ECOFYS

sustainable energy for everyone

Assessing design options for a market stability reserve in the EU ETS

Assessing design options for a market stability reserve in the EU ETS

By: Alyssa Gilbert, Long Lam, Cathrine Sachweh, Matthew Smith (Ecofys)
Dr. Luca Taschini and Sascha Kollenberg

Date: 10 November 2014

Contract Reference No. TRN 726/12/2013
Ecofys Project No. MARUK14551

Disclaimer

The views expressed in this report are those of the authors, not necessarily those of the Department of Energy and Climate Change and do not reflect Government policy.

This report included discussions with stakeholders, but these discussions did not constitute a comprehensive consultation process and as such the stakeholder views should be considered a non-representative sample.

The model used in this report allows the users to test different mechanisms (different types of market stability reserves – MSRs), checking their "correcting" performance and assessing how these different MSRs address the excessive market imbalance. As such, the model should not be used to predict prices of emission allowances. The modelling results allow us to evaluate which design would perform better in terms of overall emissions, frequency and use of the reserve, and overall compliance entities welfare.

Acknowledgements

London, 2014

Ecofys is grateful for the time and thought contributed to this project by a number of stakeholders and government departments. In particular, staff at the Department for Energy and Climate Change, and Business, Innovation and Skills and HM Treasury have devoted extensive time and thinking to this work.

Summary

The European Union Emissions Trading System (EU ETS) is currently significantly oversupplied. Several factors have led to an imbalance between supply and demand for allowance over recent years, with the current surplus[1] in the market growing to over 2.1 billion European Union emission allowances (EUAs) in 2013, more than a full year's emissions. A supply flexibility mechanism has the potential to address the current imbalance, and prevent a similar imbalance from persisting in the future. More specifically, the European Commission (EC) proposed the introduction of a Market Stability Reserve (MSR) in January 2014. Information on the impacts of a supply flexibility mechanism is scarce, and there are many uncertainties. This report builds on the theoretical literature and discussions with stakeholders to inform the design of a supply flexibility reserve. Modelling has been used to test how different triggers and threshold levels impact the performance of such a reserve against a range of criteria. The report finds that the choice of trigger levels is less significant than theory may indicate and concludes that the EU's proposed MSR is a good starting point, but careful review will be necessary.

The current market imbalance could lead to a more expensive pathway towards a low-carbon future

There is currently a significant supply/demand imbalance in the EU ETS. The cap of the EU ETS was designed based on assumptions of how emissions and therefore demand would develop, however this demand has not been as expected. Several factors have contributed to this market imbalance including the economic downturn, the influx of cheap international credits into the system and the overlap between the GHG emission reduction target encapsulated in the EU ETS cap and the EU's renewable energy and energy efficiency targets. These factors have created a significant surplus of allowances, resulting in low allowance prices, as shown in Figure 1.

[1] The surplus of allowances is the difference between the issued allowances (supply) and emissions (demand) accumulated from the start of Phase II of the EU ETS in 2008, taking the use of international credits into account (see section 3.1.1 for further details).

Figure 1 EUA December contract prices and surplus of allowances at the end of each compliance year. Source of prices: Thomson Reuters Point Carbon. Source of surplus: European Commission

Should this surplus be considered a problem? In theory, some surplus allowances in the EU ETS could contribute to normal market function by acting as a buffer for fluctuating demand. However, the price has reduced significantly over the past 5 years and remains lower than expected, and as such is unable to provide a stable and credible long-term price signal at the appropriate level to stimulate low-carbon investments. Regulators, investors and certain ETS participants are concerned that if investments are not made now, costs to make deep carbon reductions later on will be more costly. The result will be higher aggregate costs, both for society and for firms themselves, to meet the increasingly stringent cap. This concern is borne out by the literature and by modelling carried out for this report.

It is possible that the current large surplus in the system could be caused by early abatement in light of scarcity expected in the future. However, the correlation of the reduction of emissions with the fall in production related to the recent recession indicates that the surplus is not a result of abatement. Furthermore, in reality participants in the market do not look far ahead to the future, certainly not to 2050. Participants tend to make abatement investment decisions on the basis of a 3-5 year outlook for industry, and possibly further for utilities. Therefore the current surplus does not relate to early abatement.

As a result of this unintentional surplus, and the resulting low prices the EU ETS is not incentivising companies to follow the most cost-optimal pathway towards the EU's 2050 targets. In addition, unexpected shocks such as technology change or an economic boom or recession, could change the cost-optimal pathway again. As a result, choosing another rigid cap up front, even with the lessons learned in previous phases, will not guarantee a good balance under all circumstances -the EU ETS is not designed in a way that allows supply to be adjusted after such shocks. It is important to find a way to improve the EU ETS to ensure that it can provide an incentive to reduce emissions along the cost-optimal pathway.

A rules-based responsiveness system like an MSR is a possible solution
The European Commission (EC) has proposed that an MSR should be introduced from 2021 in the EU ETS. The MSR will manage the supply of allowances, and thus the surplus on the market, in order to ensure a credible and stable carbon price signal for low-carbon investments. Theoretically such an MSR would solve the current supply/demand imbalance, and also create a self-regulating system from this point onwards.

In order to achieve its stated goals, the MSR should only respond to unanticipated shocks and not micromanage the market. Such a reserve would withdraw allowances from circulation into a reserve, or re-inject them, taking on a banking function. It would only act in exceptional circumstances, in order to restore the balance of the system such that participants are sent the right signal to make decisions that set the economy onto a cost-optimal emissions reduction pathway. It is important that adjustments of supply take place in a pre-defined and predictable manner, without opportunities for further political involvement, to limit any increase in uncertainty that the changes could have on participants.[2]

There is no perfect MSR design: price corridor, surplus and absolute price triggers all have their merits

There are various design options for an MSR, in terms of the choice of trigger type and trigger levels. In this study, six key trigger-types have been judged against key criteria developed in conjunction with DECC. The criteria are described below:

- **Stable long-term price signal**: Provide a more stable low carbon investment signal by increasing stability of long-term prices;
- **Resilience to shocks**: Improve policy resilience by allowing the EU ETS to respond, in a timely and predictable manner, to unanticipated outside shocks or events;
- **Certainty about the circumstances under which supply adjustments will be made**: Increase certainty about how and under what circumstances supply would be adjusted within phases. Rules based and not open to political interference; and
- **Balanced supply and demand:** Help address the current surplus and prevent a recurrence of chronic supply-demand imbalance
- **Preservation of system integrity**: Preserve the integrity of the system (including ensuring emissions remain within environmental targets and maintaining market efficiency[3]) and be robust to a wide range of external circumstances

Table 1 Assessment for selected trigger options against the key criteria

Trigger type	Stable price signal	Shock resilience	Adjustment certainty	Balanced market	System integrity
Surplus	Limited	**Yes**	**Yes**	**Yes**	**Yes**
Price corridor	**Yes**	**Yes**	**Yes**	Limited	Limited

[2] Uncertainty can have a negative impact on abatement investment decisions within the EU ETS, because of the increased risk this brings.
[3] This factor could be seen to include a number of facets such as liquidity, manipulation risk, price discovery, cost-effectiveness in reaching long-term goals.

Trigger type	Stable price signal	Shock resilience	Adjustment certainty	Balanced market	System integrity
Price trend	Limited	Yes	Limited	Limited	Yes
Hybrid surplus/price	Limited	Yes	Yes	Yes	Yes
Change in economic conditions	Limited	Limited	Yes	No	Yes
Production change	Limited	Limited	Limited	No	Yes

Table 1 shows the expected performance of different types of trigger against the key criteria and shows that no single trigger meets all criteria.

The literature indicates that a price corridor approach could be the most cost-effective and capture the economic efficiency of both a carbon tax and ETS, provided that the corridor and the reserve thresholds were set appropriately. It is also capable of providing a clear price signal as market participants know the price bounds and can observe prices on a continuous basis adjusting their behaviour accordingly. It also offers investors certainty, to some degree, about the price of carbon that they can use in making investment decisions. On the other hand, the delineation of a strict price corridor and behaviour as described above may limit discovery of the cost-optimal pathway, should this be outside the price corridor. The self-same transparency of price that enables a more certain price signal also provides more opportunity for gaming the MSR, although specific rules can limit manipulation. Using price trends as a trigger instead of an absolute price would be harder to manipulate, but this gain comes at the expense of less certainty about when the MSR would kick in.

A surplus-based trigger is in keeping with the EU ETS's quantity-based character and potentially enables increase economic efficiency as it would enable the cap to be adjusted as new information is revealed. This economic efficiency would be achieved if thresholds are set correctly, but there is limited literature about what the suitable trigger volumes should be. Unlike price based mechanisms, a surplus-based system is less prone to gaming. The trigger should limit potential price swings due to an external shock, despite some volatility observed around the time of allowances being injected or removed.

A trigger based on absolute price for an MSR is likely to be difficult politically as it ignites concerns about fiscal sovereignty at the European level, whereas price average trigger may not. A price based trigger offers an opportunity to assess the trigger point more transparently and regularly, than in a surplus-based system and therefore retune the system very quickly after an unexpected shock.

The choice of threshold levels is difficult: the right level of surplus could serve as the threshold, but is challenging to determine

It is clear that the choice of thresholds is important, to some degree, for all trigger types. However, there is limited literature about what the suitable surplus thresholds should be. The EC proposal and others have argued that thresholds under a quantity-based MSR have and should be established with hedging as the starting point.

However, it is not clear that a surplus is fully necessary for hedging. Some stakeholders argue that the surplus is only used for hedging because there is a surplus at the moment, and without such supply available the market will find other means to hedge. Even without a surplus, firms can borrow one year's worth of free allocation plus four months of auctioning, equating to 1 billion EUAs for the 2013 compliance year. Forward contracts can also potentially be used to hedge without being covered by a physical emission allowance, albeit at higher prices and risk. As industrial firms and utilities are generally more risk-averse, this is where the financial sector can play an important role.

Others argue that the surplus is needed for hedging and that there is a relationship between the right level of surplus and a stable market. If the surplus is reduced and held significantly below the level of hedging demand plus industrial banking, there is a risk that firms reduce their emissions beyond what is cost-optimal in order to stick to their hedging strategy. Investigation of the current surplus in the EU ETS indicates that a large portion is used for hedging, especially for utilities, with estimates ranging from 500 million to 1.5 billion. Setting a fixed level is challenging as hedging demand is likely to change over time indicating that review of the trigger levels will be needed.

The EC's MSR design uses both surplus and price increases

The European Commission's proposed MSR uses both the surplus and price increases as a trigger. The EC's MSR is designed as a rule-based mechanism that withdraws and injects allowances in the market through auctions under pre-defined conditions (see Figure 2):

- If the surplus in the market exceeds the upper threshold of 833 million allowances, allowances equal to 12% of the allowance surplus are withheld from future auctions.
- If the surplus in the market drops below the lower threshold of 400 million allowances, 100 million allowances, or everything in the reserve if less than 100 million allowances remain, are injected in to the market through increasing the future auction volume.
- If the surplus does not drop below 400 million, but if for more than six consecutive months, the price of allowances is three times higher than the average price during the preceding two years, up to 100 million allowances in the reserve are also injected in the market through future auctions.

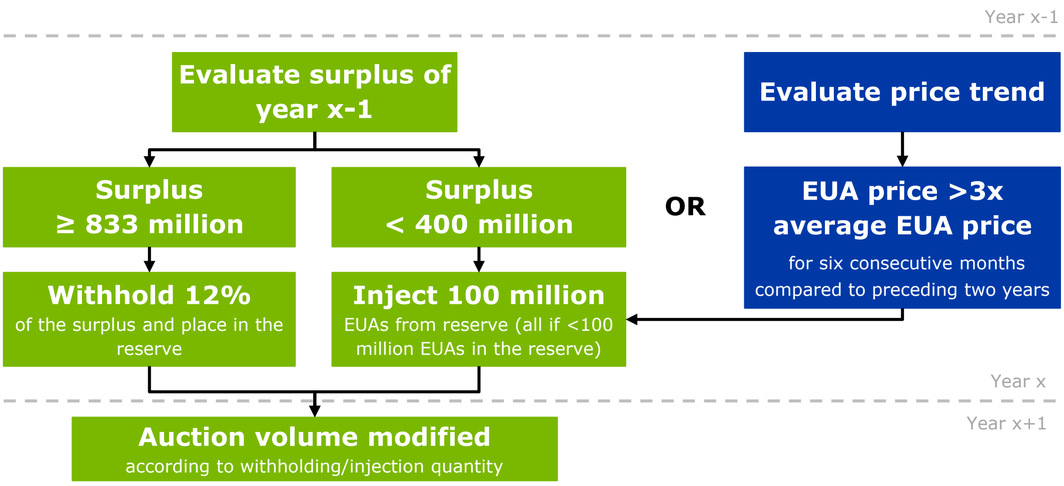


Figure 2 Diagram of the European Commission's MSR proposal

The EC defines the surplus as the difference between the total cumulative emissions and allowances issued, taking the use of international credits into account. Verified emission data in the EU ETS is published annually in May of the following year and any adjustments to the auction volumes will take place in the year after. The adjustment will therefore occur two years after the threshold for intervention has been reached.

A surplus-based trigger seems suitable within the EU ETS, which is a pure volume-based system. In the EU ETS a surplus-based mechanism is less prone to gaming than a price-based system[4]. The trade-off is an increased risk of volatile prices around the adjustment date as the behaviour of market participants could amplify the impact of the injection/removal on prices. When withholding, this amplifying behaviour could trigger the price-trend threshold to inject allowances, depending on threshold settings.

