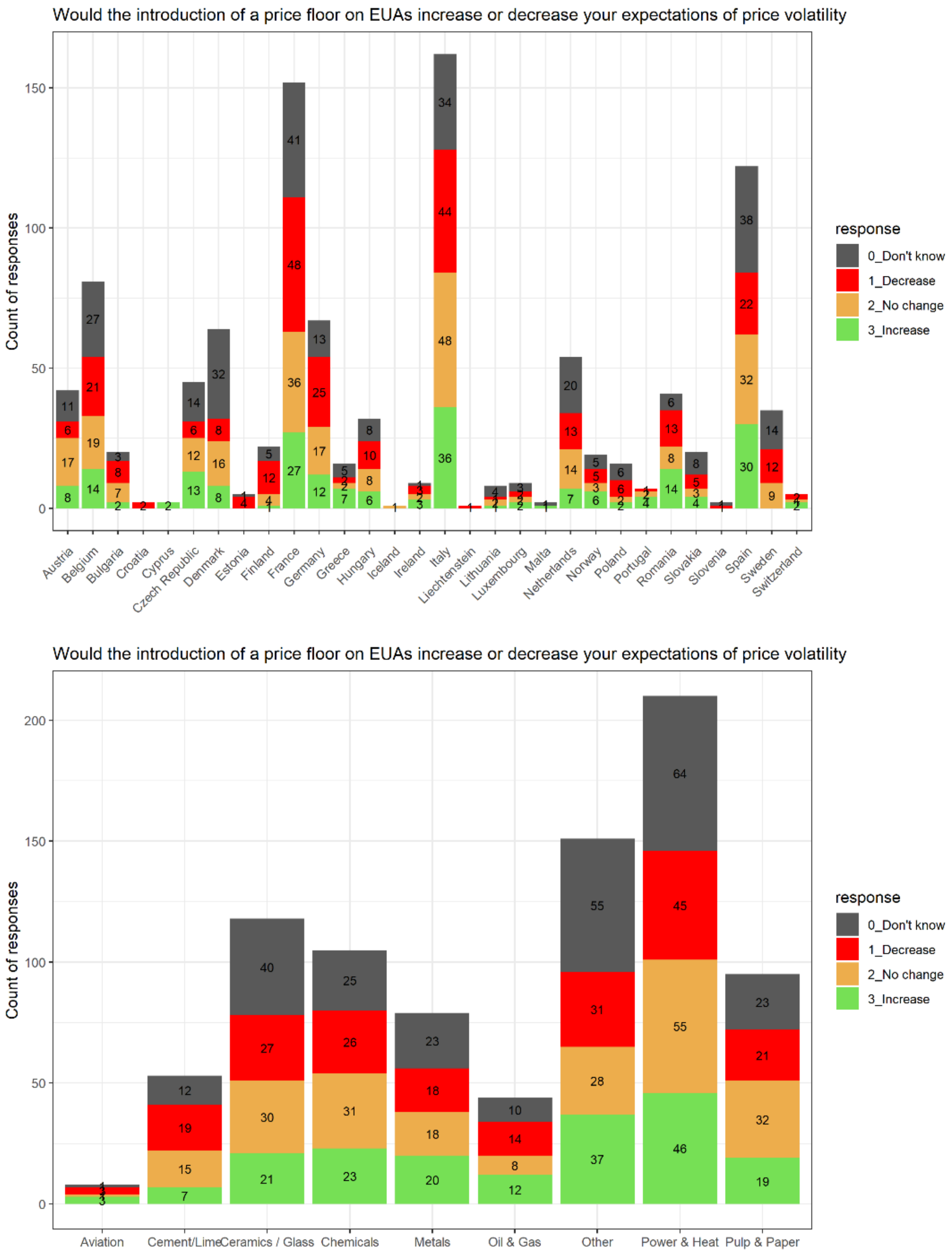


Source: Vivid Economics

8.2.10 Q10: Price floor impact on price volatility

Q10: There is no consensus on the impact of a price floor on price volatility. Nearly 30% of respondents are unsure about its impact on price volatility, with the remainder being split roughly equally groups that think the price floor would increase, decrease, or have no impact on price volatility. There are no statistically significant differences across countries and sectors.

Figure 74 Survey response to Q10

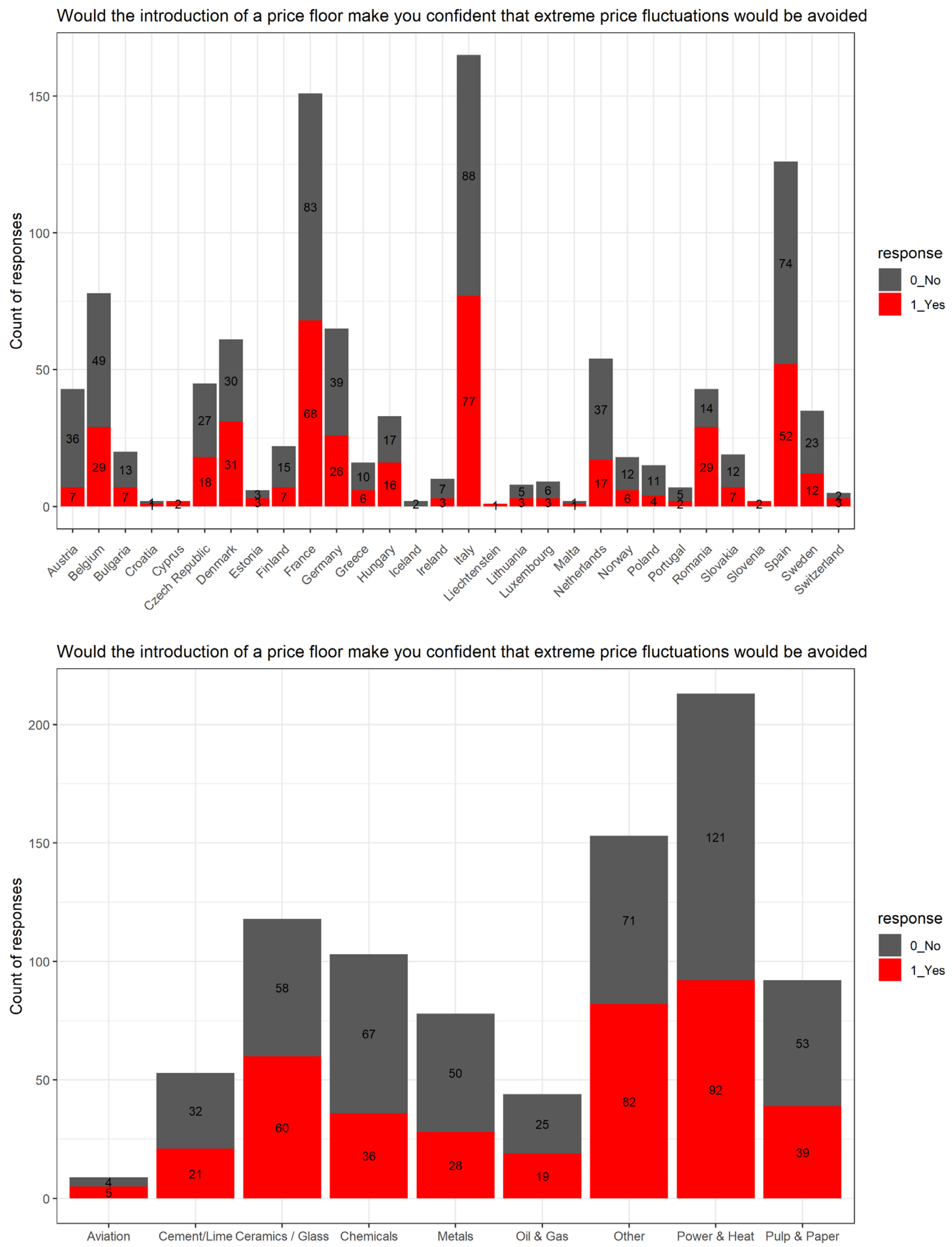


Source: Vivid Economics

8.2.11 Q11: Price floor impact on extreme price fluctuations

Q11: Similarly, there is no consensus on whether a price floor would prevent extreme price fluctuations, with 44% respondents believing that it would and 56% saying that it would not. The mixed opinion can be attributed to different perceptions of the level of a price floor if it is implemented in the future.

Figure 75 Survey response to Q11

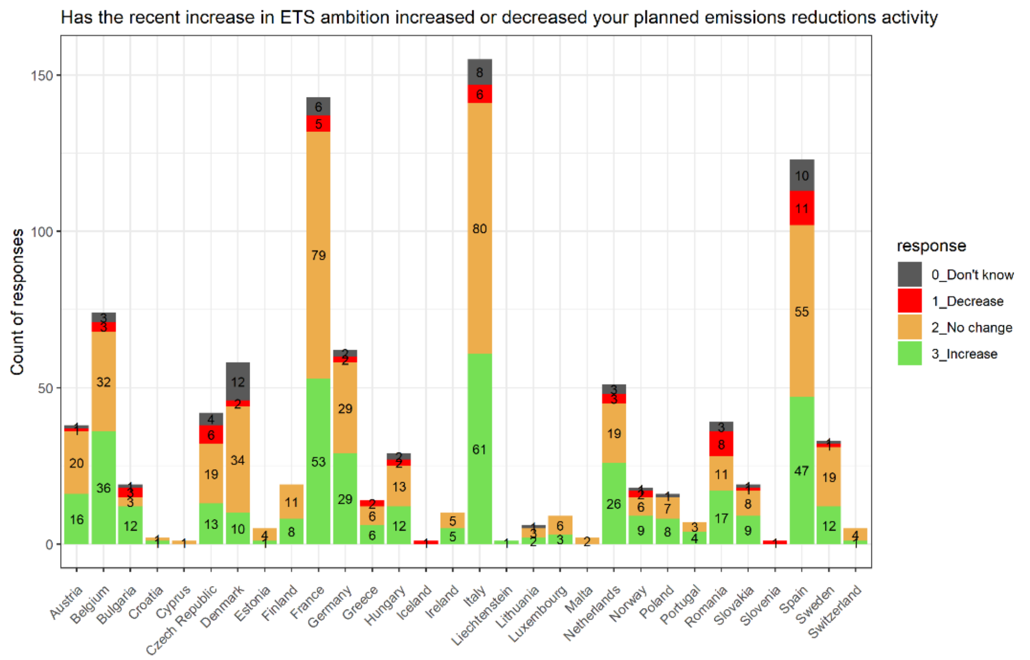


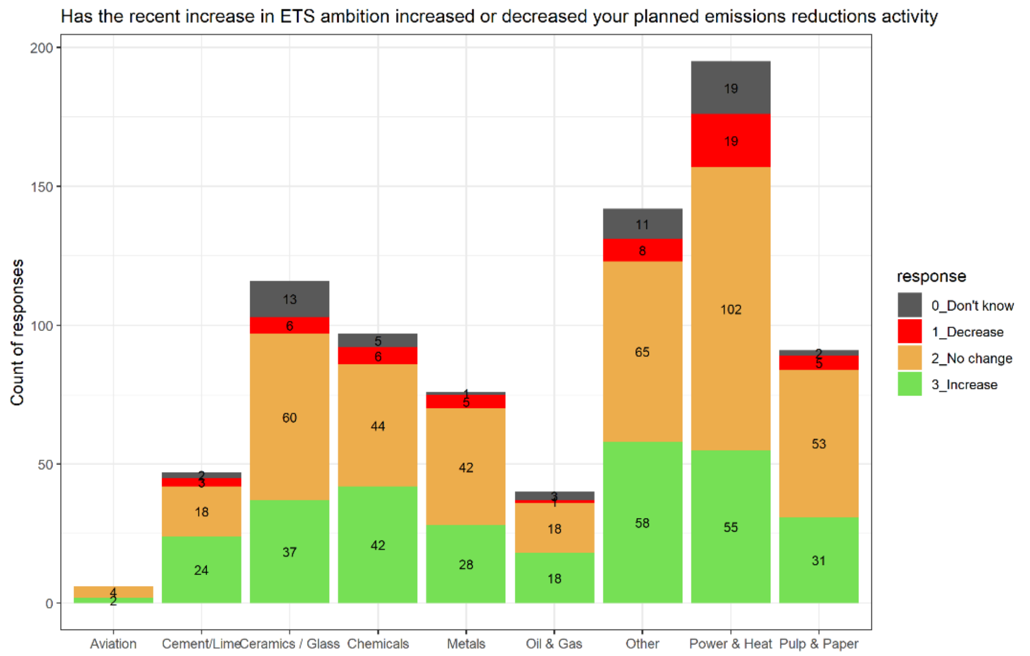
Source: Vivid Economics

8.2.12 Q12: Impact on planned abatement – higher ETS ambition

Q12: The recent increase in ETS ambition increased planned abatement for 36% of respondents, while 50% claimed that it had no impact. This confirms that the higher climate policy ambition does have a noticeable impact on market expectations and mitigation behaviour, even though some covered entities have so far remained unresponsive to recent policy signals. The positive response is more common amongst the cement and chemicals sectors, potentially due to the fact the carbon price is expected to reach a level that warrants significant consideration in investment decisions, unlike in the power sector where decarbonisation is already well under way. Covered entities based in Belgium and the Netherlands are also more likely to have increased their abatement investments in response to higher policy ambition in recent years.

Figure 76 Survey response to Q12



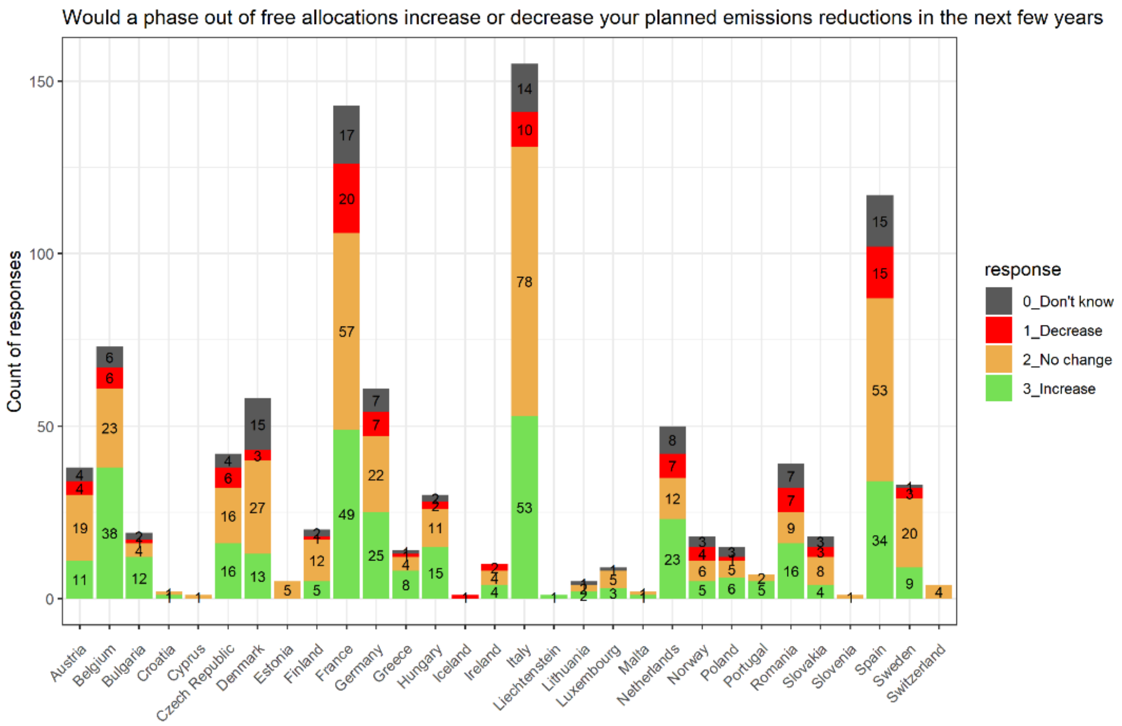


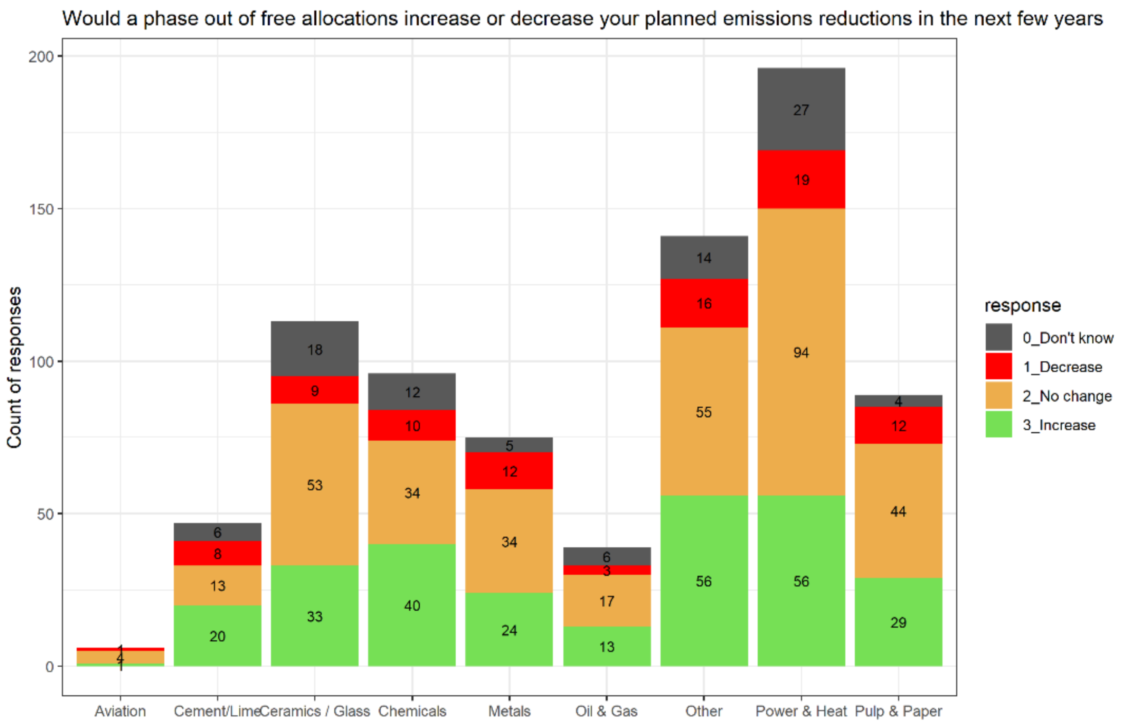
Source: Vivid Economics

8.2.13 Q13: Impact on planned abatement – phasing out free allocations

Q13: A phase out of free allocations would increase the planned abatement activity in the next few years for 34% of respondents, while 43% claimed that it would have no impact on their emissions reductions. There are no statistically significant differences across countries and sectors. The results indicate that phasing out of free allocations will have some positive impact on abatement in the near term.

Figure 77 Survey response to Q13



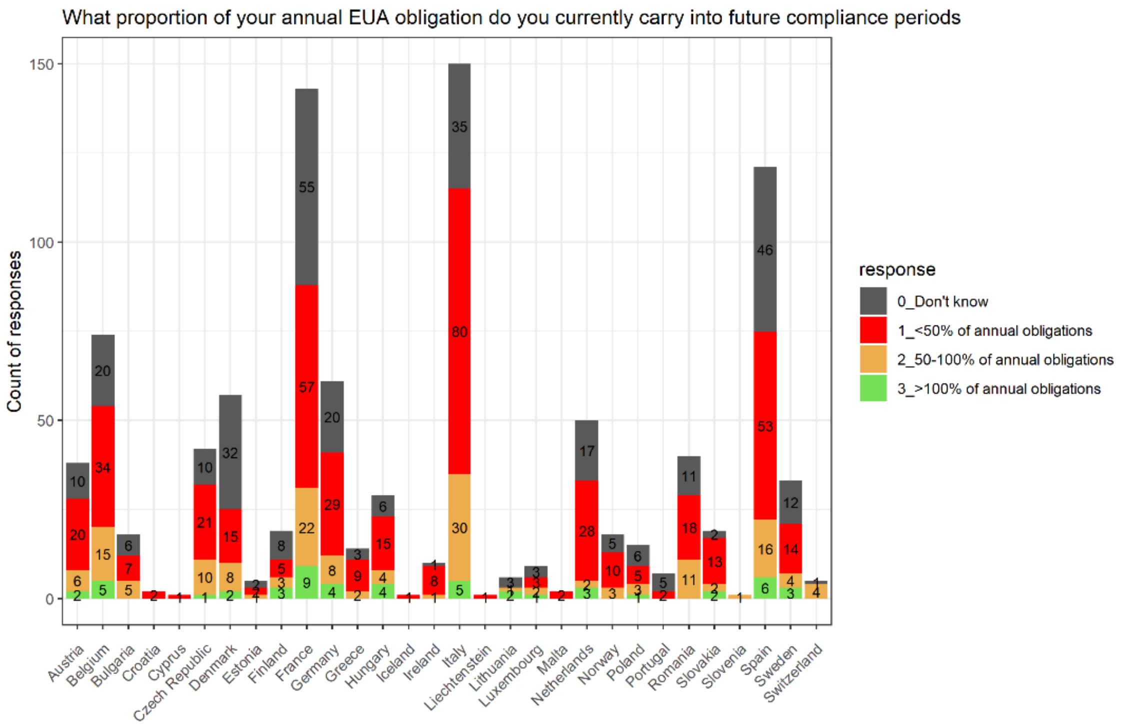


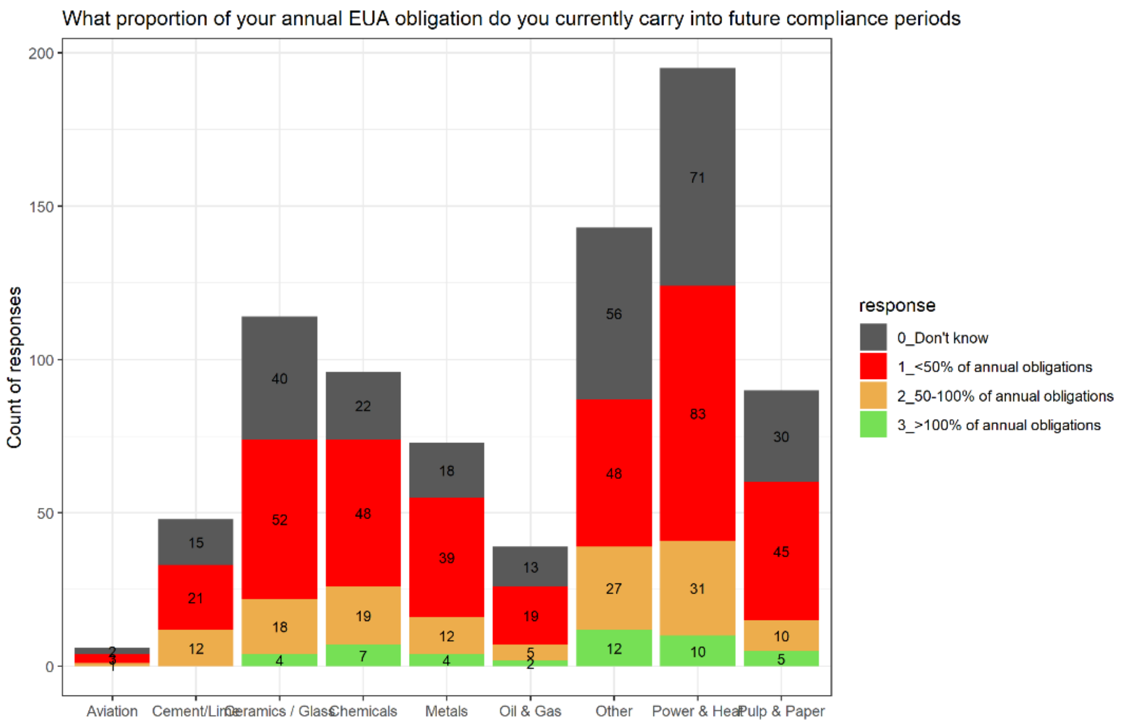
Source: Vivid Economics

8.2.14 Q14: Current hedging behaviour

Q14: When asked about their current EU allowance holdings, around a third of respondents are unable to provide an estimate, with the majority of the remaining responses claiming that they carry below 50% of their annual obligations into future compliance years. Only 5% of respondents hold allowances beyond 100% of their annual obligations, and they spread across most sectors.