The surplus band of 400 to 833 million selected in the EC's proposal is towards the lower end of estimates of current hedging volumes gathered in this study from some participants. However, while it is uncertain how the hedging demand will change over time there is some level of consensus it is likely to reduce over time, as renewable generation increases and emissions reduces. It is also not even clear that a surplus is necessary for hedging. As such, starting at the lower end of hedging estimates seems like a pragmatic compromise.

There are different opinions on whether an MSR will improve the EU ETS, however, our modelling shows that it can have a positive impact. Other commodity markets show that reserves can be successful in addressing market imbalances

The ability of an MSR to impact the investment decisions of participants has been questioned. If participants have perfect foresight of price developments and behave accordingly, the fact that some allowances are stored in the MSR will have no impact on the overall price signal as participants will anticipate the eventual return of allowances. The modelling of a range of MSRs undertaken in this study confirms that when perfect foresight is assumed, the MSR does not achieve its goals.

In practice, however, firms generally only look a few years into the future when making investment decisions based on the carbon price. The modelling exercise in this study shows that actual impact of an MSR is heavily dependent on the real outlook of participants (as an aggregated group). When it is assumed that participants look five years ahead, an MSR stimulated abatement activity in earlier years than would otherwise have been the case.

By withholding or injecting allowances, the MSR redistributes abatement efforts across the modelling horizon and thus helps to reduce total costs from the otherwise delayed abatement. It improves the economic efficiency of the system and brings it closer to the cost-optimal pathway, represented by equal abatement effort over time as shown in the top diagram in Figure 3. With an MSR the annual abatement moves closer to annual abatement under perfect foresight compared to the status quo. Starting the MSR sooner increases the cost efficiency benefits.

[4] Particularly given that the proposed MSR assesses the level of emissions (versus supply of allowances) rather than surrendered allowances.

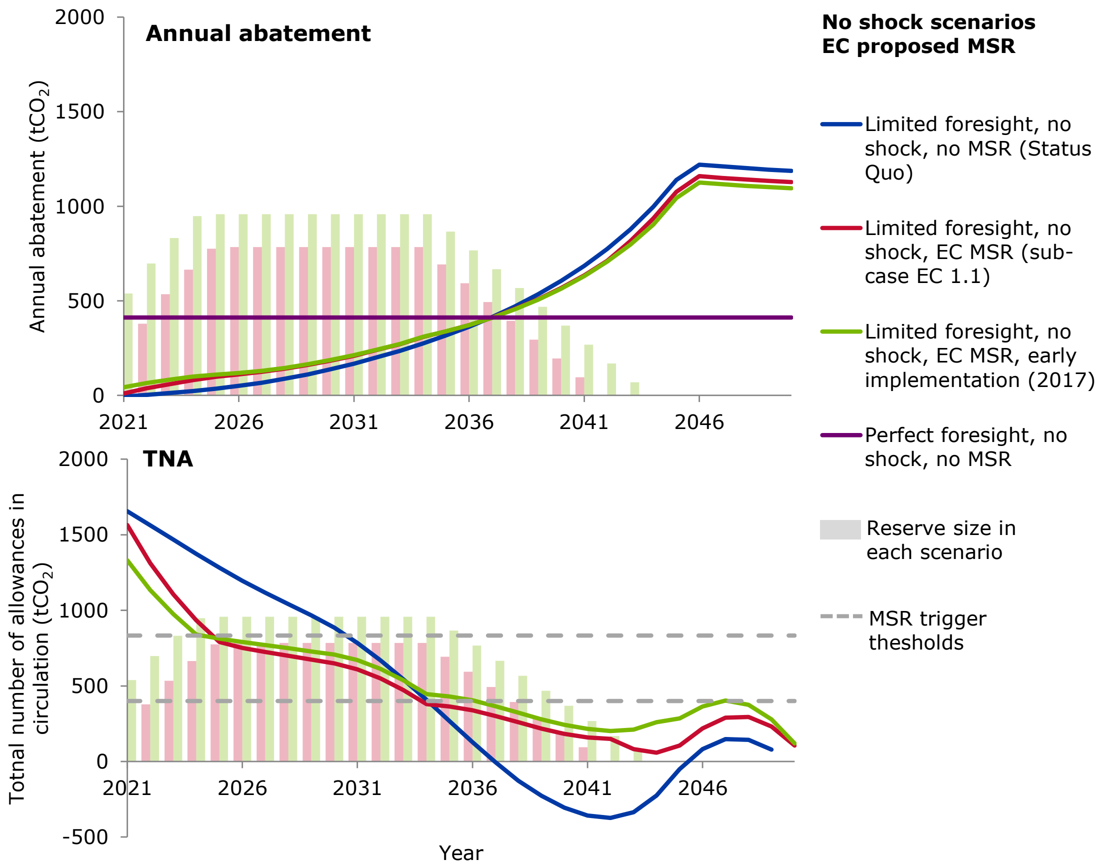


Figure 3 The annual abatement (top) and total number of allowances in circulation (bottom) with the reserve size in each scenario for the status quo and the EC MSR with different starting dates, and annual abatement under perfect foresight

Discussions with market participants in this study and evidence from literature also indicate that the MSR has the potential to increase prices and stimulate abatement. The current surplus is larger than the hedging demand. This means that the marginal demand is mainly driven by speculators, and the higher rate of return sought by speculators drives prices lower than when demand is for hedging or compliance purposes. If the MSR holds a number of allowances that reduces the surplus below the hedging demand for a period of time, higher prices may result. By reducing the MSR could send a stronger signal to abatement than market participants perceive otherwise.

Reserves have been used in food and currency markets to smooth long-term price changes, e.g. currency reserves in China manage currency appreciation in a way that has benefitted economic growth. Oil and food markets use reserves to reduce supply (restriction/ storage) in times of oversupply which helps to stabilise prices against this, a good parallel with the current surplus in the EU ETS. Other markets such as food and petroleum, the size of the reserve also had a bearing on their impact, with larger reserves typically providing a greater stabilising impact against higher prices. Their impact in the case of low prices is dependent on the mechanism, but can stabilise, reverse or sustain the trend.

Not all aspects of existing reserves were successful. The commodity markets, for example the food market shows that regular reviews are required to ensure that the operation of the reserve continues to reflect market realities and that price triggered reserve mechanisms can be vulnerable to external actors and shocks, in particular speculation. This vulnerability was an important reason for the failure of a number of reserve mechanisms, where there were insufficient resources, credibility and/or willpower to address the problems. Any MSR created for the EU ETS has to consider carefully the potential role of speculators and the ways in which the mechanism can itself be vulnerable to shocks.

The EU ETS has the benefit over commodity markets in that policy creates the supply and storage has virtually no costs. Nonetheless, as in all commodity markets, decisions about how the reserve should operate are political to some extent. Even if the MSR is created as a politically-independent and rule-based predictable system, it is likely that any design will still have, and need, political involvement, for example during review periods.

Early introduction lowers overall compliance costs much more than threshold choices
In this study, a comprehensive modelling exercise tested and compared the behaviour of the market in different MSR designs. Although this modelling produces allowance prices, it is important to reiterate that these are not price projections. The absolute price levels are a function of the assumption and model inputs and as a standalone output no meaningful conclusions can be drawn from the allowance price graphs. It is the relative price performance of different MSR designs that is of interest. The price performance of the MSR designs is assessed by comparing the price trajectories and final aggregated compliance costs of the designs with each other and the status quo.

All of the MSR design approaches have the ability to respond to both types of shock: positive and negative. When tested against the current surplus situation in the EU ETS, they all kicked-in at similar points in time, and impacted market behaviour in some way.

The literature and discussions with stakeholders implied that the choice of trigger levels can have a big impact on the extent to which an MSR actually returns participants onto the cost-optimal pathway. However, the modelling exercise showed that the choice of threshold levels, within those tested, had an impact on the size of the reserve and the duration over which it withholds allowances but a relatively minor impact on the resulting aggregated costs of compliance. The same was true when the reinjection volume was modified.

The exception was the choice of price thresholds to inject allowances. In the modelling exercise, by selecting a relatively high price ceiling, the hybrid system, and other price-based approaches removed allowances, and did not re-inject them into the market again within the model horizon. This effectively reduced the cap in the system and lead to higher aggregated costs of compliance. A price ceiling could be set much lower, but this would increase the opportunity for gaming.
The increased cost of compliance was not as large in other designs where the selected injection threshold is similar the one suggested by the EC, as is the case in many of EC MSR scenarios, as well as in the hybrid scenario 2.5 (without a shock).

More importantly, the modelling exercise showed that timing was the single biggest factor in lowering compliance costs overall. Bringing the implementation of all MSR designs forward, earlier than 2020, reduced aggregate costs and would have the added benefit of bringing greater certainty to participants, who are now expecting an intervention anyway.[5] Instead of tweaking the thresholds, introducing the MSR in 2017 would have the largest impact on lowering the aggregated costs faced by compliance entities.

In conclusion, the EC's proposal is a sensible starting point, but there are a number of risks…

The surplus-based trigger, as proposed by the EC, seems to be a sensible political compromise for a reserve. A surplus-based measure comes out favourably from the literature and theoretical discussion, as well as from the modelling exercise and political considerations. The MSR is a patch that is intended to fix the perceived market imbalance in the EU ETS over the entirety of the period from now to 2050 to put the system back on the cost-optimal pathway and keep it there by addressing future shocks.

Given the large surplus in the market, without reforms the EU ETS will remain on a non-cost-optimal pathway for well over a decade from the time that the original shock occurred in 2008. Therefore, it is important to consider an early implementation of the MSR or faster withholding of allowances to address the surplus more quickly and reduce the risk of lock-in of carbon-intensive technology. Furthermore, a mechanism that is designed now should be tested relatively soon or, as suggested by some stakeholders, the thresholds should be re-examined periodically.

The purpose of the MSR is to not only move the current market, with a huge surplus, closer to the cost-optimal pathway and correct for myopia, but also to provide the system with responsiveness to deviations from the cost-optimal pathway when this changes due to unexpected shocks. The EC's proposal has the potential to do this, however, the exact response of such an MSR to shocks is unknown and would have to, to a certain extent, be discovered by the market; modelling can only provide a limited understanding of the possible market responses to an MSR. The ability for the proposed MSR to respond appropriately to such shocks will depend on whether the trigger and intervention levels are set appropriately. In the current design these levels have been set to withhold allowances faster in the current circumstance of high surplus. Levels for withholding and injecting will be more equal when the market is in balance. This accommodates the dual objectives of the MSR. There is a risk that the MSR may actually respond too slowly to the current imbalance to prevent lock-in of carbon-intensive technology, but on the other hand, there is a risk that it responds too strongly to address future imbalances: a sub-optimal measure to address either of the problems although no evidence for this was found in this study. The purpose of the MSR is to not only move the current market, with a huge surplus, closer to the cost-optimal pathway and correct for myopia, but also to provide the system with responsiveness to deviations from the cost-optimal pathway when this changes due to unexpected shocks. It is important to note that modelling can only provide a limited understanding of the possible market responses to an MSR.

[5] Given the existing evidence on the benefits of early action to reduce emissions, early abatement is likely to be cheaper than delaying abatement and buying allowances as the stringency of the cap continues to increase.

The technical arguments for modifying the trigger thresholds as defined by the Commission are few, and furthermore, any discussions about the trigger type and threshold level will most likely a lengthy negotiation process and in the end a political choice. Therefore if the current approach appears palatable there is little to be gained from opening this debate.

Lessons from other commodity markets have shown that reform is a continuous learning experience and the impact may be different than intended, in particular decisions are inevitably political to some extent. The assessment planned for 2026 will tell how successful the MSR is. As a next step, it is important to define clearly what this assessment should look for. Some important indicators of failure would be if there was evidence of gaming, if the MSR was triggered too often and when not required, or if a shock occurred that was widely understood to have impacted the cost-optimal pathway, and there was no response. Metrics such as price or the number of allowances in the reserve will not provide an adequate measure of the MSR's success alone. Other potential indicators of success are investments in low-carbon measures in the EU ETS compliance sectors or the number of new low-carbon patents.

Glossary

Cost-effectiveness	The equality of marginal abatement costs among regulated firms, regardless of the level, is a necessary condition for any given level of environmental quality to be achieved at the lowest overall cost, a condition known as cost-effectiveness.
Cost-optimal pathway	The time pathway in which the policy is regarded as cost-effective and economically efficient over time, i.e. the inter-temporal or dynamic efficiency.
Credibility	The credibility of the EU ETS to achieve GHG emissions reduction in a cost-effective and economically efficient manner.
Economic efficiency	Economic efficiency in GHG emissions reduction policy is the point where the marginal benefits from emissions reduction is equal to the marginal abatement costs. In practice the economic efficiency of a policy is uncertain as the marginal benefit and marginal cost curve are uncertain.
Intervention	Any adjustment made to the market supply or demand by non-market participants, i.e. regulators. Intervention can be rule-based or subject to political discretion.
Stability	Orderly functioning of the market and ability to absorb unanticipated shocks to keep the system on a cost-optimal pathway.
System integrity	Prevention of abuse in the EU ETS such as market manipulation or too much political discretion and at least maintaining the overall GHG reduction ambition to guarantee the environmental outcome of the system, which could all jeopardise the cost-optimal pathway.