Figure 78 Survey response to Q14



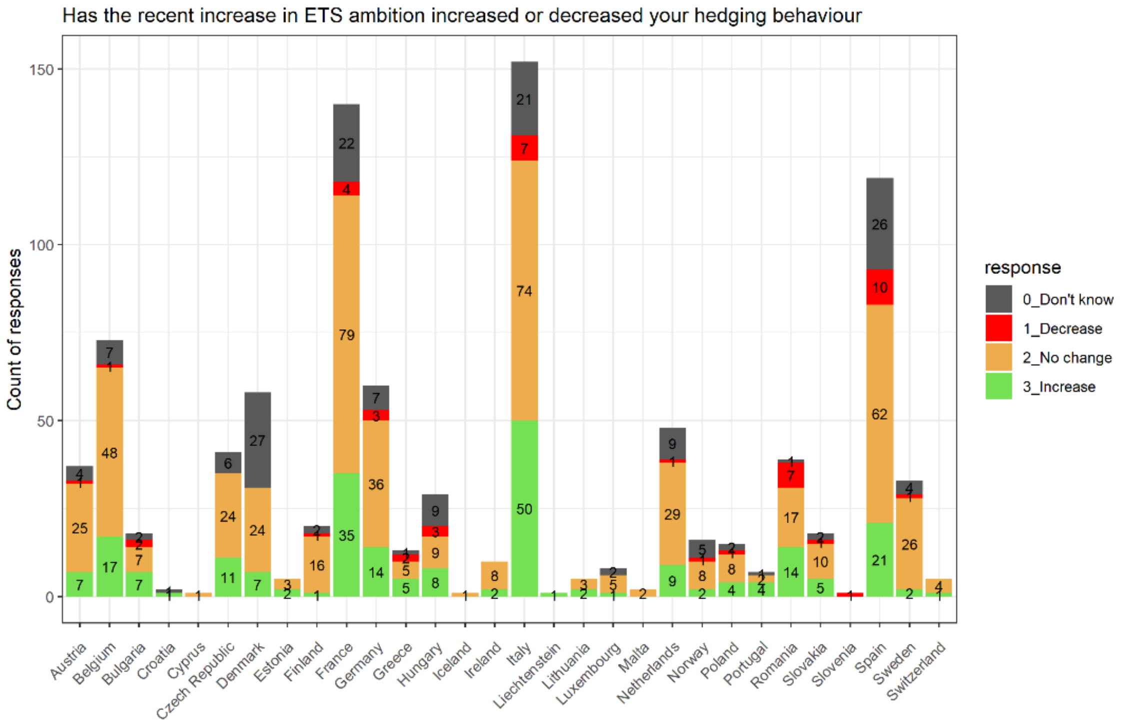


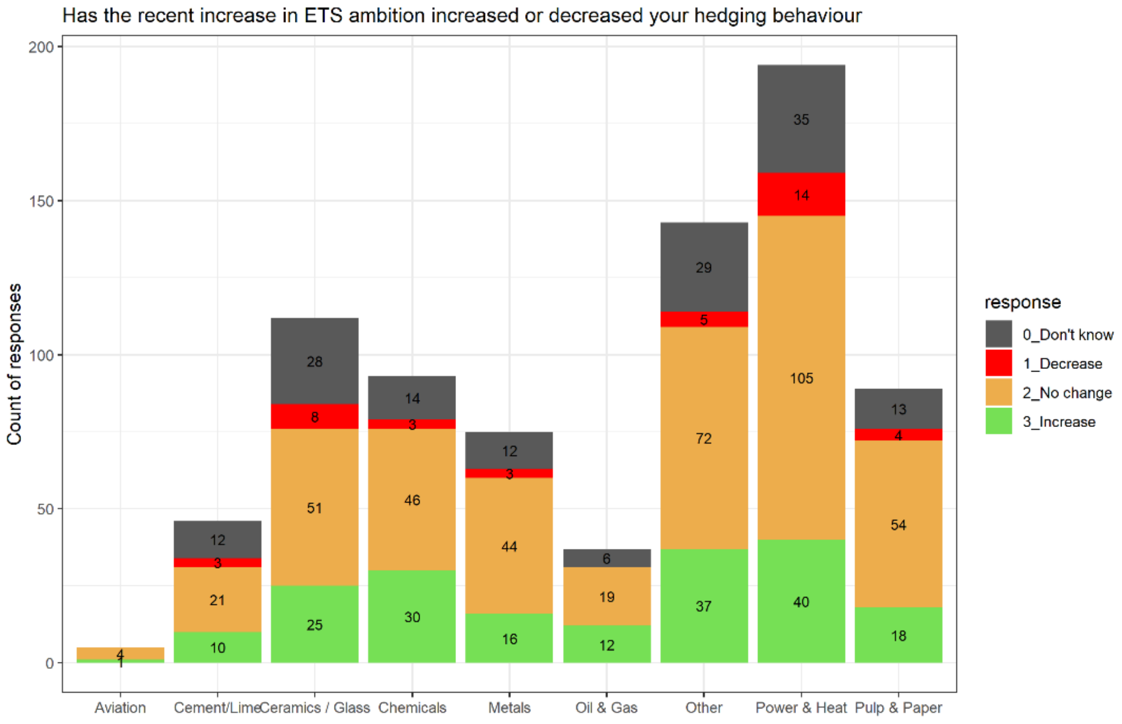
Source: Vivid Economics

8.2.15 Q15: Impact on hedging behaviour – higher ETS ambition

Q15: The recent increase in policy ambition within the EU ETS increased hedging amongst 24% of respondents, although there is also a majority of 52% said that it had no impact on their hedging behaviour. Just 5% of respondents reduced hedging in response to the higher policy ambition. These results are roughly consistent across different countries and sectors. The results suggest that policy ambition increased overall hedging behaviour in the market by raising price expectations.

Figure 79 Survey response to Q15



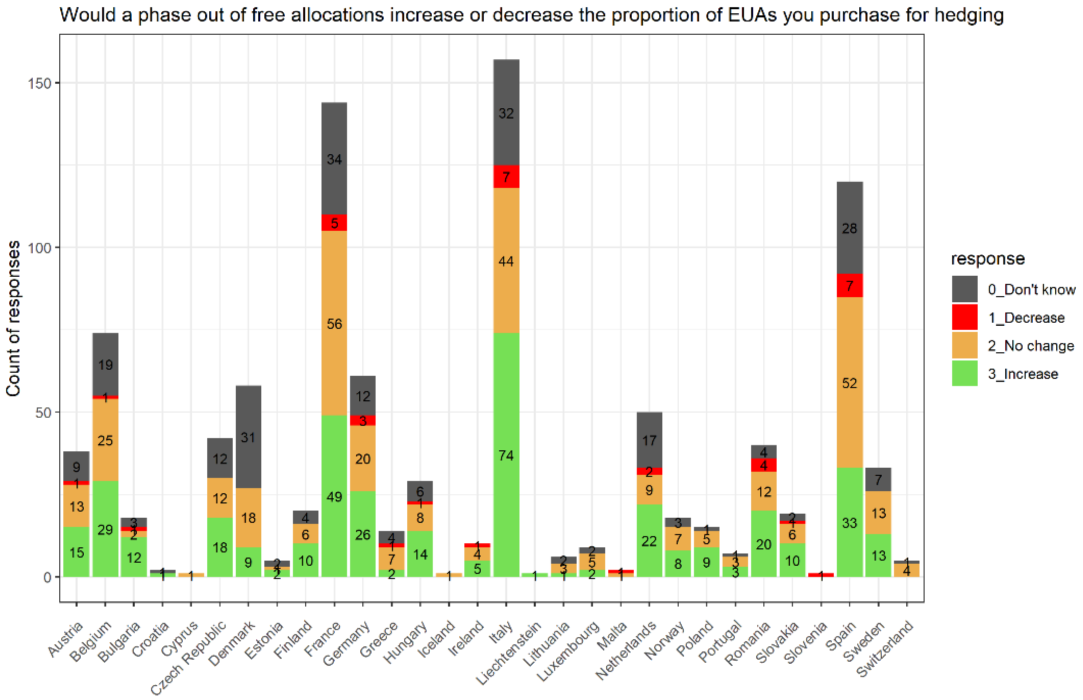


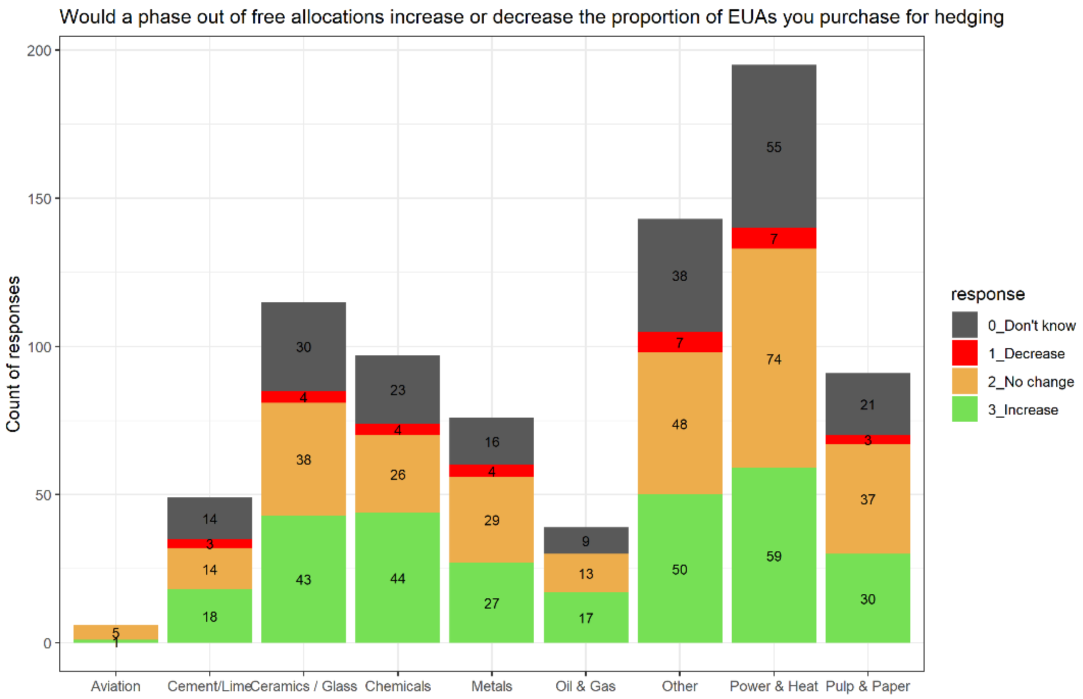
Source: Vivid Economics

8.2.16 Q16: Impact on hedging behaviour – phasing out free allocations

Q16: A phase out of free allocations would increase hedging amongst 36% of respondents, compared to 35% who would not increase hedging in response, and another 4% who claimed that they would reduce hedging. Again, the trends are similar across countries and sectors. The results are in line with economic intuition that increased exposure to carbon costs would generally encourage firms to increase hedging. Some firms are unlikely to alter their hedging behaviour because they lack the administrative capacity to do so. It remains highly uncertain how much would hedging demand increase in the event of phasing out free allocations.

Figure 80 Survey response to Q16



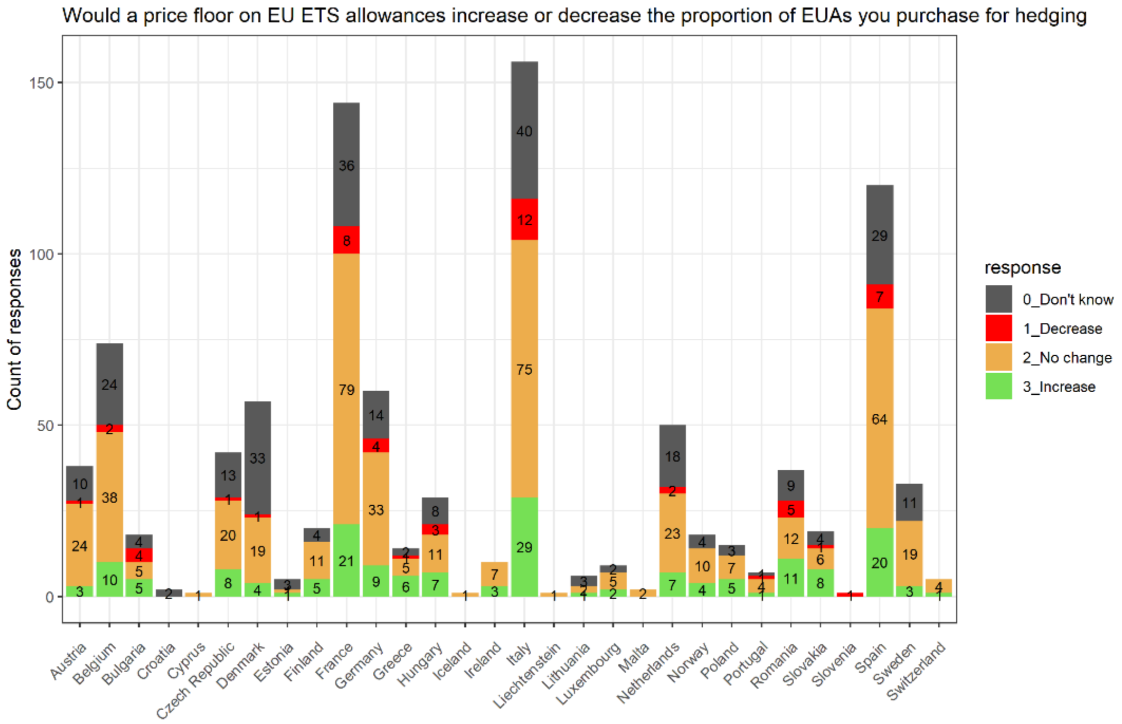


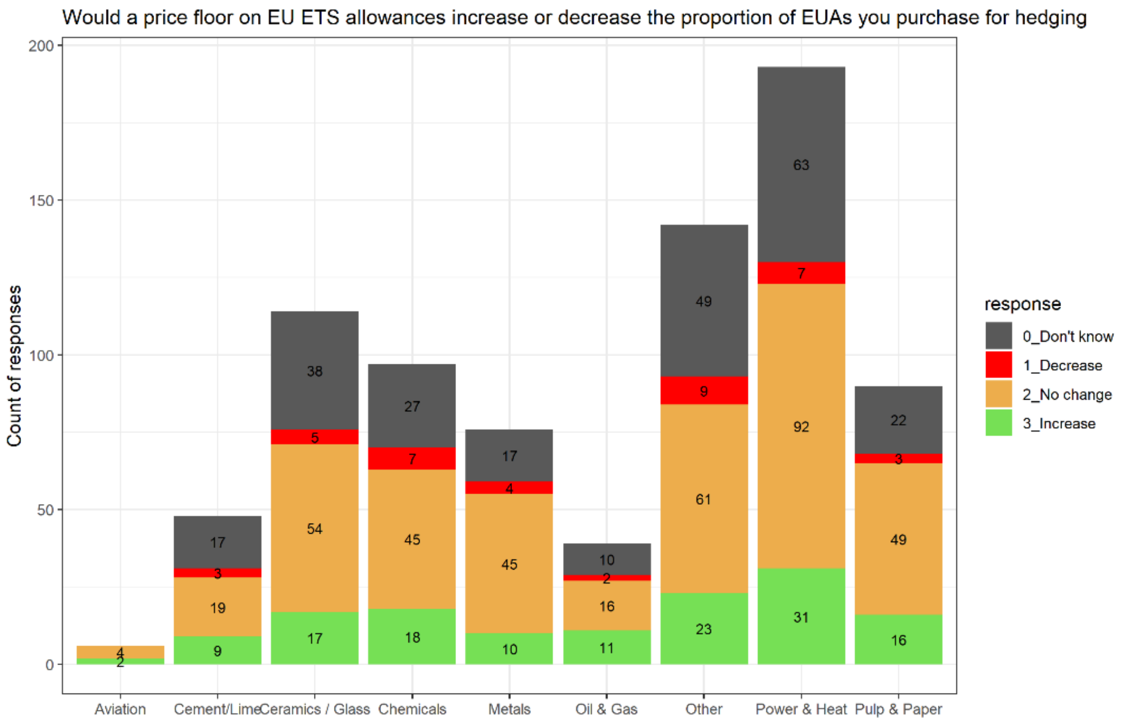
Source: Vivid Economics

8.2.17 Q17: Impact on hedging behaviour – price floor

Q17: Nearly a half of respondents would not change their hedging behaviour in response to a price floor, while 17% claim they would increase hedging and 5% would decrease hedging. A significant minority of 30% are unsure or unable to answer the question. Overall, it appears that a price floor would not meaningfully affect hedging demand. Similar patterns are observed across different countries and sectors. The results also partly reflect the uncertainty over the level of the price floor amongst survey respondents.

Figure 81 Survey response to Q17



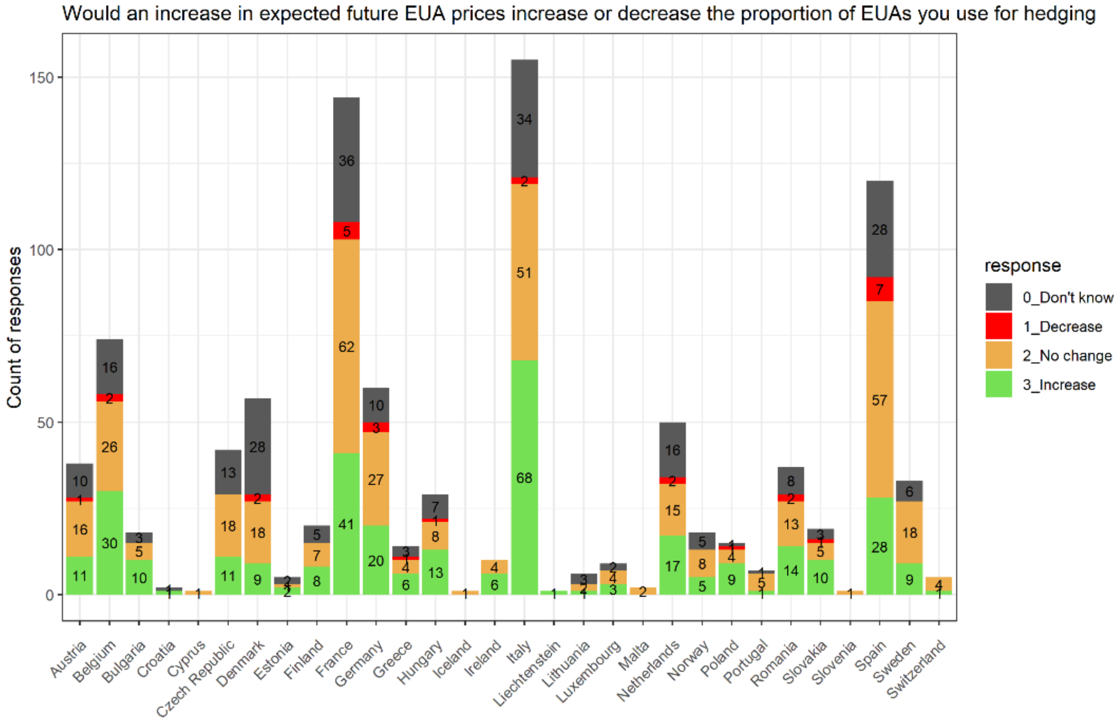


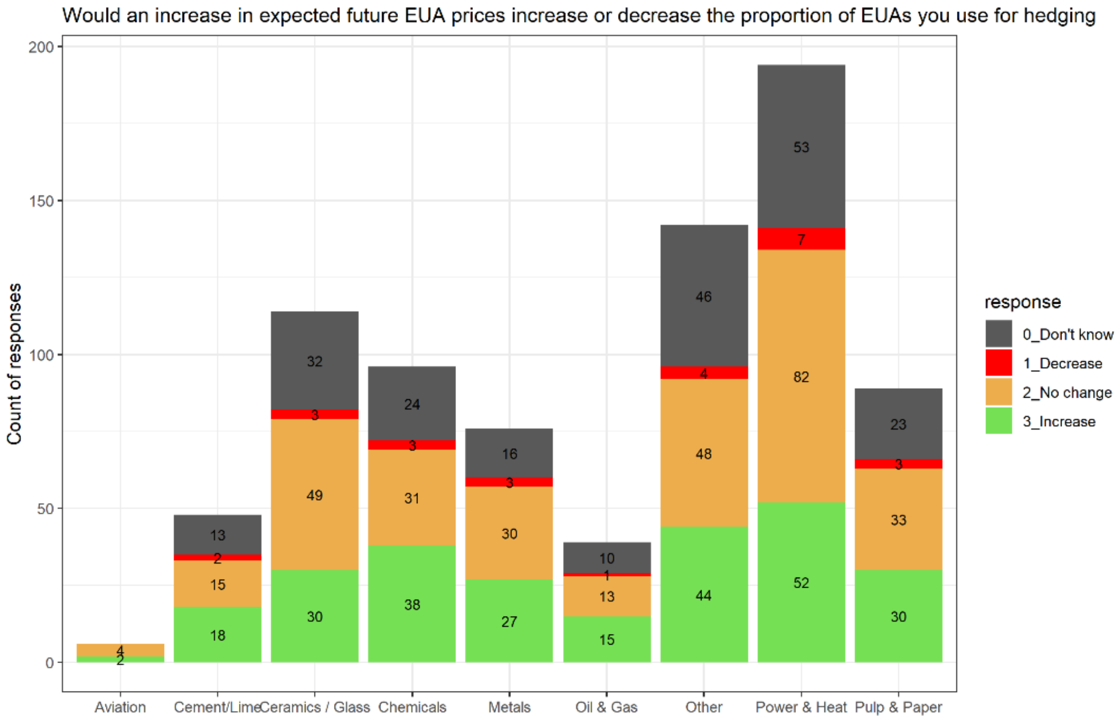
Source: Vivid Economics

8.2.18 Q17: Impact on hedging behaviour – higher price expectations

Q18: An increase in price expectations would increase hedging amongst 32% pf respondents, while 38% claimed that it would have no impact. Respondents from Bulgaria, Ireland, Poland, and Slovakia are more likely to respond that they would increase hedging. This is suggests that even though a majority of covered entities do not explicitly consider the MSR in their hedging behaviour, the MSR could still influence hedging indirectly through affecting broader price expectations.

Figure 82 Survey response to Q18





Source: Vivid Economics

9 Annex 4: Competitiveness and the MSR

9.1 Competitiveness in the EU ETS

This review considers the impact of the MSR on growth, jobs, the EU's industrial competitiveness and the risk of carbon leakage under Directive 2003/87/EC and Decision (EU) 2015/1814, Article 3 of the 2015 legislation establishing the MSR.

Competitiveness considers the potential impact on a range of factors that could affect a firm's performance.[141] Competitiveness is a key concern in the EU ETS where carbon pricing introduces changes to production costs that can impact the relative position of firms. In markets where international competition is high, firms are at risk of carbon leakage, where production, investments or other activities move to jurisdictions where carbon costs are lower. When there is no means of offsetting or equalising relative costs between regulated firms and competitors, carbon leakage can lead to a transfer of emissions outside of the EU's scope without reducing net global emissions.

The EU ETS impacts competitiveness by creating additional production costs associated with carbon liabilities that may be passed on to consumers. The costs each firm faces varies depending on parameters relating to the EU ETS like the allowance price and levels of free allocation, as well as on exogenous factors, for example abatement opportunities or market structure. Firms that are covered by the EU ETS will experience a change in their production costs to varying extents. In many cases, firms will be able to pass on some or all of these costs to consumers, which can in turn spur product substitution and behaviour changes towards lower-carbon alternatives – as the policy is intended to do. Higher EU allowance prices will increase compliance costs for regulated entities, which could reduce their competitiveness if they are unable to pass on the cost increase. Highly variable EU allowance prices reduces competitiveness through reducing the incentive and ability of regulated entities to plan and make investments.

Competitiveness impacts from the EU ETS are most likely for regulated entities producing carbon intensive goods that are traded on international markets. The risk of a loss in competitiveness is identified by the EU as most pronounced for firms that have both a large increase in costs because of the ETS (typically because they are emissions intensive), and who are unable to pass on this increase in costs (typically because of international competition). These industries are referred to as emissions-intensive, trade-exposed (EITE) industries. EITE industries are often producers of homogeneous goods, especially industrial commodities, who may rely on emissions-intensive manufacturing processes for which abatement options are limited or expensive. Their products are often traded on regional or international markets, so producers may not have a high degree of pricing power. Firms outside of the direct scope of the ETS may also be indirectly affected; they may face changes in production costs if, for example, they receive production inputs (e.g., electricity) from firms facing a carbon price.[142]

Changes in competitiveness creates a risk of carbon leakage, and potential impacts on growth and jobs. If international competitors do not need to comply with equally stringent carbon regulation, the carbon price creates a differential in production costs. As a result, domestic firms are competing in markets (through imports or exports) where foreign producers may not face an equivalent implicit or explicit carbon price. This potential loss of competitiveness can cause firms to reduce their production or investments into productive capacity, with implications for local growth and employment. The risk of carbon leakage occurs when a reduction in domestic production is replaced by more emissions intensive production in other jurisdictions. This is important to consider since it may appear that the carbon price has reduced emissions. However, if

[141] https://www.jstor.org/stable/25048725?seq=1
[142] If free allocation is provided to industries which can pass through costs it may lead to windfall profits for firms (assets rising more than liabilities)

production has simply moved to a jurisdiction with less stringent environmental regulation, emissions could fall in the European Economic Area but increase overall – a situation known as carbon leakage.

Carbon pricing can also motivate firms to innovate or change their conduct in a way that can be beneficial to their overall competitiveness. A price incentive can encourage firms to innovate, either in their production methods to reduce carbon and energy costs, or by offering low-carbon products and services to attract new sources of demand. Expenditure in research and development may increase in response to the increased incentives for carbon abatement, which may lead to breakthroughs that go beyond offsetting the carbon price.[143] Firms can also invest in capital, upgrading to more efficient technology and processes to reduce overall costs. Carbon pricing may stimulate demand in other sectors outside of industry, for example new sources of demand for marketing may arise to market green aspects of products.