Table of contents

List of figures

List of tables

1 Introduction

The European Union Emissions Trading System (EU ETS) has experienced a significant shift to an oversupplied market over the past years and the surplus has grown to the equivalent of a year's emissions. Various reasons have been given for this persistent market imbalance including the economic downturn, the influx of cheap international credits in the system and the overlap between GHG emissions targets and the renewable energy and energy efficiency targets (see e.g. European Commission, 2014b; Grubb et al., 2012; Hermann and Matthes, 2012; Neuhoff et al., 2012; Egenhofer et al., 2012). These factors influenced demand patterns in unexpected ways and the market is not constructed in such a way that it can adapt to significant downward pressures;[6] the result is a huge surplus and a low allowance price as shown in Figure 4.

Figure 4 EUA December contract prices and surplus of allowances at the end of each compliance year. Source of prices: Thomson Reuters Point Carbon. Source of surplus: European Commission

In theory, a low price in the EU ETS is not necessarily a problem, because it shows that the market is working and prices are determined by supply and demand. A low price is also beneficial to firms in difficult economic times, because it lowers their compliance costs. The problem is the current cap turned out to be too high to create a real constraint on emissions and is not aligned with the 2050 GHG emissions reduction target of 80–95% below 1990 levels. This is reflected in the current low prices.

[6] The supply of allowances in the EU ETS is only able to adapt to significant upward variations in demand if as a result the average allowance market price in the last six months increases more than three times the average allowances market price in the prior 12 months as specified in Article 29a of the EU ETS Directive.

What is the extent of the so-called surplus?

The current imbalance has resulted in the surplus of allowances.[7] The current surplus has grown to over 2.1 billion European Union emission allowances (EUAs) in 2013, more than a full year of emissions in the EU ETS, without any prospects of decreasing in the short or medium term (European Commission, 2014a). In theory, some surplus in the EU ETS could contribute to normal market function by acting as a buffer for fluctuating demand, providing sufficient liquidity and avoiding heavy price volatility. However, the large scale of surplus exceeds what seems to be required for normal functionality.

The surplus continues to grow due to the banking of unused allowances for future use, coupled with lower than expected demand. The European Commission (EC) projects that the current surplus will grow from almost 2 billion EUAs in 2013 to more than 2.6 billion by 2020, only to decrease to 2.3 billion by 2030 partly as a result of the EC's proposed GHG emissions reduction target of 40% below 1990 levels by 2030 (European Commission, 2014a).

Why are the current low prices considered the symptoms of a problem?

The current success of the EU ETS in achieving its objective "to promote reductions of greenhouse gas emissions in a cost-effective and economically efficient manner" depends on the interpretation of the objective (Egenhofer et al., 2012). The EU ETS is fulfilling its purpose with respect to keeping the emissions below the current cap and allowing participants in the EU ETS to meet the cap in the most cost-effective way. However, current low prices in EU ETS may not be economically efficient as they do not incentivise low-carbon investments and could result in lock-in to carbon-intensive technology (see section 1.1). Ultimately such decisions taken now could result in a more expensive pathway towards a low-carbon future (European Commission, 2014b, Ecofys and OEA, 2014; Sandbag, 2010). By bringing emissions reductions forward instead of delaying abatement and buying allowances, the risk of lock-in resulting in a more expensive pathway is reduced. It is, however, uncertain what the cost-optimal pathway is. Given that the future is uncertain, the cost-optimal pathway cannot be accurately predicted, but must be, to a certain extent, discovered over time by the market and policy makers. For example, the pathway can be influenced by fluctuations in demand while the system is in operation. Equally, technological breakthroughs could lead to sudden drops in abatement costs, making it more financially beneficial to abate. However, these breakthroughs may rely on low-carbon investment incentives.

[7] The surplus of allowances is the difference between the issued allowances (supply) and emissions (demand) accumulated from the start of Phase II of the EU ETS in 2008, taking the use of international credits into account (see section 3.1.1 for further details).

System responsiveness can be a solution

Any measures to correct the EU ETS when it deviates from a cost-effective and economically efficient pathway would require political agreement and a lengthy and potentially contentious process to change the EU ETS Directive. The EC proposed a long list of options which could address the supply/demand imbalance. These options included the extension of the EU ETS to other sectors, tightening the annual linear reduction factor, increasing the EU's climate change reduction targets for 2020 from 20% to 30%, cancelling allowances, limiting the use of international offsets in the system and introducing a discretionary price mechanism. Based on the input from stakeholders, the EC continued to investigate the permanent cancellation of allowances and an increase in cap stringency, and introduced the option of a reserve mechanism focusing on the auction supply. The EC found that the most effective solution would be a combination of permanent cancellation of allowances and a reserve mechanism.

However, upon considering the practical and political challenges related to the introduction of two mechanisms, and in particular in relation to cancellation (European Commission, 2014b), the EC proposed the introduction of a market stability reserve (MSR). The purpose of the MSR is to "address the problem… that the market would have to continue to operate for more than a decade with a surplus of around 2 billion allowances or more… and to make the European Emissions Trading System more resilient to imbalances" (European Commission, 2014c). In other words, the MSR attempts to address the current imbalance in the EU ETS market and prevent any unexpected significant shocks to the system from causing such imbalances in the future.

Box 1 MSR design proposed by the European Commission

The MSR proposal by the European Commission

The European Commission's proposed MSR uses both the surplus and price increases as a trigger. The EC's MSR is designed as a rule-based mechanism that withdraws and injects allowances in the market through auctions under pre-defined conditions (see Figure 5):

- If the surplus in the market exceeds the upper threshold of 833 million allowances, allowances equal to 12% of the allowance surplus are withheld from future auction
- If the surplus in the market drops below the lower threshold of 400 million allowances, 100 million allowances, or everything in the reserve if less than 100 million allowances remain, are injected in to the market through increasing the future auction volume
- If the surplus does not drop below 400 million, but if for more than six consecutive months, the price of allowances is three higher than the average price during the preceding two years, up to 100 million allowances in the reserve are also injected in the market through future auctions.

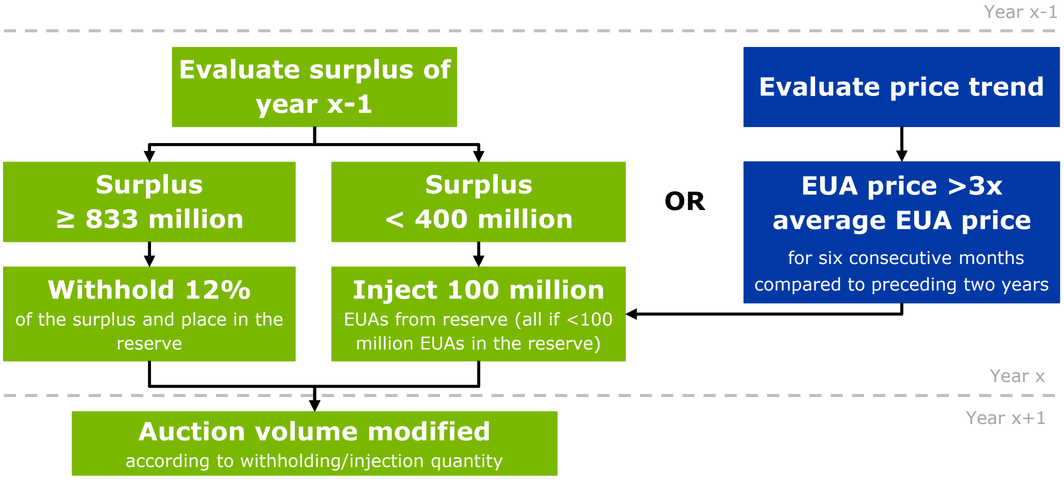


Figure 5 **Diagram of the European Commission's MSR proposal**

The EC defines the surplus as the difference between the total cumulative emissions and allowances issued, taking the use of international credits into account (see Box 3). Verified emission data in the EU ETS is published annually in May of the following year and any adjustments to the auction volumes will take place in the year after. The adjustment will therefore occur two years after the threshold for intervention has been reached.

This report looks briefly at the need for intervention in the EU ETS in the introduction, and then investigates the potential design options for an MSR more thoroughly. Sections 1.1 and 1.2 consider further the necessity for such changes and broadly speaking, the shape such an adjustment can take. Chapter 2 describes the overall methodology for this project. Chapter 3 presents the different possible designs of market stability reserves in broad terms, whilst chapter 4 investigates some of the details of specific parameters. Chapter 5 presents and assesses some design examples, including the EC's proposal. The Annex to this report provides the detailed outputs from the modelling exercise.

1.1 Intervention in the EU ETS is necessary…

The persistent imbalance between supply and demand in combination with the fact that the cap in the current EU ETS is not in line with the 2050 goals undermines the normal functioning of the EU ETS. The EU ETS has not sufficiently stimulated the investment required to meet, at the lowest possible cost, long-term 2050 targets of 80–95% GHG emissions reduction below 1990 levels (European Commission, 2014b; DECC, 2014a). This reality is reflected in the EUA prices, which are relatively low and are projected to remain much lower than the 39 €/tCO_2 by 2020 initially anticipated at the introduction of the EU ETS in the cost-effective scenario (European Commission, 2012; European Commission, 2008) and much lower than the price required to drive fuel switching (around 20 €/tCO_2; CDC Climate 2014), one of the cheapest sources of emission reductions.

The persistent market imbalance and misaligned cap has resulted in a low EUA price, unable to provide a stable and credible long-term price signal to stimulate low-carbon investments. This is perceived by the regulators, investors and certain ETS participants to be necessary to meet the objective of the EU ETS in the long term to cost effectively reduce emissions to meet long term GHG emission reduction goals. Some Member States felt pressure to introduce other instruments at either national or EU level to stimulate low-carbon investments in the power sector and secure climate and energy goals e.g. renewable energy targets or the UK carbon price floor. Such national or regulatory instruments are likely less efficient than addressing the problem through the EU ETS as a whole.

There is a theoretical support for the concept of intervention in the EU ETS
Whilst adjustment and flexibility on the supply side could go some way to removing concerns about low prices, government intervention in the system could harm the integrity of the system and reinforce the political uncertainty experienced by EU ETS participants (Ecofys and OEA, 2014). The occurrence of any type of intervention could open up an opportunity for political interference and lobbying. Even the potential for any intervention can increase uncertainty for EU ETS participants, leading to delay or redirection of investments. Careful design of changes to the system can go some way to limiting concerns about its introduction. For example, interventions that operate according to a predetermined set of rules can be more certain. Intervention in the EU ETS must therefore only be used with care and under exceptional circumstances.

From a range of interviews with experts, Grosjean et al. (2014) has identified three possible drivers that could justify intervention i.e. adjusting the supply in the EU ETS outside the scope or volume that has been set ex-ante:

1. Exogenous shocks resulting in a carbon price that may not reflect the most cost-optimal pathway to meet the objective of the EU ETS
2. Policy uncertainty in relation to the 2050 targets and lack of credibility in achieving the targets in line with the objective of the system
3. Market imperfections due to excessive short-term focus and asymmetrical information between market participants and regulators

Theoretical arguments for intervention apply to the current circumstances of the EU ETS
The theory is supported by reality. These three drivers are addressed in turn below:

1. Exogenous shocks: The EU ETS price depends on many factors, including energy prices, weather, political announcements and other special events, such as the economic crisis or new outcomes of international climate negotiations (Feng et al., 2011). This variation in price is not necessarily a social problem (Fankhauser and Hepburn, 2010); it can mean that the market is functioning well and responds as intended, e.g. dampening the impact of an energy price shock on emissions. A problem arises when unexpected exogenous shocks occur that (are perceived to) undermine the EU ETS objective. Since these sudden and unforeseen changes are not part of the original optimal policy solution, the resulting outcomes are no longer optimal.

The EU ETS does not have the ability to respond to persistent changes in economic circumstances, technological development and overlapping policies. Because supply is not responsive to changing circumstances, as it is in a 'natural' market[8], the market can only adjust to significant changes in circumstances through a significant change in price. The recent recession illustrates such an unexpected persistent exogenous shock and the impact of this on price. Under these circumstances the supply of allowances should have been reduced in line with the demand shock to adjust the market onto the new cost-optimal pathway, but there was no mechanism to do so.

2. Policy uncertainty: A lack of policy certainty is observed within the EU ETS. There is still significant policy uncertainty surrounding the long term emissions reduction targets as the EU ETS cap has not been set all the way to 2050, and the current cap trajectory is not in line with the 2050 target. As is currently the case in the EU ETS, policy makers and market players may call for intervention in the market to adjust for unexpected shocks, leading to more policy uncertainty. Other factors contributing to a lack of credibility include time inconsistency[9] and a lack of an international climate change agreement (Grosjean et al., 2014), certainly observed over recent years.

3. Market imperfections: In the EU ETS firms may focus on GHG reduction investments on their short-term strategy (Taschini et al., 2014).[10] With current low allowance prices, the carbon price signal does not significantly influence investment decisions. Emissions reductions are primarily seen as an additional benefit of investments in energy efficiency, and firms maintain a payback period of 3 to 4 years for energy efficiency investments (Martin et al., 2011). Carbon prices are also too low to have an impact on renewable energy investments at present. This behaviour shows the short-term approach taken by firms (Piris-Cabezas and Lubowski, 2013), and can be considered a market failure in relation to the stimulation of long-term investments.

There is a broad consensus that carbon prices will increase in the future with an increasingly stringent cap, but there is no evidence of firms investing in GHG abatement to hedge against the risk of potential exposure to higher carbon prices (Ecofys and OEA, 2014). Most firms do look at future carbon prices in their investment decisions, but some use the current market prices as an indicator for the future prices. Importantly, these market imperfections mean that the EU ETS may not provide the right price signal associated with the abatement required to follow a cost-optimal pathway to meet the GHG emissions reduction target for 2050.