Negative competitiveness impacts can be alleviated through a well-designed policy package that protects competitiveness, jobs, and economic growth. The EU ETS currently uses free allocation to reduce the risk of competitiveness impacts and carbon leakage for EITE sectors. In Phase 2 of the ETS, free allocation made up 90% of allowance allocation, which fell to 43% in Phase 3.[144,145] However, free allocation has remained high across phases for EITE sectors and this is expected to continue in Phase 4. Carbon border adjustments (CBAMs) represent an alternative policy for reducing the risk of competitiveness and carbon leakage impacts. The EU is currently considering the potential implementation of a CBAM as an alternative to free allocations. CBAMs have several benefits, including incentivising the adoption of carbon pricing in other jurisdictions and avoiding windfall profits. However, implementing a CBAM brings significant complexities, with the potential need to calculate different adjustments for each country and product in addition to designing exemptions and accounting for potential legal issues in its design.

Literature on the EU ETS has found limited evidence of carbon leakage in the initial ETS phases.[146, 147, 148] Joltreau and Sommerfeld (2017) estimate that competitiveness impacts in the first two phases of the EU ETS were minimal. They argue that large allowance over-allocation in the initial phases, combined with the ability of some sectors to pass costs onto consumers are the cause for the lack of competitiveness impacts. A European Commission impact assessment published in 2014 highlighted the surplus of allocation of free allowances in certain sectors in between 2008-2011.[149] If free allocation exceeds emissions, then net costs from the ETS are negative and decreasing with rises in the carbon price. Branger, Quirion, and Chevallier (2016) estimate there is no evidence of carbon leakage in steel and cement during Phases 1 and 2 of the EU ETS.[150] Many other factors like the cost of production capital, market access or the availability of labour are important for production decisions. In most cases, carbon liabilities are likely only a small component of the production and investment decision, meaning the risk of leakage is low. The relatively low importance of energy costs for EU industries may also limit the competitiveness impacts of the EU ETS. However, as discussed, the EU ETS has provisions to protect against carbon leakage risk, for example free allocation of allowances to EITE sectors and state aid for indirect costs. This, along with low EU allowance prices before 2018, may also help to explain why there has been limited evidence of leakage to date.

EU allowance prices have been relatively low in the periods studied, with carbon costs expected to increase going forward. Existing studies focus on early stages of the EU ETS, meaning the significant EU allowance price rises observed since early 2018 are not accounted for.[151] In the near to medium term, carbon leakage

[143] For example, van Leeuwen & Mohnen (2017) find evidence of increased innovation in response to environmental regulation in the Netherlands. https://www.tandfonline.com/doi/full/10.1080/10438599.2016.1202521
[144] https://ec.europa.eu/clima/policies/ets/pre2013_en
[145] https://ec.europa.eu/clima/policies/ets/allowances_en
[146] https://www.tandfonline.com/doi/full/10.1080/14693062.2018.1502145
https://www.tandfonline.com/doi/full/10.1080/14693062.2018.1502145#:~:text=Empirical%20literature%20on%20the%20EU,This%20reduced%20incentives%20for%20innovation.&text=Innovation%20effects%20have%20so%20far%20been%20small%20but%20positive.
[147] https://www.tandfonline.com/doi/abs/10.1080/14693062.2020.1805291
[148] https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3050323
[149] https://ec.europa.eu/clima/sites/clima/files/ets/reform/docs/swd_2014_50_en.pdf
[150] http://www.iaee.org/en/publications/ejarticle.aspx?id=2779
[151] https://onlinelibrary.wiley.com/doi/abs/10.1111/joes.12356

risks may increase as EU allowance prices are projected to increase faster than the EU's major trading partners in most cases, and free allocation could continue to decline. However, the introduction of a CBAM in this time period would likely reduce this risk. In the long term, with the potential for increasing proliferation of carbon pricing globally, the scope for transferring productive capacity closes; therefore, the risk of competitiveness impacts and leakage is reduced.

There is some evidence that the first two phases of the EU ETS supported moderate levels of additional innovation and investment.[152] Calel and Dechezleprêtre (2016) estimate that the EU ETS has increased innovation activity in low-carbon technologies by 30% for regulated entities compared to a control group.[153] Abrell, Ndoye and Zachmann (2011) found that the second phase of the EU ETS resulted in emission reduction when controlling for changes in output, indicating emission reductions achieved through means other than reducing output.[154] Petrick and Wagner (2014) found that German manufacturing firms reduced their emissions in response to the EU ETS between 2007 and 2010, investing in improving energy efficiency and by curbing the consumption of natural gas and petroleum products. They found no evidence of adverse impacts on employment, turnover or exports.[155] However, Wagner et al. (2014) found that while ETS regulated manufacturing in France reduced emissions significantly, they also reduced their employment by 7%.[156] Verde's (2020) recent review of the econometric evidence concludes that there is no decisive evidence on employment impacts from the EU ETS.[157]

9.2 Competitiveness and net carbon liabilities

Free allocation acts to reduce the average carbon price facilities face, reducing the cost impact of the EU ETS. Carbon liabilities vary significantly between and within sectors. This is particularly the case for industry's receiving free allocations, where relative liabilities can differ significantly between firms. Within the cement sector, for example, there is considerable variation at the facility level, as demonstrated in the histogram of allocation as a share of emissions over the period 2008-2019 for cement facilities in Figure 83.

152 https://www.tandfonline.com/doi/abs/10.1080/14693062.2020.1805291

153 http://eprints.lse.ac.uk/62723/1/__lse.ac.uk_storage_LIBRARY_Secondary_libfile_shared_repository_Content_Dechezlepretre,%20A_ENVIRONMENTAL%20POLICY%20AND%20DIRECTED%20TECHNOLOGICAL%20CHANGE_Dechezlpretre_ENVIRONMENTAL_POLICY_AND_DIRECTED_TECHNOLOGICAL_CHANGE.pdf

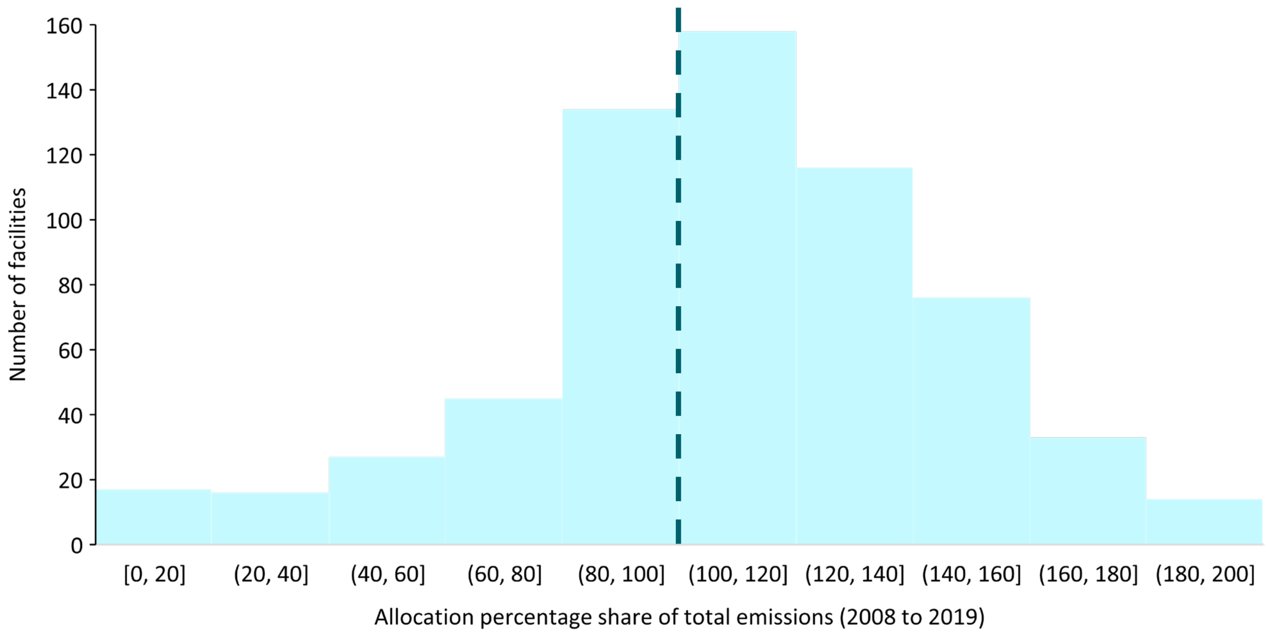
154 https://www.researchgate.net/publication/254454774_Assessing_the_impact_of_the_EU_ETS_using_firm_level_data

155 https://www.econstor.eu/bitstream/10419/94357/1/781557828.pdf

156 http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.642.888&rep=rep1&type=pdf

157 https://onlinelibrary.wiley.com/doi/abs/10.1111/joes.12356

Figure 83 There is considerable variation in cement's facility level allocation as a share of emissions



Source: ICIS, 2021, Compliance Database

The variation in the average carbon cost at the facility level is important for investment decisions. Impacts on competitiveness are felt at the facility level, the level at which investment decisions are made. Significant facility level net carbon liabilities within an EITE sector could indicate a risk of carbon leakage if suitable investments are not available. In Figure 83, the majority of facilities' allocation share is close to 100%, depicted by the dotted line, meaning emissions and allocation are broadly similar for the majority of firms. In this sense, free allocation provides sufficient protection against competitiveness impacts. Some facilities have an allocation share above 100%. The ETS provides allocation based on historical activity levels, meaning declines in heavy industry's output and emissions following the financial and Eurozone crisis were not initially reflected in allocation levels. Sufficient free allocation for the majority of facilities suggests they are less likely to face a loss in competitiveness and carbon leakage risk for any given carbon price.

Any MSR induced impact on competitiveness are likely to differ significantly by facility. EU allowance price increases are likely to benefit those that receive allowance allocations in excess of their total emissions, in Figure 83 these are facilities who are to the right of the dotted line. For these facilities, a rise in EU allowance prices would result in a greater rise in their assets than their liabilities. An EU allowance price rise would have detrimental impacts on those with free allocations less than their total emissions. Those to the left of the dotted line in Figure 83 would experience a greater rise in their liabilities than their assets. However, for most firms it is likely the MSR will have little effect given their free allocation and emissions are broadly matched. This means that the MSR may have a larger effect on intra-sectoral competition within the EU states than on competitiveness with external producers.

9.3 Methodology

FIMM+ is calibrated to 2018 emissions intensities and production according to the European Commission's specifications for modelling used to assess the impact of a CBAM. The model is based around the Cournot model of oligopoly, familiar to academic economists, and is conceptually similar to the qualitative Porter's Five Forces model, widely used in corporate strategy analysis. It is a partial equilibrium model, solved algebraically. The project for which FIMM+ was specified is assessing the role of energy taxation and prices for the clean energy transition in the context of sector integration and carbon border mechanisms. The model is set up to assess the impact from seven key EITE sectors: paper, refined petroleum, fertilisers, cement, steel, aluminium and other organic chemicals. The sectors are modelled for both the EU-27 and the rest of the world. The price rise starts from an EU allowance price of 19 EUR/tCO_2e. This starting EU allowance price reflects the average EU allowance price for 2018. The model provides annual results of key indicators of economic activity and competitiveness in five-year increments. The modelling results with and without an MSR induced price rise are compared for the year 2020.

Results of the analysis are discussed in Section 3 of the review.

10 Annex 5: Literature Review

10.1 Methodology

The objectives of this literature review are to present the views expressed in recent and relevant literature and, when appropriate, interpret these views to provide relevant context. The approach used in this literature review has been designed to assure transparency and structure. It outlines the reason to include or exclude (and the level of prioritisation of) a certain source to provide traceability. In addition, when presenting the findings, the sources are directly evident. This has been designed to achieve a well-structured approach to minimise the risk of overlooking potentially relevant documents.

The first step to bring structure into the review, was the introduction of four analytical blocks:

Block I: Looking backwards - impacts of the MSR until now;

Block II: Long term expectations – expected future impacts of the MSR on the EU-ETS;

Block III: Relation with increased climate ambition – the role of the MSR in the light of the EU's increased climate ambition & strengthening of the EU-ETS; and

Block IV: Cross-cutting issues – other impacts and findings relevant for other tasks.

The analytical blocks have been constructed based on the Terms of Reference (ToR), the preliminary research in the proposal and inception stage, and on discussions with the broader team on linkages between tasks. Whereas block I, II and III are mostly based on the ToR and preliminary research, block IV has been added at a later stage in order to serve other tasks better and to increase the efficiency and knowledge exchange within the project.

The second step was to categorise all identified research questions, i.e. attaching each question to an analytical block. The research questions have been identified using a similar process as the first step.

The third step was the finalisation of the list with potentially relevant publications. The list has been constructed by using the list with relevant publications from the proposal—including the relevant publications mentioned in the ToR—as a starting point. This list was complemented with literature identified by team members working on other tasks. Lastly, a search was performed to mitigate the risk of overlooking potentially relevant publications by using the specialised software Publish or Perish[158].

In Publish or Perish, the team performed a search on *title words* combined with *key words of publications*. Title words used in this search include *EU ETS, European Union Emission Trading System, MSR and Market Stability Reserve.* These were also keywords in case combinations of them yielded different results, in addition to the keywords *Impact, Structure and Effect*. All combinations between title words and keywords allowed us to identify and include relevant articles beyond those collected from the ToR and from team members.[159] Any literature that could be found via Publish or Perish using the same search criteria after 12 January 2021, is not taken into consideration.

The fourth step was to assess the reliability and relevance of all papers on the list. For this, the red/amber/green (RAG) rating was used. Table 16 shows how the reliability and relevance are assessed.

[158] For more information: https://harzing.com/resources/publish-or-perish

[159] As the keywords were defined in English, non-English publications were excluded from the search and thus the literature review.

Table 16 RAG rating: how to assess reliability and relevance

Criterion	Strong evidence	Medium evidence	Weak evidence
Reliability: How reliable is the evidence's methodology?	Reliable: E.g. literature is published in peer-reviewed journals	Indicative: E.g. grey literature that is judged to be relatively free from institutional bias	Unreliable: E.g. evidence is published by advocacy groups unless externally commissioned to neutral organisation
Relevance: How relevant is the evidence for the analysis	Relevant: The literature provides new insights directly relevant to the research questions.	Supporting evidence: The literature entails relevant information on certain aspects linked to the research question.	Irrelevant: The literature does not provide information that is useful towards answering the questions

Based on the assessment, a RAG-rating was generated for each publication following the assessment matrix, as shown in Table 17.

Table 17 RAG rating: interpretation rating codes

	Relevant	Supporting evidence	Irrelevant
Reliable	RR	RS	RI
Indicative	IR	IS	II
Unreliable	UR	US	UI

* (RR = Reliable + Relevant); (RS = Reliable + Supporting evidence); (RI = Reliable + Irrelevant); (IR = Indicative + Relevant); (IS= Indicative + Supporting evidence); (II = Indicative + Irrelevant); (UR = Unreliable + Relevant); (US = Unreliable + Supporting evidence); (UI = Unreliable = Irrelevant)

The RAG rating was used to bring focus in the literature review. In other words, in case a publication was rated reliable and relevant (RR), the publication has been analysed with more rigor compared to a publication which was rated unreliable and relevant (UR). In addition, studies that were found unreliable and supporting (US) and irrelevant and indicative (II) were also excluded. For each red rated publication (US, II and UI), a check was done on its summary and conclusions to confirm whether it is valid to exclude them from the full list for the literature review. For example, academic studies that only drew conclusions based on an MSR without an invalidation mechanism were deemed irrelevant and indicative and have therefore been excluded.

The fifth step was the actual performance of the literature review. For this, we used a structured approach, as shown in Table 18. As per this structure, each column refers to a specific research question (RQ), grouped in one of the four analytical blocks. Each row refers to a different publication. As part of the review process, the project team actively searched for input relevant to the specific research questions within the document being reviewed. In case a certain paper provided relevant input, the input was included in the corresponding cell. In addition, general notes and a summary of each publication was provided (unrelated to specific research questions). This structured review has had various advantages:

1) **Targeted review:** It enabled a proactive search for relevant input in the publications. As a result of this, the team was not only able to identify relevant input from very relevant (RR) papers), but also from supporting publications (RS).
2) **Gap analysis:** It allows for immediate (and visual) identification of information gaps. For this, the *overall assessment* row is used. In this row, one can isolate a specific research question and compile the input from various publications to that specific research question. Based on this, it can be assessed if sufficient information has been gathered to answer a certain research question, or whether an information gap is present.

3) **Workable tool:** It allows team members working on other tasks to easily identify the papers which are of relevance for a certain analytical block and research question. In addition, team members can directly see and use the input from a specific publication to research questions relevant for their tasks.

Table 18 Structure literature review

	Block I		Block II		Block III		Block IV	
Publication	RQ A	RQ B	RQ A	RQ B	RQ A	RQ B	RQ A	RQ B
1	Input 1 to RQ A							
2								
3								
…								
Overall assessment	Overall quality of input for RQ 1							

Note: RQ: research question

The sixth step was to check the findings from literature per overarching research question from the fifth step as quality assurance and break them down into more targeted research questions in line with the other tasks. This also allowed us to conduct a gap analysis to find on which topics literature is still limited and add these to the literature findings in the synthesis report. The main findings from literature were consolidated and presented in a backward-looking section and a forward-looking section.

The seventh step involved a review of the consolidated findings from the literature review by Professor Grischa Perino, an expert on the MSR. Following his review, additional literature sources were added, and findings were incorporated in the literature review. The final list of sources used for this literature review is provided in the next section.

10.1.1 Consulted literature sources

The following list of literature was reviewed. The list considers publications from academia, research institutions, think tanks and grey literature. Publicly available reports from market analysts and confidential market reports from ICIS were also consulted, but the limited information relevant for this literature review was found. Most reports were forward looking on EU allowance price projections with limited analysis focussed specifically on the MSR. The analyst reports that did contain potentially relevant information on the MSR were often outdated as these reports were published infrequently.

Table 19 List of reviewed literature and associated RAG score

#	Author	Title	Year	RAG score
1	Azarova and Mier	MSR under Exogenous Shock: The Case of Covid-19 Pandemic	2020	RR
2	Beck and Kruse-Andersen	Endogenizing the cap in a cap-and-trade system: Assessing the agreement on EU ETS phase 4	2020	RS
3	Bocklet and Hintermayer	How does the EU ETS reform impact allowance prices? The role of myopia, hedging requirements and the Hotelling rule.	2020	RS
4	Bocklet, Hintermayer, Schmidt and Wildgrubbe	The reformed EU ETS-intertemporal emission trading with restricted banking	2019	RS
5	Bruninx and Ovaere	Estimating the impact of COVID-19 on emissions and emission allowance prices under EU ETS	2020	RR

#	Author	Title	Year	RAG score
6	Bruninx, Ovaere and Delarue	The Long term Impact of the Market Stability Reserve on the EU Emission Trading System	2019a	RR
7	Bruninx, Ovaere, Gillingham and Delarue	The unintended consequences of the EU ETS invalidation policy	2019b	RR
8	Burke and Taschini	COVID-19, emissions trading and the implications for a future UK ETS	2020	IS
9	Chaton, Creti and Sanin	Assessing the implementation of the market stability reserve	2018	RS
10	European Commission - CLIMA	Report on the functioning of the European carbon market	2020	RS
11	European Environment Agency	The EU Emissions Trading System in 2019: trends and projections	2019	RS
12	Falcke and Madlener	Potential Impacts of the Planned Market Stability Reserve on Speculators' Behavior in the EU Emissions Trading System	2016	RI
13	Flues and Van Dender	Carbon pricing design: Effectiveness, efficiency and feasibility: An investment perspective	2020	RS/RI
14	Friedrich, Fries, Pahle and Edenhofer	Rules vs. Discretion in Cap-and-Trade Programs: Evidence from the EU Emission Trading System	2020	RR
15	Galdi, Verde, Borghesi, Füssler, Jamieson, Wimberger and Zhou	Emissions trading systems with different price control mechanisms: Implications for linking.	2020	RR
16	Gerlagh and Heijmans	Climate-conscious consumers and the buy, bank, burn program	2019	RR
17	Gerlagh, Heijmans and Rosendahl	COVID-19 tests the Market Stability Reserve	2020a	RR
18	Gerlagh, Heijmans and Rosendahl	An Endogenous Emission Cap Produces a Green Paradox	2020b	RR
19	Gilbert, Lam, Sachweh, Smith, Taschini and Kollenberg	Assessing design options for a Market Stability Reserve in the EU ETS	2014	RR
20	Graichen, Graichen and Healy	The role of the EU ETS in increasing EU climate ambition	2019	IS
21	Healy, Graichen, Nissen and Gores	Trends and projections in the EU ETS in 2019	2019	IR
22	Hepburn, Neuhoff, Acworth, Burtraw and Jotzo	The economics of the EU ETS market stability reserve	2016	RS
23	Holt and Schobe	Price and quantity "collars" for stabilizing emissions allowance prices: an experimental analysis of the EU ETS Market Stability Reserve	2015	RS
24	ICIS	The Market Stability Reserve (MSR) – How silver is the bullet?	2014	IS
25	ICIS	EU ETS Monthly Market Briefing - December 2020	2020	IS
26	Kollenberg and Taschini	Dynamic supply adjustment and banking under uncertainty in an emission trading scheme	2019	RS

#	Author	Title	Year	RAG score
27	Marcu, Caneill and Cecchetti	Preparing the review of the EU ETS Market Stability Reserve	2019a	IS
28	Marcu, Alberola, Caneill, Mazzoni, Schleicher, Vailles, Stoefs, Vangenechten and Cecchetti	2019 State of the EU ETS Report	2019b	RR
29	Marcu, Caneill and Vangenechten	Background Paper - The EU ETS Market Stability Reserve: Coping with Covid-19 and Preparing for the review	2020	IS
30	Matthes, Graichen, Gores and Fallasch	How to raise Europe's 2030 climate ambition: Implementing a - 55% target into the EU's policy architecture	2020	RS
31	Mauer, Okullo and Pahle	Evaluating the performance of the EU ETS MSR	2019	RR
32	Osorio, Tietjen, Pahle, Pietzcker and Edenhofer	Reviewing the Market Stability Reserve in light of more ambitious EU ETS emission targets	2020	IS
33	Pahle and Quemin	EU ETS: The Market Stability Reserve should focus on carbon prices, not allowance volumes	2020	IR
34	Perino	New EU ETS Phase 4 rules temporarily puncture waterbed	2018	RR
35	Perino	Reply: EU ETS and the waterbed effect	2019	RS
36	Perino, Ritz and Van Benthem	OVERLAPPING CLIMATE POLICIES	2020	RS
37	Perino and Willner	Procrastinating reform: The impact of the market stability reserve on the EU ETS	2016	RS
38	Perino and Willner	EU-ETS Phase IV: allowance prices, design choices and the market stability reserve	2017	RR
39	Quemin	Using Supply-Side Policies to Raise Ambition: The Case of the EU ETS and the 2021 Review	2020	RS/RI
40	Quemin and Trotignon	Preparing the 2021 EU ETS MSR review and the road to greater EU climate ambition	2019a	RS
41	Quemin and Trotignon	Emissions trading with rolling horizons.	2019b	RS
42	Rosendahl	EU ETS and the waterbed effect	2019	IR
43	Ruf and Mazzoni	THE EUROPEAN CARBON MARKET: THE IMPACT OF HIGHER CARBON PRICES ON UTILITIES AND INDUSTRIES	2019	IR
44	Schmidt	Puncturing the Waterbed or the New Green Paradox? The Effectiveness of Overlapping Policies in the EU ETS under Perfect Foresight and Myopia	2020	RR
45	Schopp and Neuhoff	The Role of Hedging in Carbon Markets	2013	RS/RI
46	Tietjen, Lessmann and Pahle	Hedging and temporal permit issuances in cap-and-trade programs: the Market Stability Reserve under risk aversion	2020	RR
47	Vivid Economics	Study on Market Stability Mechanisms. Design, operation and implications for the linking of emissions trading systems	2020	IR
48	Vollebergh and Brink	What can we learn from EU ETS?	2020	RR

10.2 Findings

10.2.1 Has the MSR helped in addressing supply and demand imbalances so far?

Literature suggests that there is consensus that to date the MSR has helped to balance supply and demand of emission allowances, and reduced the surplus in the market. European Commission (2020) note that the drop of the total number of allowances in circulation (TNAC) in 2019 was primarily due to the MSR. This is supported by recent studies. Graichen et al. (2019) share the observation that the MSR is currently absorbing allowances from the market and the reduced auctioning volumes are driving down the surplus. Combined with the invalidation of allowances in the MSR in 2023, they note that the inherited surplus from the second trading period will be eliminated and argue that the MSR is the most important element for stabilising the EU ETS market in the short term. Pahle and Quemin (2020) also conclude that one of the objectives of the MSR to reduce past supply-demand imbalances may be deemed attainable. This conclusion is supported by model simulations from Bruninx et al. (2019a) and Beck and Kruse-Andersen (2020) that show the MSR is effectively absorbing the surplus. This echoes the findings from Marcu et al. (2020) that many stakeholders consider the MSR doing its job to balance the allowance market.