[8] Where lower demand and prices create a signal for lower production and higher demand and prices create a signal for higher production.

[9] Time inconsistency refers to the preference of policy makers at the time of announcing policy measure changing over time due to various influences such as lobbying, reducing the credibility of the announced policy measure.

[10] Firms may be unable to borrow capital to invest in projects that have a rate of return higher than the interest rate or may be capital constrained, limiting their ability to employ a long-term strategy for investments in GHG emissions reductions.

A further market imperfection is the asymmetry of abatement information between the regulators and market participants and future uncertainties in general (Fell and Morgenstern, 2010). There is no guarantee that the regulators' perceptions of the cost-optimal pathway are correct, although the regulator may have a better perspective of the social cost-optimal pathway and setting the cap in phases already requires the regulator to take some view on the correct pathway. Firms may have a better view of their own cost-optimal abatement pathway and discount rates under the cap than the regulator (Fell and Morgenstern, 2010), although many firms are still likely to take a short term view, compared to targets, when considering costs. Market participants do let regulators know what, in their view, the optimal emissions pathway is, but this could result in the ratchet effect (Harstad and Eskeland, 2010); market participants may exaggerate their compliance costs or make emissions-intensive investments in a bid to gain more lenient regulation in the future. By providing regulators with the ability to adjust the supply, interventions could be made to take into account new information e.g. on abatement costs as, and if, it becomes available to regulators or is signalled by changes in the market over time.

Is intervention the only approach?

In theory, dynamic efficiency should be achievable in systems with long enough commitment periods and appropriate banking and borrowing. Therefore, interventions may be seen as second-best policy alternatives to setting appropriate long-term targets in systems with banking and limited borrowing (Fankhauser and Hepburn, 2010). In reality, future uncertainty, and in particular political uncertainty, reduces dynamic efficiency as firms may delay their investments and include risk in their decision-making calculation by increasing the required return on investment (Ecofys and OEA, 2014). This behaviour combined with firms short term focus leads to a deviation from the cost-optimal pathway.

An alternative to intervening in the EU ETS directly would be to refine policy coordination, if these overlapping policies are perceived to play a significant role in the supply/demand imbalance. Overlapping policies that affect the demand for allowances and distribution of emissions abatement effort across firms could also compromise both the cost effectiveness and environmental impact of the policy (Goulder, 2013). Firms facing overlapping policy may abate more than would have been driven by the allowance price alone. As a result, the allowance price other firms face will reduce, sending a weaker signal and reducing the impact of the EU ETS in reducing emissions. Because the marginal abatement cost of firms vary and the overlapping policy may drive higher cost abatement, the policy will not remain cost-effective anymore. Some overlapping policies are introduced to the low price symptom, e.g. the UK carbon price floor. The structural reform of the EU ETS is focussed on making changes to the system directly to improve its ability to achieve its long-term target in a cost-effective and economically efficient manner.

Following the theoretical arguments and observations from the EU ETS it appears clear that intervention in the EU ETS is needed. This study does not look further into whether intervention in the EU ETS is justified, but how an intervention can be designed to address unexpected shocks, the credibility of the system in achieving its goals and market imperfections in a robust and transparent manner.

1.2 …without compromising the integrity[11] of the system

Intervention should be aimed to promote orderly functioning of the EU ETS and facilitate goal attainment: to reduce GHG emissions at the lowest cost over time. At the same time, this intervention should not compromise the integrity of the EU ETS by at least maintaining the overall GHG reduction set by the cap. Clear and transparent rules for intervention should be set in advance and designed in a way that is not open for abuse or open to too much discretion.

The environmental integrity of the system would be compromised if the injected allowances exceed the overall GHG reduction ambition, essentially inflating the cap of the system. The environmental integrity can be safeguarded by imposing a quantitative restriction on the injected allowances in the form of a reserve (Murray et al., 2008; Fell and Morgenstern, 2010). A reserve would be filled with the allowances that are held back or withdrawn from the market and the limit on the quantity for injection is set by the amount of allowances in the reserve. This ensures that allowances issued in the system will not be more than the initial cap in line with the overall ambition, accumulated over time.

1.3 An allowance reserve can improve the functioning of the system

The notion of a reserve in emissions trading stems from the price versus quantity instrument discussion. A combination of the two instruments in a hybrid form with a reserve is a way to capture the advantages of both instruments, while maintaining the environmental integrity of the system. See the box below for a summary of the key arguments in the price versus quantity instrument debate in literature and the role of an allowance reserve. How an allowance reserve can improve the functioning of the EU ETS in further elaborated in section 3.1.

[11] Maintaining the environmental outcome of the system and safeguarding the cost effectiveness and economic efficiency.

Box 2 Discussion on a price versus quantity instrument and the role of an allowance reserve

The price versus quantity instrument discussion and the allowance reserve

Economic instruments regulating price (e.g. a carbon tax) or regulating quantity (e.g. an ETS) achieve identical results if the regulator has perfect information and full certainty about the future: regulating price will yield the desired quantity and vice-versa. In reality the regulator does not have complete information on the benefits and costs of emission reductions and this duality no longer holds under uncertainty (Weitzman, 1974). The regulator would need to make a trade-off between certainty in carbon price and uncertainty in emissions outcome by choosing a carbon tax or certainty in emissions outcome and uncertainty in carbon price with an ETS (Roberts and Spence, 1976). The discussion on whether a price or quantity instrument is the optimal instrument to reduce GHG emissions remains an open debate.

All things being equal, at any point in time a carbon tax and an ETS are both cost-effective; cost-effectiveness is obtained if all compliance parties face the same marginal abatement costs regardless of the level. The economic efficiency of the instruments under uncertainty or, more precisely, the loss of economic efficiency, is different though. The point at which the marginal benefit and marginal abatement curve intersect is the level of tax or cap at which the instrument will be economically efficient. Under uncertainty, this precise point is unknown and a proxy of the marginal benefit and cost curve is used to set the level of tax or cap. This proxy is difficult to estimate correctly, leading to a loss in economic efficiency as shown in Figure 6.

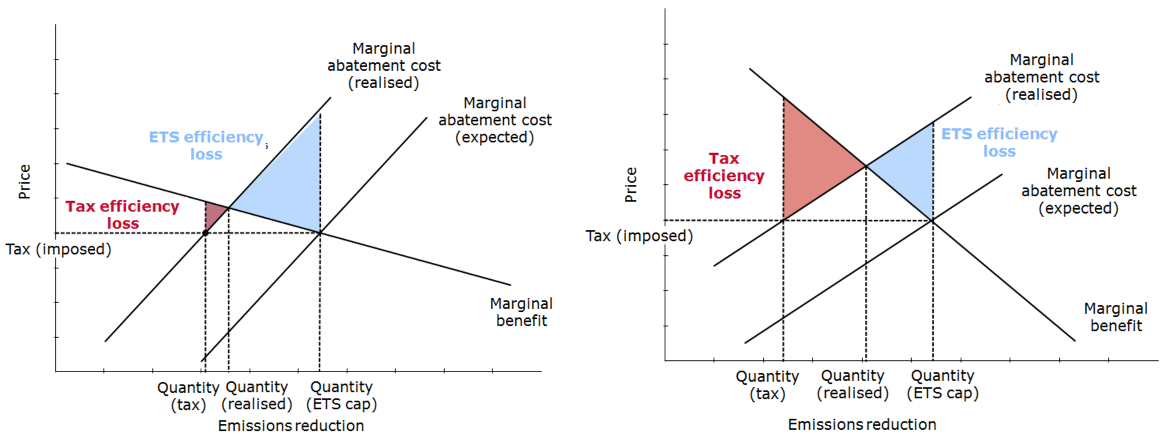


Figure 6 Comparing economic efficiency of a tax and an ETS with a flat (left) and steep (right) marginal benefit curve (left). Adapted from Weitzman (1974).

Hepburn (2006) provides three aspects to consider when choosing between a cost and quantity instrument in light of economic efficiency under uncertainty:

1. *The relative steepness of the marginal benefit and cost curve* – A price instrument is more efficient than a quantity instrument if the marginal benefit curve is relatively flat compared to the marginal cost curve. If the steepness of the curves is reversed, a quantity instrument is more efficient.
2. *The correlation between the marginal benefit and cost curve in terms of uncertainty* – A quantity instrument is relatively more efficient than a price instrument if the correlation is positive. If the correlation is negative, a price instrument is relatively more efficient.

3. *The risk-averse nature of firms* – A price instrument may be more efficient with many risk-adverse firms as these firms would be less willing to rely on trading to meet their obligations, undermining the efficiency of a quantity instrument.

Proponents of a carbon tax argue that the marginal benefit curve is relatively flat as GHG emissions are a stock pollutant, which means that the damages from climate change gradually accumulate over time. Various early studies, therefore, argue that a price-based measure would be more economically efficient and produce larger net benefits than a quantity-based measure; with a flat marginal benefit curve the efficiency loss of tax would be smaller than an ETS as shown in Figure 6 (e.g. Pizer, 1999; Hoel and Karp, 2002; Newell and Pizer, 2003). Others argue that the damage from climate change is not simply a relatively flat curve, because at a certain tipping point the damage curve will become very steep (Keohane, 2009; Metcalf, 2009). The preference for either instrument could change depending on the expected correlation in uncertainty. If one expects uncertainty in marginal benefits and costs are positively correlated under shocks in e.g. technological or economic development, a quantity instrument would be preferred. The preference also hinges on the expected degree of risk-aversion of firms. The choice between a price or quantity instruments is therefore heavily reliant on the perception of uncertainty and of risk-aversion.

The price versus quantity discussion becomes more complex if the economic efficiency over time, i.e. the dynamic efficiency, is considered. This is not only the discovery of the actual level of cap or tax at which economic efficiency is achieved. The point at which economic efficiency is achieved also changes over time with new developments and shocks, and these uncertainties can change the preference for a price or quantity instrument (Newell and Pizer, 2003; Karp and Zhang). The choice between a tax or cap control depends upon the assumption on the dynamic structure of cost uncertainty, e.g. the correlation structure of cost shocks across periods. (Parsons and Taschini, 2012). Temporary shocks to abatement cost favour the use of a tax, while permanent shocks favour a cap control.

To improve the economic efficiency of an ETS under uncertainty, many studies propose the use of a combined carbon tax and ETS design. Restraining the price within certain bounds (i.e. a price corridor) in an ETS would be a way to apply this theory. A price corridor can capture the economic efficiency of a carbon tax while maintaining the certainty of environmental outcome, in terms of GHG emissions, of an ETS (Pizer, 2002; Newell et al., 2005; Burtraw et al., 2009; Fell and Morgenstern, 2010). The loss of economic efficiency would be limited to at least the lowest economic efficiency loss due to the choice of cap and price corridor, which should be set around the economically-efficient point. By adjusting the supply of allowances when the market price appears to be beyond the corridor, the loss of economic efficiency is reduced.[12] In theory, frequent adjustment of the cap or tax level could minimise the loss of efficiency, but it also increases uncertainty for market participants. This could actually increase the loss of efficiency due to delay in taking abatement measures (Ecofys and OEA, 2014; Hepburn, 2006) and for an ETS distort trading (Harstad and Eskeland, 2010).

[12] This is not only valid for ETS with a price corridor, but any mechanism that allows an adjustment of the supply. The key difference is that that a different indicator is used to approximate changes to the economic efficient point, e.g. the carbon price, surplus or economic indicators (see section 3.4 for further details on these triggers).

A reserve would allow the price to move beyond the corridor in case the economic efficient price turns out to be higher than the price ceiling. In principle, the most significant disadvantage of combining a carbon tax and ETS design is the increased complexity of the instrument.

By setting a price corridor within the restrictions of the reserve, the regulator can signal the cost-optimal pathway to achieve future targets to the market that it perceives to be correct (Murray et al., 2008). Whether this signal will actually have an impact on the behaviour of firms depends, amongst others, on the firm's perception of required future abatement (Maeda, 2012). If future abatement needs are very uncertain, an adjustment to the trigger price would have a larger impact on abatement; by setting a price ceiling, the regulator indicates what abatement measures the firms should take and the maximum price at which it is expected that firms need to buy allowances to meet their obligation. At the same time it still allows discovery of the cost-optimal pathway if the ceiling is set sufficiently high. When future emissions and abatement needs are relatively certain, an adjustment of the supply would be more effective; firms know what level of abatement is needed to meet the cap and any changes to the cap (see section 3.4.4 for further discussion).

In a corridor approach, the reserve can also reduce sharp price fluctuations in the event market participants are holding on to their allowances for future and not willing to sell or there is a sudden dip in demand for allowances on the market (e.g. after all compliance entities have surrendered their allowances once a year). The trade-off for reduced price volatility is an increase in emissions volatility (Gruell and Taschini, 2011; Stranlund et al., 2014). The price corridor changes the abatement behaviour of firms. In an oversupplied market with a reserve, firms will abate more than without a reserve, as a minimum price makes the case for abatement financially more attractive, while, in a tight market, firms will abate less as long as the reserve is not empty, as emission allowances guaranteed against a certain price. Since GHG emissions are stock pollutants, from an environmental perspective it does not matter when the emissions are emitted. Politically, emissions volatility might be less desired though, as political messaging in achievement of the targets[13] may be diluted if the emissions in the final year are significantly higher than the target. In the specific case of the EU ETS, a price corridor faces even more political challenges (see section 3.3.1).

In conclusion, the efficiency arguments vary depending on the context for the instrument. Arguments for choosing the instrument go beyond solely efficiency arguments though. Considerations with respect to implementation also play a large role in the choice of instruments, which are related to distribution of policy burden, international competitiveness, use of revenue, administrative burden and international linking, although these can all be designed in a way to have a similar impact in both instruments (Goulder and Schein, 2013). In the end it is not the consideration of economic efficiency, but political considerations that have played the determining role in deciding on the final instrument (Hepburn, 2006; Fell and Morgenstern, 2010; Goulder, 2013).

[13] Single year political targets, such as 20% reduction by 2020, are converted into cumulative emissions and achievement is then measured against the overall GHG budget in the EU and United Nations Framework Convention on Climate Change (UNFCCC) context.

Other ways to tackle the market imbalance by making the supply more flexible include borrowing, the use of offsets, provisions to alter the trajectory of the cap or linking to other systems (e.g. see Ecofys and OEA, 2014; DIW Berlin, 2013; Fankhauser and Hepburn, 2010; AnalysisGroup, 2010). In particular if firms face uncertainty in abatement costs, borrowing can significantly improve the cost-effectiveness of firms (Parsons and Taschini, 2012; Fell and Morgenstern, 2010; Ellerman and Montero, 2007). However, options other than the considerations for a reserve are beyond the scope of this study.

In conclusion, a reserve could potentially improve the responsiveness of the EU ETS to unexpected exogenous shocks without compromising the integrity of the system. This study will investigate the various, specific design details and practical considerations that need to be taken into account in designing such a response mechanism.

2 Methodology

2.1 Overall approach

This section describes the methods used in this study to assess different design options for a market stability reserve in the EU ETS. The literature acts a starting point. Whilst the literature contains several designs of a market stability reserve, these were not tested by market participants and an analysis of the impact of such mechanisms on market participants was lacking. To fill the gap left by literature, the impact of various designs of a market stability reserve was tested in interviews with stakeholders and experts. This analysis was further complemented by economic modelling of the carbon price response to various market stability reserve designs. This allows the study to compare and assess the performance of these different market stability reserve designs, taking the European context into account.

This section will describe the methodological approaches in this study. Measures taken to ensure the quality of this report are provided in Annex IV.

2.2 Literature review

The literature review addressed both the design and impact of a market stability reserve. In particular, it addresses the questions and topics listed in the Terms of Reference compiled by DECC. The literature review has been split in two parts:

1. Literature covering supply flexibility and cost-containment in environmental economics; the focus was on the design aspects of allowances reserves and the impact of reserves on the market.
2. Literature on other commodity markets with a reserve mechanism; for reasons given in Annex I, we selected three commodity markets and further reviewed the literature in these areas to draw the key lessons applicable to this work.

The literature has been taken from a range of sources including academic literature, thought pieces from NGOs and trade organisations and responses to the EC's consultation on structural reform.

2.3 Stakeholder and expert consultation

The discussions with stakeholders and experts were primarily focussed on active market participants and observers, because the emphasis of the study is on impact of different market stability reserve designs on the behaviour of the market. A broad stakeholder engagement was not the purpose of this study, as the project team did not expect that it would necessarily provide reliable answers for several reasons:

- Within the scope of the project, engagement would not have been comprehensive and, therefore, might not be truly representative

- In asking very hypothetical questions about behaviour, even the respondent themselves might not truly know the answer
- Questions related to behaviour in this study that could be considered confidential, relating to trading strategies etc. within the EU ETS

Stakeholders and experts in this study consists of active carbon market traders, carbon market observers, utilities, an NGO and stakeholders in other existing markets with a reserve. The selection of expert categories have been compiled in discussion with DECC, whereas the individual contacts within each category was subject to the availability and willingness of the stakeholders to contribute to this study.

Interviewed stakeholders and experts:

- JP Morgan (carbon market trader)
- SSE (utility)
- EDF Energy (utility)
- E.ON (utility)
- Dr. Ruben Lubowski, Environmental Defense Fund[14] (NGO)
- An international energy company with significant trading activities on various carbon and commodity markets
- An international industrial firm with large EU allowance trading activities
- California Air Resource Board[15]

The stakeholder and expert consultation consisted of meeting in person or holding bilateral phone interviews. The interviews were designed to fill in the gaps in the literature review on the relevant environmental economics topics on market responsiveness/market stability, and careful questions were prepared in advance and circulated to the interviewees to ensure a productive conversation. Although the input of stakeholders and experts may be anecdotal, it helped balance the theoretical information from the literature review and analysis phases.

The discussions with the stakeholders and experts did not constitute a comprehensive consultation process and as such, the stakeholder views should be considered a non-representative sample.

2.4 Economic modelling

The team used the Kollenberg and Taschini (2014) model (KT model) to assess the impact of the market supply reserve on compliance firms' behaviour (changes in trading and abatement through time) and the resulting allowance price. The model outputs are explicit and, as such, provide simple and accessible results to demonstrate how market participants may respond to different designs of a market supply reserve (MSR). The results are likely to reinforce the critical role played by market expectations about future cumulated abatement efforts and their costs (under perfect and limited foresight).

[14] Views provided by Dr. Ruben Lubowski are his personal views and do not necessarily represent the views of the Environmental Defense Fund.
[15] Discussions were limited to e-mail exchanges

Kollenberg and Taschini (2014) model an emissions trading system where compliance entities are small (price takers on the allowance market) and have to comply with the regulation by offsetting their emissions by the end of the horizon – the foresight is limited, 5 years, or perfect, 37 years. In particular, firms can abate emissions and trade allowances. Depending on the relative cost difference between abatement and trading, companies adapt their abatement and their trading behaviour. The model identifies abatement and trading strategies and allows for the decomposition of the allowance price, explicitly identifying the expected abatement effort within foresight.[16] Hence, the model is able to capture changes in the market expectations about future abatement efforts, e.g. the difference between expected total cap and expected total emissions, and it reflects these changes in the allowance price. This permits an intuitive interpretation of the allowance price. When the market-wide expectation about the abatement effort within the foresight is over-compliance, i.e. too many allowances are on the market, the allowance price equals zero (MAC price is zero). Conversely, when the market-wide expectations about the abatement effort within the foresight is under-compliance, i.e. too few allowances are on the market, the allowance price equals the corresponding marginal abatement cost. For a detailed description of the model inputs, model outputs, model assumptions and how this model relates to the DECC carbon pricing model, see Annex III.

The model allows us to compare the impact of different market supply reserve designs considering different triggers levels and different states of the world (shock scenarios), e.g. good and bad state of the economy (see Figure 7). As a sensitivity analysis, the model allows us to choose different trigger levels and shock scenarios under each design option in order to test how different mechanism configurations respond to the same scenarios. The selection of the trigger level is part of the sensitivity analysis, e.g. selecting trigger levels, is an iterative process. Trigger levels are chosen based on their illustrative quality in order to provide common ground for comparison along different MSR designs.

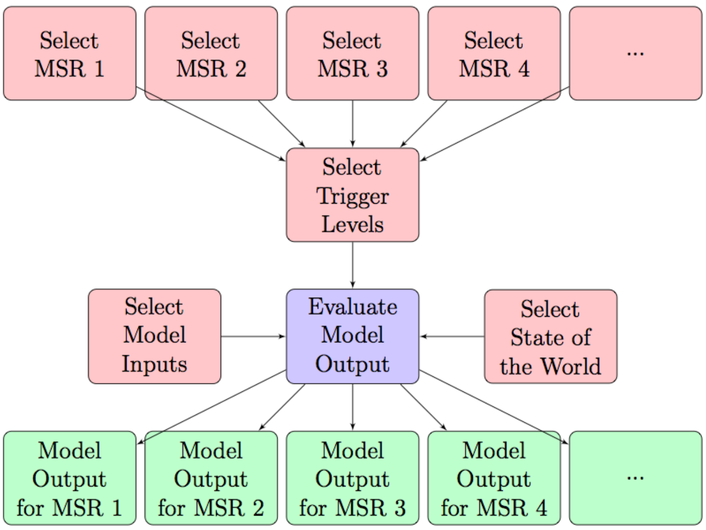


Figure 7 **Schematic overview of the procedure used for economic modelling**

[16] KT model allows to test the different mechanisms (different types of reforms). As such, the model will not be used to predict allowance prices: the level of modeled prices under each possible reserve mechanism does not represent likely levels of prices in the EU ETS; it is the relative difference in modeled prices and their behavior in time across scenarios that is insightful.

3 Comparing market stability reserve designs

Introducing an allowance reserve aims to provide the system with an internal, rules-based mechanism to address a market imbalance and improve the resilience of the EU ETS to demand shocks. A reserve aims to allow the supply of allowances to be regulated until the reserve is exhausted, thereby "ensuring inter-temporal efficiency" (European Commission, 2014b) and containing compliance costs to some degree.

The role of a market stability reserve (MSR) in the EU ETS is elaborated further in section 3.1. Section 3.2 presents lessons that can be learned from other commodity markets, keeping the fundamental differences between emissions allowances and other commodities in mind. Section 3.3 establishes the set of criteria developed in conjunction with DECC for the MSR. Section 3.4 provides a scoping of the various market stability mechanisms found in literature and practice, and compares the impact of those market stability designs. Finally, in section 3.5 the different designs will be evaluated against the criteria as the most appropriate designs to investigate in further detail.

3.1 The role of a market stability reserve

The purpose of the MSR in the EU ETS is to tackle the current surplus in the market and address future imbalances between supply and demand to ensure the objective of the EU ETS will be achieved. Unexpected shocks to the system could cause market imbalances, changing the cost-optimal pathway (see section 1.1). Some flexibility will help put the market onto its new cost-optimal pathway in the case of extreme events.[17] This will be done through managing the supply in order to ensure a credible and stable carbon price signal for low-carbon investments.

The MSR would act as a buffer responding to unexpected shocks by regulating the allowances available to the market:

- When the shock causes a market imbalance in the form of excessive oversupply, resulting in persistently low allowance prices, the market volume is reduced and allowances are put into the reserve
- When the shock causes a market imbalance in the form of excessive undersupply, resulting in persistent high allowances prices , the market volume is increased and allowances are released from the reserve (assuming there are allowances in the reserve)

It is important to understand whether or not the market is delivering sufficient scarcity within the foresight of participants such that low-carbon investments are made at the right time and emissions reductions are achieved in a cost-effective and economically efficient manner. In this report we look closely at these two different interacting factors: **sufficient scarcity** and the **length of foresight** of market players.

[17] It is important to note that the cost-optimal pathway cannot be accurately predetermined, but must be discovered, to a certain extent, by the market. Fluctuations are expected in demand while the system is in operation, and given that the future is uncertain the cost-optimal pathway cannot be known in advance.

The system gives an indication of scarcity…

The main indicator for scarcity is the carbon price. The carbon price in the EU ETS is not determined just by the existing demand and supply, but expectations about future supply and demand as well. Therefore, in theory, the carbon price of today is the future carbon price discounted back to the present.[18] Given that the cap on emissions is decreasing over the years, in order to meet the more stringent cap in the future, more costly abatement options will need to be taken up, increasing carbon prices. However, future demand is unpredictable due to uncertainty in economic output, political decisions and technological development.

…but participants might not apply it in an optimal way

If the long term considerations are not sufficiently taken into account by the participants in their abatement strategies, due to their short-sightedness or because the cap is not in line with the long-term target, the future scarcity will not be captured in the price. As a result, the cost of meeting future GHG reductions is likely to rise even more than is currently expected, as more dramatic, and probably more expensive, reductions will be required later on. An MSR could support the abatement strategy consistent with the gradual transition to lower emissions (European Commission, 2014b) by amplifying the signal that participants take today and encouraging a longer-term view.

The scarcity in the system, or, more precisely, the lack of scarcity, is reflected by the surplus in the system. The key question can therefore be seen as what the "right" or workable level of surplus in the system should be, including the option for it to be zero. For consistency with the EC's MSR proposal, the same definition for the surplus is used (see box below on what the surplus might include). It is important to note, however, that the amount of surplus in the system may not be the same as the amount of allowances available at a given price. This is because the surplus is held by market participants, and they may retain it for future use rather than make it available to the market. The private banking behaviour of participants is difficult to predict, but could overlap with the role of the MSR. This behaviour is discussed further in section 3.1.2.

3.1.1 The "right" level of surplus

It is important to see the current surplus in context. The EU ETS was established with the intention to fix the supply in line with the agreed GHG emissions reduction target and then allow the demand to determine the market price. The current surplus is the result of the flexibility in emissions reduction trajectories and some surplus can be expected to build up in the market to act as a buffer against times of higher demand. As there is now a very large surplus available, it is being used by different market participants for different reasons, but this does not equate to saying that a surplus is needed to allow orderly function of the market in all these cases, as described in this section, or desirable in terms of reaching long-term goals.

[18] In the long term the allowance price is determined by expectations for the future supply and demand discounted back to the present, which vary depending of the degree of foresight i.e. the amount of years for which the future supply and demand is considered. On the short term many other factors have an impact on the volatility of the carbon price such as temperature, energy prices and special events and announcements as shown by Feng et al. (2011). The short-term volatility of the carbon price is, however, not the focus of this study, because the purpose of the market stability reserve is limited to tackling extraordinary circumstances that may impact the long-term carbon price.