10.2.2 What has been the effect of the MSR on allowance prices so far?

Some studies support the notion that the structure of the MSR has reinforced the market belief in the future scarcity of allowances—resulting in higher EU allowance prices—while others dispute the extent to which the price increase was driven by the MSR. Marcu et al. (2020) argue that price formation is due to the anticipation in the market of future scarcity rather than present scarcity. Since the future supply of allowances is determined by regulation, Gerlagh et al. (2020a) note that one of the key drivers of prices in the EU ETS are expectations about future regulation. Many studies (e.g., Healy et al., 2019; Marcu et al., 2020) observed that since the process of introducing the MSR and the political agreement to reform the MSR for the fourth EU ETS trading period has started, the EU allowance price has been steadily increasing despite the presence of a large surplus of supply. Vollenberg and Brink (2020) suggest that this indicates that the MSR has been able to support the market belief that scarcity will increase in future. This corresponds with the view of Pahle and Quemin (2020), which agree that the run-up of prices was driven by anticipated MSR supply-reducing impacts in the future. Friedrich et al. (2020) share these conclusions and note that the substantial EU allowance price increases that began in March 2018 coincided with the month the EU ETS reform with a strengthened MSR with invalidation mechanism were passed into law. Ruf and Mazzoni (2019)—market analysts—have similar observations and further add that, since mid-2017, financial market actors have become active on the EU ETS market, leading to additional demand for allowances. However, Bocklet and Hintermayer (2020) argue that the price increase over the past years cannot be explained by a specific element of the MSR or ETS reform, but only in combination with myopia and hedging requirements of market actors. This is supported by model simulations from Bocklet et al. (2019) and Beck and Kruse-Andersen (2020) that find only a small proportion of the price increase can be related to the MSR. Future prices remain uncertain as they strongly depend on the belief of market actors about these prices market imperfections such as regulatory uncertainty and hedging requirements (Pahle and Quemin, 2020; Bocklet et al. 2019).

10.2.3 How has the MSR responded to market shocks to date?

While EU allowance prices have been resilient against recent market shocks— including the impacts of COVID-19, studies do not agree on the relative contribution of the MSR. Following an initial drop after COVID-19 restrictions came into force in March 2020, the EU allowance price quickly recovered and has remained well above EUR20/tCO_2e since mid-May and into 2021. Observations from Marcu et al. (2020) find that the general sentiment among market stakeholders was that the MSR was mainly or partly responsible for this price resilience. Gerlagh et al. (2020a) agree that the development of the EAU price since the COVID-19 restrictions indicated that MSR has increased the resilience of the EU ETS market to shocks. The authors note that the drop in demand induced by the COVID-19 pandemic exceeds that resulting from the 2008 financial crisis. However, EU allowance prices fell less in 2020 than in 2009 and recovered swiftly. Accompanied by their model simulations, they therefore conclude that the MSR works well in stabilising the market against short-lived demand shocks as it was designed. However, if the market anticipates that the repercussions of the pandemic would be long lasting and the future allowance demand would decrease as much as present demand, the authors find that MSR would be ineffective. This is in contrast with the results from Azarova and Mier (2020). They not only conclude that the MSR is an effective instrument to deal with an exogenous shock, such as the COVID-19 pandemic, but also that the MSR performs better under more severe and longer lasting impacts of the pandemic as more allowances would be invalidated. They explain this through the reinforced invalidation mechanism—allowances moving into the MSR lowering the auction volume of the following year, which increases the likelihood of allowances being invalidated as the invalidation threshold (auctioned allowances of the previous year) is lowered. In a profound recession scenario, the surplus would grow more than in a fast recovery scenario, resulting in the MSR absorbing more allowances and lowering the cancelling threshold. The authors recognise that small adjustments fundamentally change the dynamics of the MSR, to which they attribute the difference compared to the study of Gerlagh et al. (2020a). Other studies indicate that EU allowance price resilience may relate to the market belief of future scarcity as Gerlagh et al. (2020a) points out. For example, Bruninx and Overae (2020) also simulated the impact of COVID-19 on allowance prices and found that a negative demand shock should have a very limited effect due to the MSR. They further conclude that the initial drop of the EU allowance price of the COVID-19 restrictions was not due to the immediate demand shock, but to changes in the belief of market participants of the future allowance market. Pahle and Quemin (2020) therefore argue that the limited price impacts from the COVID-19 crisis are driven by the anticipation of higher ambition targets rather than the presence of the MSR.

10.2.4 What has been the MSR’s impact on price volatility?

Forward-looking studies argue that the MSR increases price volatility, but findings from recent empirical studies on the price volatility thus far indicate the contrary. Various studies have expressed concerns that the MSR might increase price volatility and price uncertainty (e.g., Gilbert et al., 2014; Falcke and Madlener, 2016; Perino and Willner, 2016). Mauer et al. (2019) explain that the MSR might increase rather than decrease price volatility for three reasons: 1) it shortens the allowance banking regime, inhibiting firms’ capacity to reduce and smooth their compliance costs through banking activities, 2) the MSR is triggered with a lag, meaning that it cannot immediately offset a demand or supply imbalance, and 3) the MSR has a fixed outtake rate and is therefore incapable of fully offsetting a demand imbalance. In addition, Flues and Van Dender (2020) argue that the MSR—in isolation—increases price volatility in the market as the quantity of emission allowances in circulation does not provide a clear indication about future price levels. However, no evidence in literature or market analyst reports was found to suggest that price volatility has increased since the MSR was adopted. On the contrary, the studies on the impacts of COVID-19 on the EU allowance price seem to indicate that the MSR has had a positive influence so far in reducing price volatility as intended (Bruninx and Overae, 2020; Azarova and Mier, 2020; Gerlagh et al., 2020a).

10.2.5 How does the MSR change the interaction of the EU ETS with other climate and energy policies?

Literature on the impact of the MSR on the interaction of the EU ETS with other climate and energy policies have so far been limited to theoretical discussions. This includes arguments suggesting that climate policies overlapping with the EU ETS would not having any additional impact on the overall emission reductions in the EU ETS in the long term due to the waterbed effect, even with the MSR in place, as allowances are eventually returned to the market (Perino and Willner, 2016; Perino, 2018). However, Azarova and Mier (2020) highlight that since the introduction of the invalidation mechanism in the MSR, a discussion among academics has started whether the latest form of the MSR will temporarily puncture the waterbed effect[160] or, on the other hand, could eventually lead to an increase of emissions in the long term. Perino (2018) argues that, given the large surplus in the market, the MSR will contain sufficient allowances to be invalidated; any additional allowances placed in the MSR will therefore also be invalidated. Climate and

[160] Puncturing the waterbed effect refers to the MSR absorbing and invalidating additional surplus of allowances resulting from other climate and energy policies, leading to additional emission reductions under the EU ETS.

energy policies that lead to additional emission reductions will therefore lower the demand for allowances, increasing the surplus on the market. This results in more allowances being put into the MSR that will be invalidated. Since cancelling allowances effectively lowers the overall cap, the waterbed effect is considered punctured. This effect decreases the closer the TNAC comes to MSR intake threshold of 833 million. However, Rosendahl (2019) argues that this claim is incomplete since abatement efforts today will reduce the demand for EU allowances both today and in the future. If market participants expect the demand for allowances to be lower due to additional emission reductions from other policies, this would lead to a drop in the EU allowance price, resulting in higher emissions in the short term, also known as the green paradox. This, in turn, lower the TNAC and thus the number of allowances being absorbed into the MSR and invalidated. Rosendahl (2019) further argues that while many abatement efforts are announced today, they will only take effect in the future. In the case where abatement takes effect mainly in the future when the MSR has stopped taking in EU allowances, it will decrease the demand for allowances and thus their price. This makes it cheaper to emit and could lead to higher emissions in the long run. Further studies from Bruninx et al. (2019b), Gerlagh et al. (2020a), Schmidt (2020) and Perino et al. (2020) show that ultimately, the impact of overlapping policies on the overall emissions in the EU ETS varies per policy depending on timing of implementation, type of abatement options targeted and the magnitude of impact the overlapping policy has. Flues and Van Dender (2020) also highlight that the effect of accompanying policies on the carbon price level and emissions in an ETS with an MSR is complex. It differs depending on whether accompanying policies lead to an immediate shift of emissions between emitters regulated under the ETS, or whether accompanying levels trigger an accumulation of allowances in circulation over time. Given the complex interaction of the EU ETS with overlapping policies and invalidations only taking place from 2024, no empirical literature was found on the actual impact of the MSR on the interaction with other climate and energy policies.

10.2.6 What has been the impact of the MSR on competitiveness?

The impact of the MSR in other ETS areas such as competitiveness and low-carbon investments is not yet evident in literature. Various studies provide suggestions to assess the wider impacts of the MSR. Pahle and Quemin (2020) indicate that measuring the MSR impacts on firms' behaviours and investments would be a most valuable indicator beyond merely looking at the EU allowance price and surplus. Marcu et al. (2019a) note that any assessment of the MSR impact on competitiveness will need to combine qualitative and quantitative considerations, to fully appreciate the multifaceted nature of the relationship between the EU ETS and economic activities. As indicators, the authors suggest the impact of the MSR on direct and indirect costs, the change in auction revenues for Member States caused by the MSR functioning and the implications of the MSR functioning on the innovation and modernisation funds. Gilbert et al. (2014) mention investments in low-carbon measures in the EU ETS compliance sectors or the number of new low-carbon patents as potential indicators of success. However, literature on indicators of the MSR beyond the surplus and EU allowance price to assess its impact on competitiveness, investment and low-carbon patents appear to be lacking. Marcu et al. (2019a) suggest that any wider impacts on the MSR on for instance low-carbon investments may only be noticeable in the coming years, since the average time for business to take investment decisions— for the purpose of final investment decisions towards low-carbon projects—is in the range of 3 to 5 years. The authors reaffirmed this in various stakeholder discussions, where several stakeholders noted that they believe the MSR review in 2021 comes too early as the MSR does not have enough of a track record to undertake a fact-based analysis as there is only one observation of the TNAC per year. The authors also note that, however, it will be virtually impossible to completely insulate the effects that the MSR has on the competitiveness of EU ETS sectors. Other factors will always come into play such as the overall EU-wide macroeconomic situation, country-specific economic trends, sector-level economic cycles and international trade issues (Marcu et al., 2019a).

10.2.7 What are the expectations of the MSR's current design for the future (in reducing surplus, stabilising price fluctuations, and responding to shocks)?

Studies forecast that the MSR will continue absorbing allowances for at least the next 2 years but are not in agreement on the surplus development towards 2030, or the associated impact of COVID-19. Pre-COVID projections such as from the European Environment Agency (2019) estimates that the TNAC could be under the intake threshold from 2022 onwards and, therefore, no further allowances would be added to the MSR from 2024 onwards. They further estimate that the current surplus will decline during the fourth trading period but remain above the outtake threshold until 2030. On the other hand, Marcu et al. (2020) observe that most market analysts such as Ruf and Mazzoni (2019) expect that from 2024 onwards—when the intake rate is 12%— the TNAC will rise significantly by 2030. Furthermore, Marcu et al. (2019b) conclude, based on pre-COVID projections from various studies, that current design of the MSR will not be able to absorb surpluses from new sources of imbalance which might emerge during Phase 4 of the EU ETS. However, these forecasts were not only made pre-COVID, but also under the premises of the current form of the EU ETS, i.e., prior to the introduction of the European Green Deal and the revised 2030 emission reduction target of -55%. However, the recent study by Azarova and Mier (2020) find that the impact of the COVID-19 does not lead to significant changes to the overall trend of the surplus. They also find that the length of the COVID-19 restrictions impact affects the magnitude of allowances being absorbed and subsequently invalidated due to the reinforced invalidation mechanism. The other recent study that considers the impact of COVID-19 on the allowances in the MSR by Gerlagh et al. (2020a), shows the reverse effect with more allowances being invalidated in the MSR under persistent and large reductions of demand. However, the authors recognise that they may underestimate the cancelling of EU allowances in the persistent scenarios as their model assumes market participants have perfect foresight until 2050. Generally, the impact on future TNAC and total invalidations is very sensitive to model parameterisations (Bruninx et al. 2020; Perino, 2019).