Box 3 Definition of the surplus in the EU ETS

What does the surplus include? It is important to note that the surplus can be defined in different ways. According the European Commission's MSR proposal, the surplus, also referred to as total number of allowances in circulation, for year x is the allowances issued from 2008 to year x plus the international credits used from 2008 to year x, minus the emissions from 2008 to year x and allowances in the MSR in year x (European Commission, 2014c). Within this definition it is possible for the surplus to be negative if firms 'borrow' allowances: the deadline for firms to surrender allowances equal to their annual emissions is four months into the following year, allowing them to use all allowances issued in that period (except between trading phases). Given the timing of allowance issuing in the EU ETS, this is a year's worth of freely allocated allowances and four months of auctioned allowances. If the emissions in year x are higher than the allowances issued in year x plus the surplus from year x-1 and international credits used, these additional allowances of year x+1 can be used to meet the compliance obligation, resulting in a negative surplus (shortage). For the 2013 compliance cycle these additional allowances are estimated at 1 billion EUAs (1.1 billion without backloading) of which 800 million EUAs are freely allocated to industry and heat production. If the additional allowances are considered as part of the surplus, the level of surplus would increase significantly, but it would not be possible for the surplus to be negative anymore.

The surplus held in the current market is used for a variety of purposes (Neuhoff et al., 2012):

- **Hedging by utilities** Utilities hold allowances for future use to hedge against exposure of their generation portfolio to price changes, allowing them to price carbon more accurately into their production process. Alternatively, utilities can also enter derivative contracts with banks that bought emission allowances as arbitrage opportunities. Schopp and Neuhoff (2013) estimated that the required level for hedging was between 1.1 and 1.6 billion by the end of 2012, for which the surplus can be used. This does not include industrial banking. The estimate corresponds largely with the survey conducted by BNEF (2014) but is higher than estimates by ENEL and Fortum of approximately 700–1000 million in Phase III (see section 4.1.1). According to some interviewed stakeholders, it is more logical for utilities to hedge through forward contracts, which are in line with the delivery date of electricity sale forwards. Restrictions on risk exposure in their hedging strategy also prohibit utilities from holding too many allowances. These derivative contracts are generally backed by physical allowances as the surplus is very large.
  Currently the most industrial firms have little to no need to hedge as industrial installations can be certain that they will receive free allowances. With free allowances set to decrease in line with the cap over Phase III, the hedging need of industry may grow.
- **Banking by manufacturing industry** Industry in the EU ETS receives free allowances and in Phase II many received more free allowances than were needed to cover their emission. These allowances are banked by the majority into the next year (Martin et al., 2013). Some firms only participate passively in the EU ETS, banking any surplus in free allowances and only buying allowances when facing a shortage. In Phase III the free allowances are expected to be insufficient to cover the emissions, so firms may have an even stronger incentive to bank allowances. The discussions with some traders, as part of this project, indicated that a large proportion of firms are unlikely to trade on the market. As one interviewee pointed out, if the allowance price remains low it has a marginal impact compared to other business operations (Ecofys and OEA, 2014). Neuhoff et al. (2012)

estimated that approximately 300 million of the free allowances from 2008–2010 were banked at least until 2011. Survey responses from the recent BNEF survey on the quantity of free allowances held by industry from Phase II ranges from 300 million to over 700 million allowances, although it was not specified whether this was for future compliance or speculation.

- **Speculation** Speculative buyers hold a part of the allowance surplus in the expectation that the carbon price will increase and carry its full risk. Speculators are often financial actors, but can also include industrial firms and utilities as well. They would buy more allowances than needed for hedging if the surplus is very large and the price is low. These are the amount of allowances not held for the purpose of hedging of future electricity sales nor banking by industry for future compliance.

In reality it is difficult to determine whether allowances are held for future compliance, passively or for speculation and as abatement strategies develop this may be subject to change.

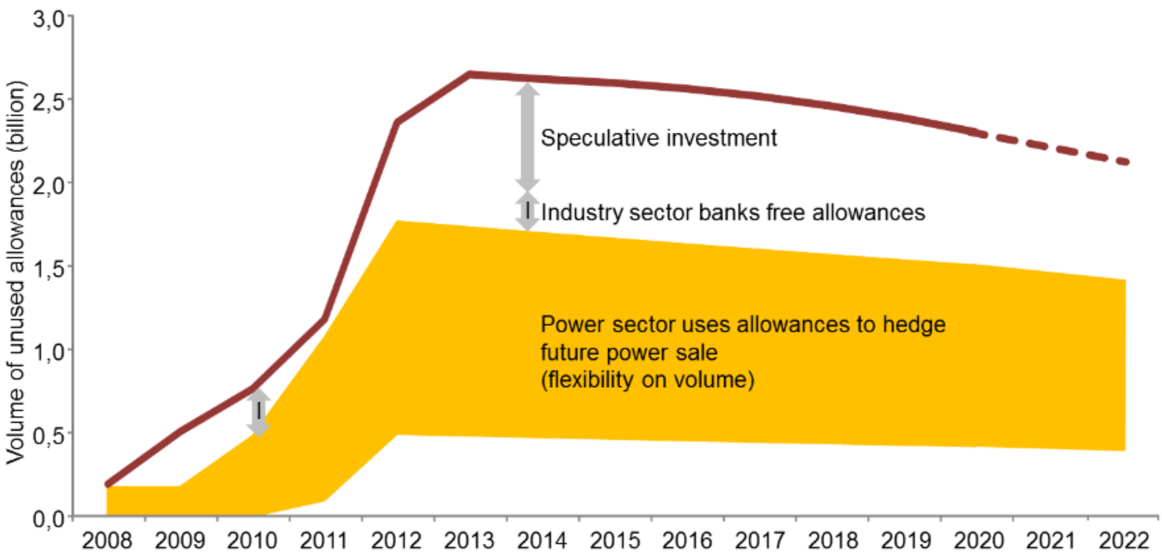


Figure 8 Example of how the surplus is used in the EU ETS based on data available up to summer 2011 (Source: Neuhoff et al., 2012).

As stated above, the market could build up some surplus as a buffer to allow for sufficient liquidity. Neuhoff et al. (2012) and European Commission (2014b) find that this liquidity is largely absorbed by the hedging demand, which is mostly related to forward electricity sales. Figure 8 shows a way in which the surplus could be used. Utilities sell electricity forward contracts up to 3 or 4 years and a share of the surplus is used to hedge for these forward sales.

According to the theoretical figure above, the current EU ETS market has a surplus that exceeds hedging demand. Neuhoff et al. (2012) interviewed various market participants and found that a clear distinction between banking for hedging and as a speculative investment was made by the interviewed parties. Speculative buyers were willing to pursue allowances as an investment if the rates of return exceeded 10 to 15%, much higher than the approximately 5% discount rate used for hedging. This meant that when the supply exceeds the demand for hedging, the discount rate for future carbon prices increases from 5% to 10–15%. This is in line with the findings of Schennach (2000) where a change in banking behaviour results in a step change in discount rate.

Schopp and Neuhoff (2013) showed that as the surplus increases, the discrepancy between current and future prices increases due to the increasing discount rate; a higher discount rate results in lower current carbon prices. Therefore, if the surplus remains within the range of the hedging demand, there is a higher chance that allowances can be sold at the higher future carbon price, which in turn leads to higher current carbon prices. If the hedging demand is exceeded, prices are primarily driven by speculative investments as there is a larger risk that the future prices, and thus higher returns, may not be reached. Speculative investments, therefore, demand a higher rate of return for investments, resulting in a higher discount rate and depressing of the current carbon price signal for investments. This is in line with Piris-Cabezas and Lubowski (2013), who estimate that the current EU ETS prices are consistent with future prices discounted at 20%, a discount rate corresponding to investments associated with significant perceptions of risk.

Conversely, if the surplus is too small, this could limit the ability of firms to hedge against future carbon risk if they are not able to access financial contracts for this purpose. This reduced liquidity in the market could potentially result in rapidly changing and unstable prices.

This discussion would imply that the "right" level of surplus is within the range of the hedging demand after accounting for the amount of allowances banked solely for future compliance. Various studies found that there is a strong correlation between the electricity price and the EU ETS allowance price (Aatola et al., 2013; Fell et al., 2013), which would indicate that the hedging demand of the utilities are primarily driving the allowances prices (Schopp and Neuhoff, 2013). On the other hand, one could also question whether any surplus at all is needed for hedging. As one interviewee pointed out, utilities use the surplus to hedge because there is a surplus.

Electricity forward sales can also be hedged through allowance futures contracts, which can already be bought from exchanges and may or may not be backed by holding surplus. The allowances that come onto the market between the date for compliance in the following year provide an additional buffer as well. The surplus would only be needed to absorb the potential fluctuations in emissions in each compliance year. Discussions with stakeholders, as well as evidence from the functioning of the first phases of the EU ETS, indicate that the financial market players will enter where there is an opportunity to make money through arbitrage. The flexibility and opportunistic nature of the financial sector means that is where there is demand, forward contracts will be available for sale.
This highlights the importance of the financial sector in the EU ETS to provide liquidity in the market. The difference between using the surplus to hedge and forward contracts is the price. Forward contracts that don't use the surplus are likely to be more expensive than utilising readily available surplus, because the lack of surplus indicates a tight market. With the current surplus, it is possible for all forward (and future) contracts to be covered by physical allowances. However, if the forward contracts were backed to a lesser extent by physical units, the prices of forwards will increase as the seller, e.g. financial intermediaries, would be short-selling[19]. The seller would be betting on the future prices, exposing itself to higher risks and therefore demanding a higher price

[19] Most trades are currently a relatively risk free carry trades, which takes advantage of the increase in future prices. Banks can borrow money cheaply and purchase EUAs now. These can then be sold at a higher price in the future with the price locked in now through a financial contract. So long as the future price curve increases more quickly than the costs of borrowing money then a profit can be made, while industry benefit on the other side of the trade from what is in effect a cheap loan to purchase EUAs.

for forward contracts. An increase in prices for forward contracts could, in-turn, stimulate low-carbon investments to limit the exposure to high allowance prices.

Since utilities sell power forward contracts, using allowance forward contracts with the same timeframe to hedge seems a logical choice. Industrial compliance entities may not be able to sell their production on forward contracts though. This makes hedging with allowance forward contracts to cover their future compliance costs riskier, because their future production and thus their future demand for allowances is uncertain. The consideration then becomes whether the risk of entering into forward contracts justifies the risk of investing in abatement measures instead as a measure to hedge against future compliance costs. In the current market this may be less relevant as the majority hedging demand comes from utilities. This may become more important in the future as free allowances for industrial entities decrease.

The appropriate level of hedging, and thus the "right" level of surplus to stimulate low-carbon investments, is difficult to determine, because each compliance firm has different hedging strategies. For utilities these depend, amongst other factors, on their current and future generation portfolio, which can be translated into a range of hedging demand changing over time. Hedging demand can vary based on a range of factors related to the general electricity market e.g. weather, fuel prices etc. Several interviewees indicated that hedging demand also changes over time. This demand can increase due to an economic boom or the reduction of free allowances for industrial firms, and changing power market structures may mean that Eastern European utilities would also need to hedge or hedge further into the future. It can decrease as a result of an economic recession or a decrease in emissions due to the increasingly stringent cap or installing more renewables. Furthermore, hedging needs and approaches may be linked to confidential business strategies. On top of this, demand from hedging for surplus allowances is linked to the structure of the derivative market. This makes it difficult for the MSR to regulate the surplus to the "right" level and interviewees stated that the right level would have to be evaluated closer to the introduction of the MSR.

3.1.2 The market stability reserve in the market

In theory, allowing market participants to bank should smooth out prices and prevent shocks. Any allowances that are withheld by the MSR reduce the number of allowances available for market participants to bank. This limits the ability of firms to abate in a cost-effective manner by shifting measures across time and hedge against any uncertainties in abatement costs, emissions and policies (Stranlund et al., 2014; Rubin, 1996; Schennach, 2000; Newell et al., 2005). By reducing allowances on the market, the power of the firm to absorb these uncertainties is reduced. However, in coming to this understanding, studies assume that there is certainty about the long-term target and that this is binding (Stranlund et al, 2014; Murray et al, 2008). In practice, firms do not perceive long-term targets as certain and their foresight is limited, which may mean that firms' own choices would not follow the cost-optimal pathway for the system as a whole. Therefore, the banking of allowances could be taken on by the regulator, putting the allowances in a reserve with the intention to keep the system on a cost-optimal abatement pathway to reach the long term GHG emissions reduction target.

The MSR allows discovery of the cost-optimal pathway and adjust the supply accordingly

The determination of the cost-optimal pathway still remains a challenge. Even in a situation where both individual participants in the system and the regulator had complete certainty on long-term targets, information asymmetry would still play an important role in determining the cost-optimal pathway, as discussed in section 1.1. Regulators and firms may have different perceptions of the cost-optimal pathway, which needs to be discovered, to a certain extent, over time. The surplus in combination with banking allows firms to temporally shift abatement to match their perceived cost-optimal pathway and absorb potential abatement cost shocks. By regulating the surplus through an MSR, the Commission could potentially produce a less cost-optimal abatement pathway. It is therefore important that decisions about when the reserve acts in the market and what actions it would take are carefully considered (Tschach Solutions, 2013).

…***but it should not micromanage the market***

The MSR should only intervene in the market in exceptional circumstances (see section 1.1). Frequent intervention would reduce the efficiency gains from trading (Harstad and Eskeland, 2010). It would prevent the EU ETS from acting cost-effectively, because frequent interventions might lead to unpredictable carbon prices, and may encourage firms to take different abatement decisions than might be cost-optimal. Firms may prefer to keep their allowances for future use rather than abating and trading, increasing the compliance costs of firms in need of allowances. This reduces the ability of the market to deliver the lowest cost abatement. If the market is micromanaged, it may become more efficient to use a different policy instrument to reduce GHG emissions. Clear rules must be set to define what would be considered as exceptional circumstances:

- If an MSR is implemented with clear and transparent rules, the intervention can be anticipated and included in the trading strategy of the market participants.
- If an MSR is subject to manipulation or political discretions, the MSR may offer little advantage over market participants banking, depending on the relative merits of ad-hoc political decisions and the private sector decision-making, and under these circumstances the MSR could even add more uncertainty to the market due to its size.

…***nor simply mimic banking by market participants***

Even with clear and transparent rules, some stakeholders are still concerned that an MSR is ineffective without any price consideration as it merely mimics the private banking function. Current carbon prices should factor in future supply. Therefore, in theory, there is no reason for carbon prices to increase while allowances are in a reserve and could be returned at any time or price if participants are sufficiently forward looking, unless participants believe that there is a possibility that these allowances might be cancelled. However, where the threshold for return is sufficiently high, such that there is uncertainty whether the allowances will return, or return within a timeframe that is significant for the compliance participants, such a reserve could still impact decision-making.

Importantly, in practice the market does not look as far ahead as is assumed in theory. Perfect foresight, tested in some of the modelling in this project, exists in theory alone. Climate change mitigation targets are uncertain both due to intra-EU factors, and the wider UNFCCC negotiation framework. Participants see the future targets as uncertain and the banking value of allowances is heavily discounted, leading to the market responding more to short-term decisions such as backloading. Discussions with stakeholders indicate that foresight is limited, although the exact

extent of foresight is not known, and varies between type of market participant and individual player.

In the case of limited foresight, if the MSR holds a number of allowances that reduces the surplus below the hedging demand for a period of time beyond the market's foresight, higher prices may result due to (expectations of) lower supply to meet hedging demand. Further discussion about the way participants look to the future in practice is provided in section 3.4.2 and in the modelling, section 5. The box below also outlines how the uncertainty of carbon prices in the EU ETS also impacts firm's behaviour. These strategies demonstrate a mismatch between theoretical expectations of perfect foresight and what might occur in practise.

Box 4 Business strategies to deal with uncertainties

How businesses deal with uncertainty

In all markets there is a level of uncertainty on what the future prices will be, which affect the decision to either invest in measures to mitigate the risks associated with this uncertainty or employ other strategies to minimise the risk. Specifically for the EU ETS, firms can use various strategies to address the risk associated with the uncertainty in future allowance prices (Ecofys and OEA, 2014):

- Reducing emissions by investing in abatement measures (although no evidence was found that this strategy is currently used)
- Trading strategies using various financial instruments available on the allowance market
- Commercial engineering to minimise or pass-on the risk to other parties
- Lobbying and initiating legal challenges
- Delay investments and decisions until more information is known
- Flexibility strategies through diversification of their business portfolios

Firms use a combination of the instruments above to adjust to unexpected circumstances and protect their interests, which would lead to an adjustment of their demand for allowances.

Interviewees also expressed that how the reserve is seen by the market depends on the design of the reserve. The reserve will be priced into trading decisions to some degree, but it depends on what the threshold to return allowances to the market will be and at what rate the allowances are returned. The interviewees did not have a view on what the exact impact of the reserve would be on the market, as these would depend on many design variables and the economic situation at that time. They believed that the impact of the MSR would have to be evaluated when the implementation date draws closer and moves into the hedging timeframe of utilities, i.e. in two years' time at the earliest. Some interviewees responded that at the moment the only impact the MSR has on the market is symbolic and when the MSR has been put into legislation will it have a real impact on the market.

There are concerns that an automated intervention may lead to more volatile prices (Trotigon et al., 2014); thresholds and parameters can be set wrong or the adjustment comes too late since it cannot respond as quickly to market developments as market participants that can trade allowances much faster than a reserve is able to.

In designing an MSR, or any intervention, interactions with other proposals also need to be considered. The current discussions of the MSR need to consider both the operation of the MSR in the market in general terms, but also specifically the way the MSR would land in today's market (or the market at the time of implementation). This particular question raises two additional considerations:

1. The degree to which the MSR would tackle the current surplus
2. The interaction of the MSR with other proposals e.g. back-loading

In this context, back-loading is important. Back-loading leads to a reduction in the surplus in 2014-16 and a rebound in 2019 and 2020 and, therefore, does not affect the average size of the surplus that is estimated to be around 2 billion allowances in Phase III and IV, peaking at 2.6 billion in 2020 (European Commission, 2014b). In addition, the EC's MSR proposal also introduces a smoothing mechanism to spread out the auctioning of back-loaded allowances into the first two years of phase IV, to prevent additional supply-demand imbalances at the transition between phases (European Commission, 2014c).

3.2 Experiences from other commodity markets

Mechanisms to provide more market stability are deployed in various commodity markets. Supply buffers of commodities are held in case of sudden price changes as a result of unanticipated exogenous shocks or market imbalances. These stocks could be held for supply security or act as a market stability reserve that attempts to provide more certainty to the market. Price control mechanisms try to control commodity prices within a certain range by setting upper and lower limits. Measures regulating demand for commodities are another way of providing more market stability.

Experiences in various commodity markets with market stability mechanisms, in particular supply reserves, can provide some insight for the design of a market stability reserve in the EU ETS. The oil, food and currency markets summarised below in Table 2[20] demonstrate the key characteristics and examples of the impact of such measures. However, comparisons of the emissions trading market with the commodity markets must be made with care (Fell et al., 2012):

- Emissions allowances are not a physical commodity and supply limitations are political rather than physical due to production capacity or resource limitations, for example
- Emissions allowances have almost zero cost of carry, meaning that there is no financial cost in banking allowances for future use or selling, while other commodities have storage costs, depreciation or additional costs due to their perishable nature

The objectives of the mechanisms in the different commodity markets are also very different. The objective of an MSR in the EU ETS is to ensure emissions are reduced in a cost-effective and economically efficient manner by avoiding extreme market imbalances and, therefore, providing a more stable investment signal. Regulating the quantity or price is a way for the MSR to achieve this. This is different from the mechanisms in the other commodity markets, where regulating the price itself is the primary objective of the reserve mechanism, often supplemented with supply security and other economic objectives. Another key difference in the EU ETS is that the intention is to gradually reduce the dependence on and demand for the commodity (i.e. emission allowance), while in the other commodity markets maintaining demand is desired.

Furthermore, it is often the case that reserves are created explicitly to save or store allowances for later use. In the case of the EU ETS, the current MSR proposal includes a reserve as part of regulating the market, not explicitly as a safety buffer, although it could also have such a function in the longer term and in different circumstances than we see now.

These key differences should be taken into account when considering the experiences from other commodity markets.

[20] The selection criteria and more detailed case studies of these three commodity markets are provided in Annex I.

Table 2 Overview of selected commodity market characteristics for further evaluation

Market	Mechanism	Objectives	Decision structure	Outcomes and impacts
Oil	OPEC	Stated: • Price stabilisation • Secure supply • Return to producers Actual implied: • Producer income maximisation • Avoid fuel switching	• Bi-annual and extraordinary meetings • Aggregate total production limit agreed by consensus	• Decision system is problematic in practice but is long-lived, over 50 years • OPEC production quotas often ignored, hence switch to aggregate limit. Also often ignored – typically falls to Saudi Arabia to 'police' the system. • OPEC decisions have significant market and price impacts • Prices have increased significantly in recent years, more a result of supply constraints and demand growth than OPEC
	IEA reserves / US Strategic Petroleum Reserve (SPR)	• Security of supply (inc. emergencies) •	• Consensus of IEA 28 countries • US president decision	• Decisions are difficult to reach – took 4 months, following US deciding to act, to agree a release in 2011 • Reserve release had only modest, and short term impact on rising prices, was not sustained
Food	Buffer stocks (Cocoa)	• Food security • Price stability	• National systems, rule-based and discretionary; OR • (Cocoa) International agreement on rules and prices, and rule-based use of buffer stocks	• Administration of food buffer stocks problematic: high storage costs, wastage, mismanagement, political interference. Stocks rarely used at 'right' time. • Some success in buffer stocks moderating downward price trends and price spikes, but becomes costly when mitigating upwards price trends • Cocoa – agreements in place for 16 years (1973-1990), provided some price stability for producers, but eventually failed due to: difficulty to find agreement between producers and consumers, some major players opted out, prices rarely remained in ranges, cost, private reserves.
Currency	Currency Peg (UK and ERM)	• Exchange rate stability - and ancillary economic and trade benefits • Currency union	• Central banks and political leaders • (ERM) EU central banks agreed fixed rates and margins rules, adjustments agreed politically	• Some currency pegs successful – size is important, must be backed by significant currency reserves and political will (i.e. China), and some flexibility • Most currency pegs unsuccessful – peg becomes unrealistic compared to 'actual value', investors and capital leave, very high costs to government to maintain peg – often peg is abandoned (i.e. Mexico 1995, SE Asia and Russia 1997) with severe economic consequences • UK ERM – unsuccessful, speculators gambled successfully that UK government could/would not afford to defend 'overvalued' pound. Led to UK withdrawal, subsequent economic crisis, devaluation and recovery. ERM eventually became the Euro currency.
	UK flexible mechanism	• Interest rate stability • Exchange rate stability	• Rates set by Monetary Policy Committee and market feedback	• Relatively low oversight, low cost, higher certainty for markets • Open to manipulation by markets, function called into question and reforms underway

Lessons learnt for the EU ETS

The experiences from these three markets can help inform the design of an MSR in the EU ETS. Keeping the differences in objectives, nature and cost of carry in mind, the following lessons relevant for an MSR in the EU ETS can be extracted:

- **Reserve mechanisms can be good at supporting prices in times of oversupply, to the benefit of suppliers/producers** – evidence from food markets shows that using reserves to reduce supply (restriction/storage) in times of oversupply helps to reduce price falls. ETS has the benefit over these markets that policy can directly control supply and that storage has virtually no costs and, therefore, it seems clear and aligned with policy objectives that a reserve could be beneficial at maintaining prices above a floor, though a guaranteed floor price could impose additional costs on compliance entities. Therefore, a minimum auction price would be preferred.
- **Unlike physical commodity reserves, responding to ETS undersupply should not lead to higher government costs, but it could reduce revenues –** for physical goods, oil and food, high prices caused by undersupply quickly caused financial problems for governments, and these were typically the reasons for these mechanisms to fail. Increasing the size of the reserve for oil and food to anticipate undersupply can be very costly though, because significant costs may be associated with storing these physical commodities. Addressing undersupply through reserves also had little effect in the case of the SPR, but use of supply adjustment by OPEC had significant influence. In the ETS, in times of significant undersupply the choice would be to either let prices rise, unilaterally increase supply, which would increase policy uncertainty, or increase supply through a rules-based reserve. If the reserve is not managed within the total cap, this would increase the risk of not achieving the environmental goal, particularly as the reserve approaches empty. Similar results are faced in currency markets, but markets and investors are also used to central banks unilaterally and regularly creating new supply, with signalling systems and financial instruments relatively effective at communicating and balancing the impacts of such decisions so that their impact is spread. It is important to note that in the EU ETS the costs are borne by different parties – those that must purchase allowances and end consumers when costs are passed through. Governments benefit from increasing allowance prices through auctioning. Increasing supply would depress these prices, reducing the financial benefit.
- **Decisions are inevitably political to some extent, this is unavoidable** – each of the observed mechanisms was subject to political involvement, this is simply where the debate and decisions on acceptable prices, revenues and costs happen. The most rules-based approaches, in terms of food buffer stocks and currency pegs had mechanisms that would automatically adjust – but their eventual success or failure is based on the willingness of government to bear the extra costs, and potentially face down markets, in times of crisis and ability to adjust rules so they remained relevant over time. This finding supports the will in the EU ETS to create a politically-independent and rule-based predictable system, but it is likely that any design will still have, and need, political involvement, e.g. review periods, at some point. Review periods were built into many of the mechanisms in the commodities markets, e.g. annual meetings and quotas that would trigger a review. For the EU ETS an annual frequency may create instability as allowances are surrendered once a year.

Designated review points at longer intervals, for example every five years or alongside the EU ETS phase cycle, would be more beneficial for the mechanism to adapt and evolve while limiting instability in the market.

- **Reserves promote both short and long term price stability** – when they function successfully, reserves were used in all markets to smooth price shocks in the short term, and were also used in food and currency markets to smooth long term price changes, i.e. lower global grain reserves leading to higher price volatility, and currency reserves used in China to manage currency appreciation in a way that benefitted economic growth. In these cases the size of the reserve also had a bearing on their impact, larger reserves typically providing a greater stabilising impact against higher prices, their impact in the case of low prices is dependent on the mechanism, but can be both stabilising/reversing or sustaining the trend.
- **Reserve mechanisms can be vulnerable to external actors and shocks** – although to some extent this is most relevant to physical commodities it was also observed in currency markets where fixing prices within a target band created vulnerability, particularly to speculation. This was an important reason in the failure of a number of reserve / price fixing mechanisms, where there were insufficient resources, credibility and/or willpower to address the problems. Any MSR created for the EU ETS has to consider carefully the potential role of speculators and the ways in which the mechanism can itself be vulnerable to shocks. The potential for speculation is considered when MSR designs are compared in section 3.4 of this report.

Other lessons, which are more general and/or less relevant to ETS, were summarised in Table 2 and can also be found in Annex I, these include the costs of storage and specific co-ordination (i.e. timing, control and participation) issues.