Studies find that EU allowance prices are likely to rise on the short term, but that the MSR's current design has made EU allowance price levels and fluctuations on the long term harder to predict. Marcu et al. (2019b) show that pre-COVID forecasts by most analyst show EU allowance prices climbing as the date for the invalidation mechanism of the MSR gets closer. Pre-COVID research from Vivid Economics (2020) further finds that market analysts expect a significant quantity of EU allowances to be invalidated from the MSR after 2023—which will reduce the long term impact of allowance oversupply. This in turn contributes to raising EU allowance prices, with analyst forecasts reaching EUR35–40/tCO_2e over 2019–2023. Price forecasts are influenced by many different factors though beyond the MSR including the ETS cap, fuel switching prices, trading position of market actors, speculative behaviour, implementation of the European Green Deal and COVID-19 impacts (ICIS Analytics, 2020), making it extremely difficult to directly attribute any price developments to the MSR. In addition, there seems to be a large uncertainty on future developments of these factors, including the number of allowances that will be invalidated in 2023 and thereafter (Bruninx et al., 2020). Vollebergh and Brink (2020) find that studies estimate the volumes that the MSR will invalidate range from 2 billion to 16 billion EU allowances over a modelling horizon up to 2060 (Bruninx et al., 2019a). Vivid Economics (2020) finds a range from literature between 1.7 to 3.5 billion by 2030 and indicates that the volume of invalidation depends on the foresight of market participants, future demand shocks and abatement technologies scenarios. In addition, Tietjen et al. (2020) suggest that hedging behaviour of market participants also influenced invalidation volumes as a higher hedging demand leads to a higher surplus, which in turn increases the allowances to be absorbed into the MSR for invalidation. Friedrich et al. (2020) therefore argue that the MSR has a negative impact on the stability of the EU ETS as its impact on prices is complex and hard to predict, which translates to an increase in price uncertainty in the years that invalidation is looming. The authors conclude that this increased price uncertainty makes further intervention in the EU ETS more likely, adding to price uncertainty. Mauer et al. (2019) make a similar argument, noting that invalidation may lead to commitment and credibility problems, as regulators may later have to un-invalidate allowances to contain price escalations. On the other hand, Kollenberg and Taschini (2019) support the decision for regular invalidation of excess allowances from a financial market perspective. They support the notion that invalidations may lead to higher price variability in the short run. However, they argue that (the anticipation of) a permanent invalidation of part of the MSR will, at the very least, lower the risk associated with purchasing allowances as an investment; fewer allowances in the MSR mean fewer allowances that can flow back into the market in the future and depress prices. Accordingly, this will lead to higher carbon prices in the short run as the probability of future scarcity has increased. Based on literature, Vivid Economics (2020) comes to similar conclusions from a firm's perspective, noting that the MSR is expected to lower the risk associated with low-carbon investment by increasing prices on the short term and reducing future price uncertainty.

Many studies doubt whether the MSR is adequately equipped to deal with future shocks and respond sufficiently quickly, especially shocks that fundamentally alter market price expectations. The recent study of Azarova and Mier (2020) concludes that the reinforced invalidation mechanism led to the MSR being an effective instrument to deal with an exogenous shock, especially more severe and longer lasting shocks. This conclusion is under the premises of intertemporal optimized handling of the surplus by market participants, meaning that the study assumes the surplus is being used if the cost of abatement of additional emissions is higher than the modelled carbon prices. However, Pahle and Quemin (2020) argue that the surplus is a dynamic metric, with multifaceted interactions with firms' strategies in complex ways. This is because the surplus in the market is used for a variety of purposes, with hedging by utilities, banking by manufacturing industry and speculation being the main ones (Schopp and Neuhoff, 2013; Gilbert et al., 2014). Gilbert et al. (2014) note that hedging demand is dynamic and varies depending on EU ETS design parameters—including MSR parameters—and wider energy and climate policy developments. These include decreasing free allowances to industrial firms, increase in renewable energy and energy efficiency developments and changes power market structures. Tietjen et al. (2020) further note that carbon price uncertainty—which literature finds the MSR could exacerbate (Friedrich et al., 2020; Mauer et al., 2019)—influences hedging demand. This means that changes towards the surplus, especially in combination with invalidation, could change the market belief on future scarcity and thus prices, which in turn alters the behaviour of market participants (Chaton et al., 2018; Osorio et al., 2020; Schopp and Neuhoff, 2013). As the MSR intake and outtake thresholds are static and based the notion of a hedging corridor as the starting point, the thresholds may not be adequately reflective of demand shocks as they occur (Gilbert et al., 2014; Pahle and Quemin, 2020). In addition, Burke and Taschini (2020) argue that the MSR will not be able to make the EU ETS fully responsive to external shocks. The authors substantiate this by noting that the effect on the allowance supply is delayed, with intakes calculated each May based on the previous calendar, and with corresponding monthly sums to then be withdrawn from MS auctions over the 12 months starting in the following September. This is supported by Mauer et al. (2019), which argues that since the MSR is triggered with a lag and has an inflexible outtake rate, the MSR fails to respond to immediate imbalances between demand and supply of allowances. To what degree this lag will lead to a market imbalance and price volatility will depend on the market belief on the impact of the shock on future scarcity (Marcu et al., 2020; Gerlagh et al. 2020).

10.2.8 What changes are required to the MSR to increase performance?

Literature shows that adjusting the intake rate and threshold could increase its impact but warns for unintended effects if these adjustments are not considered in a holistic manner. The main options for increasing the performance of the MSR in its current design are lowering the TNAC threshold for allowances to be moved to and from the MSR and increasing the intake rate (Graichen et al., 2019). As the EU energy mix changes and renewable energy penetration grows, hedging strategies of industrial and power companies will also change (Marcu et al., 2019a). Graichen et al. (2019) argue that as the hedging needs decline, the intake threshold of the MSR should be adjusted accordingly. However, modelling results from Quemin (2020) and Graichen et al. (2019) show that lowering the threshold only has a limited impact on the surplus and invalidated allowances. They attribute this to the limited intake rate of the MSR in relation to the significant surplus on the market. This is echoed by Marcu et al. (2020), who note that after the intake rate reduces from 24% to 12% in 2024, projections from market analyst show that the TNAC starts increasing again. This suggests that increasing the intake rate could be an effective way to strengthen the MSR. Modelling results from Graichen et al. (2019) support this notion and found that a higher intake rate is the main driver for avoiding increases in the surplus again and for ensuring that allowances are invalidated. However, Osorio et al. (2020) and Quemin (2020) warn that an increase in the intake rate without adjustments to the intake threshold may lead to the TNAC oscillating around the threshold. This results in the MSR alternating between years with absorbing allowances from auctions and without. Since the number of allowances invalidated from the MSR are linked to the auction volume of the previous year, the studies show that the oscillations would lead to less frequent invalidations but with larger volumes. While ultimately there is little impact on the cumulative invalidations over time, these fluctuations could lead to increased price volatility (Osorio et al., 2020; Quemin, 2020). Quemin (2020) also shows that not only could price volatility be decreased if the intake threshold is lowered at the same time, but it will also lead to more invalidation of allowances. Lowering the threshold would extend the intake period, which lowers the probability for oscillations to occur. The extended intake period would then in turn also change the dynamics between overlapping policies and MSR invalidations regarding the punctured waterbed effect and green paradox (Perino, 2019). This shows the importance of considering the options for strengthening the MSR in its current design together, rather than evaluating each option individually. This is reaffirmed by Graichen et al. (2019), who also find that combining a higher intake rate with a lower intake threshold leads to a much lower TNAC and more invalidation than the impact of the options separately.

Studies also suggests opportunities to increase the impact of the MSR invalidation mechanism. For example, Graichen et al. (2020) suggest establishing a sunset clause for allowances in the MSR based on the length of time since they have been moved into the reserve. Flues and Van Dender (2020) observe two types of market behaviour that could already increase the impact of the invalidation mechanism in its current form. The allowance cancelation feature of the MSR generates a multiplier effect for voluntary allowance invalidations. By holding onto allowances for several years instead of directly cancelling them, they count in the calculation of the TNAC and increases the chances of the MSR absorbing more allowances. This in turn increases the chances for the invalidation mechanism to be triggered and renders the TNAC a less reliable metric to assess the market balance. On the other hand, if allowances are immediately cancelled upon purchase, the impact would be counteracted by the MSR as the TNAC would be smaller (Gerlagh and Heijmans, 2019). Strategic investors could also use the invalidation feature in attempts to reduce the cap permanently in order to drive up EU allowance prices by holding onto these allowances (Flues and Van Dender, 2020).

10.2.9 What changes are required to the MSR in light of policy changes and increased ambition (e.g., changes to the LRF.)?

Studies show that the degree to which the MSR needs to be adjusted considering the EU's increased climate ambition will depend on other aspects of EU ETS design, in particular the linear reduction factor (LRF). According to Marcu et al. (2019a), the reforms to the EU ETS cap and/or LRF directly impacts the performance of the MSR and thus its role in broader policy. The MSR will play less of a direct role to incentivise abatement under a stronger EU climate and energy policy package compared to if policies remain largely unchanged (Marcu et al., 2020). In the latter case, measures such as increasing the intake MSR rates will become more important for meeting enhanced emission reduction targets. However, Osorio et al. (2020) warn that the MSR is currently not likely to function effectively for the full range of potential emission targets. The (unpredictable) expectations of market actors about future carbon prices and costs will—via the invalidation mechanism of the MSR—influence allowance supply. Market participants expecting higher future carbon prices due to a decreasing supply of allowances will bank allowances, resulting in a larger TNAC. This will in increases invalidations and thus increases carbon prices (Bruninx et al. 2019b). Various studies therefore argue that the MSR should not be considered as substitutes for the LRF, but as complementary measures (Graichen et al., 2019; Osorio et al., 2020; Quemin, 2020; Quemin and Trotignon, 2019). Osorio et al. (2020) show this by simulating the interaction between the invalidation of allowances in the MSR and LRF. An increased LRF has a direct effect, lowering the invalidation threshold as auction volumes decrease. It also has an indirect effect by increasing future scarcity, leading to higher carbon prices and thus increased abatement, which in turns lower demand for allowances and increases the surplus to be absorbed into the MSR and invalidated. The study finds that if the LRF increases too much, the invalidation of allowances starts to decrease again as the lower supply simply results in fewer allowances being invalidated. In addition, the authors note that the number of invalidated allowances also depend on market actors' time horizons and discount rates, as well as their expectations about the future costs of abatement. Bruninx et al. (2019b) reach similar conclusions and find that the impact of the MSR in the future is highly dependent on other MSR parameters especially the LRF, other policies—such as renewable energy targets and fossil fuel phase-outs—and the cost development of abatement options. This corresponds to the views of market analysts Ruf and Mazzoni (2019), who note that due to other policies, a part of the necessary investments for emission reductions will happen independently of the EU allowance price development. However, the EU allowance prices will determine when and how quickly these new investments take place as higher carbon prices will lead to a higher rate of return for these investments (Ruf and Mazzoni, 2019). Graichen et al. (2019) further show that all measures targeting the supply of allowances such as cap adjustment, MSR and unilateral invalidation reinforce each other. However, Matthes et al. (2020) caution that the interaction between the LRF and MSR should also consider the impact of the EU ETS to the overall compliance with the EU's Paris Agreement target. The MSR could change the achievement of this target if the MSR releases a significant quantity of allowances back to the market as these would lead to an increase of emissions. However, the authors acknowledge that against the background of the recent surplus, the fundamental changes in the European electricity market, the implications for hedging demand and the emerging adjustment of the MSR provisions, it seems unlikely that such a release will take place. Other developments that could require adjustments to the MSR include linking (Vivid Economics, 2020), for instance with the new UK ETS or other emissions trading systems around the world, but no literature was found on the potential changes needed specific to the MSR.

10.2.10 What wider changes to the MSR are proposed (e.g., replacing with a price-based stability mechanism)?

The literature's suggestions on wider changes to strengthen the operation of the MSR are centred around measures to increase price certainty. Friedrich et al. (2020) argue that the greater extent to which the effect of policy interventions—such as the MSR—on prices can be predicted, the lower the risk that they destabilise the market. Osorio et al. (2020) and Pahle and Quemin (2020) suggest that an MSR reform should go beyond adjusting existing MSR parameters as there is a need for regulatory certainty rather than price-correcting interventions in the future. They argue that regulatory complexity should be avoided as it impacts speculation and regulatory uncertainty, which both result in price volatility and uncertainty, and in turn can destabilise markets. They suggest changing triggers for the intake and outtake of allowances from quantity-based thresholds to price-based thresholds, changing the MSR into a price stability reserve. The price-based triggers would essentially serve as a price collar or price corridor, which is what various studies have proposed to lower price volatility, increase price transparency and support long run cost minimization (e.g., Hold and Schobe, 2015; Hepburn et al., 2016; Vollebergh and Brink, 2020). Instead of adjusting the MSR parameters, a price corridor could also be introduced as an additional supply-side policy (Quemin, 2020). Perino et al. (2020) and Gerlagh et al. (2020) further argue that a price-based adjustment of the allowance supply would provide policy makers greater control over the interaction between the EU ETS and other climate and energy policies to avoid unintended impacts such as the green paradox. Furthermore, replacing the TNAC-based design with a price-based design could facilitate linking with other emissions trading systems (Galdi et al. 2020) and would increase price predictability (Perino, 2018). However, Gilbert et al. (2014) caution that any additional price-based measure in the EU ETS needs to be designed carefully. Setting the wrong price levels could lead to firms deviating from their cost-optimal pathway to reduce emissions. In addition, price-based measures could create arbitrage opportunities, especially in certain cases of a rising price floor (Gilbert et al., 2014).

Company profile

Vivid Economics is a leading strategic economics consultancy with global reach. We strive to create lasting value for our clients, both in government and the private sector, and for society at large.

We are a premier consultant in the policy-commerce interface and resource- and environment-intensive sectors, where we advise on the most critical and complex policy and commercial questions facing clients around the world. The success we bring to our clients reflects a strong partnership culture, solid foundation of skills and analytical assets, and close cooperation with a large network of contacts across key organisations.

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