3.3 Criteria for the market stability reserve

The MSR in the EU ETS should be designed with particular goals in mind. In order to choose the best design, a clear set of criteria for attainment of these goals are needed. DECC has defined a set of key criteria against which to design and test market stability mechanisms:

- **Stable long-term price signal**: Provide a stronger, more stable low carbon investment signal by increasing stability of long-term prices;
- **Resilience to shocks**: Improve policy resilience by allowing the EU ETS to respond, in a timely and predictable manner, to unanticipated outside shocks or events;
- **Certainty about the circumstances under which to apply supply adjustments**: Increase certainty about how and under what circumstances supply would be adjusted within phases. Operated through rules that are predictable to the market and not open to political interference; and
- **Balanced supply and demand:** Help address the current surplus and prevent a recurrence of chronic supply-demand imbalance
- **Preservation of system integrity**: Preserve the integrity of the system (including ensuring emissions remain within environmental targets and maintaining market efficiency[21]) and be robust to a wide range of external circumstances

[21] This factor could be seen to include a number of facets such as liquidity, manipulation risk, price discovery, cost-effectiveness in reaching long-term goals.

The UK also consider that a market stability reserve would need to respect Member States' fiscal sovereignty and be supported by clear analysis to demonstrate the proposed design appropriately manages the risks of unintended consequences

3.3.1 Consensus-based policy in the diverse EU context

The establishment of the EU ETS is an impressive feat on its own in the EU, given the political challenges in the consensus-based policy environment of the EU; the European Commission (EC), Parliament and Council all need reach a consensus before a policy be implemented, changed or retracted. The Parliament and Council each houses representatives of all the Member States, which all have a view that may be very different from each other. In addition, the EC is delegated specific decision-making powers that cannot be delegated further. These elements bring some challenges and limitations to design options and implementation details of an MSR in the EU ETS that are politically feasible. For example, it would be difficult for the EC to delegate decision-making power related to the MSR to an independent body or so-called 'central bank'.

Some of these political sensitivities are already included in the criteria for a market stability reserve set out by DECC. The main challenges relevant to an MSR in the EU ETS are:

- **Respecting Member States' autonomy and fiscal sovereignty:** any European instruments such as an MSR might be interpreted as a European-wide tax if they are seen as holding the price above the market price, which could be problematic in terms of fiscal sovereignty. Furthermore, implementation designs that require handing over the control of auctioning to a central authority could undermine the autonomy of Member States in managing assets and raising revenue.
- **Need to agree between Member States:** the most cost-effective pathway for the EU ETS as a whole may not be the most cost-effective pathway for each Member State. Each Member State has different circumstances and an MSR may not be in the best interest of some Member States.

Because there is a diversity of interests amongst EU MS, political negotiations are likely to play a role in technical discussions about the MSR too.

Although none of the challenges identified are impossible to overcome, the political feasibility of MSR designs at all stages of implementation, including the review stages, must not simply be neglected. The appraisal and assessment of the various MSR designs will not focus on the political feasibility, but will highlight this where relevant.

3.4 Trigger options for the market stability reserve

Many design options for a reserve in emissions trading systems can be found in literature. The main discriminator between the different designs is the type of trigger used to initiate adjustments by the MSR. DECC has identified a list of triggers to investigate in this study, which are:

- Surplus
- Price corridor
- Price trend
- Hybrid surplus/price

- Changes in economic conditions
- Changes in production

For each trigger option, the potential impact on the market e.g. carbon prices and their volatility, and on the behaviour of market participants is discussed, including potential for market manipulation (European Commission, 2014b). Some impacts or considerations relate to all trigger options, these common issues are addressed first.

In addition to a summary of the potential impacts, each trigger is also evaluated in relation to five main criteria:

- ETS fundamentals – the degree it supports or undermines the objective and functionalities of the EU ETS e.g. the cost-optimal pathway, quantitative instrument, banking, price discovery etc.
- System responsiveness – the responsiveness of the mechanism to different unexpected shocks
- Predictability – the degree of predictability of when an intervention by the MSR occurs
- Data – the availability and reliability of the data to determine when the MSR is triggered
- Feasibility – the feasibility of implementing the MSR given the EU context

The trigger types are evaluated based on the analysis of European Commission (2014b), DECC (2014b) and other relevant literature sources, interviews with stakeholders and own analysis. The evaluation is mapped onto the key criteria described in section 3.3 to provide a summary of the relative merits of each trigger.

Chapter 4 goes into further details for selected MSR designs on the trigger levels that would qualify as an unexpected, significant shock and degree of adjustment necessary to restore the market balance. Detailed considerations of the impact of the selected MSR designs follow in chapter 5.

3.4.1 Impacts and considerations common to all triggers

Many interviewees commented that the impact of the reserve would depend on the trigger threshold levels and intervention levels (see section 3.1.2). Section 3.4.1.1 provides the common impact on the market and section 3.4.1.2 addresses common considerations choosing a trigger design. Other considerations specific to the trigger types are discussed in the individual sections that follow.

3.4.1.1 Common impacts on the market and behaviour of market participants

Regardless of the trigger selected, it is important to take note of the following considerations: setting the triggers at the right level, the role of foresight, investment behaviour, market liquidity and behaviour impact on price volatility.

The importance of setting the trigger parameters appropriately

The threshold bandwidth of each trigger, i.e. the difference between upper and lower threshold, should not be too narrow or too wide. If the threshold bandwidth is too narrow, an MSR will continuously intervene as long as there are allowances in the reserve.

However, if the bandwidth is too wide, an MSR may not intervene at all and will not be able to fulfil its purpose of addressing the market imbalance. The same is valid for intensity of the intervention: if interventions are too strong i.e. too many allowances are injected or removed, the MSR could be continuously triggered by its own previous action, and if interventions are too weak, the MSR is not effective at all.

An MSR could put firms back on the cost-optimal pathway or, if the trigger threshold levels are set incorrectly, lead to firms deviating from their cost-optimal pathway (see section 3.1.1), despite market signals. In particular, if allowances are not all returned from the reserve, this would increase overall costs, as more abatement is required than would otherwise be the case to stay within the cap.

The role of foresight

The impact of each trigger type depends on how far the market is looking ahead. Although the future emissions in the EU ETS are relatively uncertain, market participants do have a sense of whether additional abatement is needed in their foresight window, given the current supply demand balance. The uncertainty about future emissions depends, amongst other factors, on the timescale that participants are considering, which differs between market participants. If no additional abatement is needed in that time window then, although a price trigger provides a signal about the types of abatement costs that could be worthwhile, these abatement options will not necessarily be taken up. If it is expected that the reserve will change supply to an extent that would lead to scarcity, this could have an impact on abatement measures taken. However, the further market participants look ahead, the more uncertain emissions are. Some compliance entities may want to abate earlier, but also want to ensure that, at a minimum, they do not make a loss on their investment. The price signal from a price ceiling could be used as an indicator of what measures should be taken and what measures are more risky and a price floor provides certainty on minimum return. Other market participants are more driven by expected supply of allowances in their abatement decisions. A surplus trigger could act as an indicator for changes to the future supply. The different signals provided by the surplus and price triggers can help support the range of players on the market in taking abatement decisions. By using a hybrid trigger, the surplus and price signal can be combined.

Investment behaviour

Economic conditions are generally reflected in the level of surplus or allowance price, as was shown by the economic crisis in 2008; the surplus increased and the allowance price dropped (see chapter 1). Analysis of market participants' behaviour has confirmed that during poor economic times the amount of funds available for investments is already low. By restricting the amount of allowances, allowance prices would be supported and participants facing carbon costs would have fewer funds to invest in e.g. low-carbon technologies (Ecofys and OEA, 2014). Linking the trigger to remove allowances from the market during periods of reduced economic activities — which could be picked up by any of the triggers explored here — might have undesired downward spiralling effects on the low-carbon investments in the covered sectors. On the other hand, low allowance prices may cause the covered sectors to lock-in carbon-intensive technologies as the investment case for low-carbon investments cannot be made. It is therefore even more important that the covered sectors have sufficient access to funding to allow the cost-optimal pathway to be followed.

Market liquidity
The MSR reduces the volume of allowances available in the market. With a decreased number of allowances in circulation the market has less liquidity meaning that small changes in demand could result in large changes in price. The allowance price on the market is not determined by the total quantity of supply and demand, but by the allowances that are actually traded on the market i.e. the marginal demand and supply. Studies show that many industry participants currently do not actively trade in the market extensively (Martin et al., 2011; Ecofys and OEA, 2014), meaning that the majority of allowances they hold do not participate in the market and actual price formation. If a trigger is set without taking these allowances held by industry participants into account, too many allowances that actually contribute to the liquidity of the market may be taken out of the market, ultimately compromising liquidity. It is also possible that by reducing surplus and increasing prices, an MSR may change the behaviour of industry participants as carbon costs become more material to their operations.

By reducing the quantity of allowances on the market, allowance prices could also become more prone to manipulation by fewer traders, which may cause more volatile prices in the short-term, although regular auctions could go some way to counteracting this impact.

Behavioural impact on price volatility
Theoretically, the potential intervention of the MSR is always reflected in the price as the price is formed based on expectations of future supply and demand and an MSR with clear intervention parameters provide participants with some expectations about when interventions occur.

The expectation of an intervention can induce self-adjusting behaviour of market participants to strong price changes (Taschini et al., 2014). When compliance participants see prices getting close to a price ceiling for example, they might be concerned that an injection of allowances will devalue their allowance holdings, and react by selling allowances that they have. Self-adjusting behaviour can also take place in the opposite direction, inducing a price rise as the carbon price comes close to the price floor (CBO, 2010; Grüll and Taschini, 2011). Even for non-price triggers, market participants can use price changes as an indicator of expected intervention by the MSR. This self-adjusting behaviour is more likely for financial intermediaries while compliance entities may be less responsive to the extent that they bank allowances for risk management purposes.
If the intervention levels are sufficiently strong, the presence of a reserve could reduce price volatility due to the self-adjusting behaviour and allow the MSR only to intervene under unexpected persistent shocks.

The opposite behavioural effect occurs when intervention by the MSR is not expected, in particular for non-price triggers as they cannot be observed on a frequent basis. The MSR may increase price volatility at the point when the intervention is announced and volatility could be stronger the longer the time between the announcement and actual intervention. Market participants may want to sell their allowances ahead of the injection from the reserve, while buyers may want to wait until after the injection, in anticipation that prices will drop. This increase in traded supply and decrease in demand on the market would depress prices although this may be limited by expectations about how much prices will drop following injection. Since the injection would still go ahead independent of how the market responds to the announcement and remains the same in any case, the supply in the market would increase even further. Right after the injection or when prices dropped to around the expected level the demand would rebound.

The response would be reversed in the case of withholding. The impact of the MSR could, therefore, be enhanced by the behaviour by market participants, leading to more volatile prices.

3.4.1.2 Common pros and cons of each trigger option

Each trigger is evaluated on five main criteria and common considerations regarding these criteria are provided in this section.

ETS fundamentals

All trigger designs are capable of steering the market onto the cost-optimal pathway as long as the trigger levels are chosen appropriately. However, some trigger options change the fundamental operation of the EU ETS. A volume-based trigger maintains the key characteristics of being quantity-driven: the supply and demand continue to determine the price, allowing for price discovery. Economic activity triggers also maintain the quantity-driven nature of the EU ETS, but move it towards an intensity-based cap, which may not fit with the aim to decouple economic growth from emissions unless intensity is reduced over time. The price trend trigger also allows for price discovery to a certain degree, but a price corridor would move the EU ETS aware from a purely quantity-driven instrument. On the other hand, a price corridor may provide more certainty for investment decisions and does not merely mimic private banking, a fear expressed by interviewees in the case of a surplus-triggered reserve. The advantages of the surplus and price-based trigger designs can be captured by the hybrid approach, but the downside is the potential clashes of the price and surplus trigger.

System responsiveness

The main shocks to the EU ETS are market, political and technological shocks, influencing the demand for allowances. The impact of these on allowance demand manifests itself through the allowance surplus and price, so both a volume and price-based triggers could respond to all variations of shocks. Some technological shocks may not cause a market imbalance though but still have an impact on the price, which could lead to price triggers responding in the wrong direction.

On the other hand, price triggers can respond much faster to shocks as prices can be observed daily, given it a key advantage in terms of response time over all other trigger types. Any designs using the surplus as a trigger are currently limited to annual intervention as emission data is only published annually. Triggers based on economic activity may be able to respond faster than surplus-triggers, but can only respond to economic shocks. Relative triggers, including the price trend trigger, are unable to address the current surplus though and would need to be implemented with another policy measure if the current surplus is also to be addressed.

Data

For all trigger options publicly available data can be used, but not all data is equally transparent or available. Data availability is best for price-based triggers as allowance price data is readily available with resolution smaller than a day. Data on surplus is also very transparent, but only available on an annual basis. Only data for economic activity may be less transparent and significant corrections to the data is not uncommon, sometimes even a long time after the initial release.

Predictability
As long as trigger thresholds are set in advance, interventions are predictable over the long term. Most interviewees preferred absolute thresholds in terms of predictability over relative thresholds though. Using a price corridor allows the market to make decisions based on the price levels at which intervention occurs. Some interviewees expressed concerns that within the price corridor the price is actually more volatile and unpredictable, because price-based triggers are more vulnerable to manipulation. The risk of manipulation is much smaller for the surplus and economic activity-based triggers, although the impact of these triggers on the price is hard to predict.

Feasibility
The feasibility of each trigger faces both technical and political challenges. A stakeholder consultation by the EC showed that a surplus trigger is widely accepted by market participants and may be less politically contentious. Some stakeholders, in particular industry stakeholders, also voiced their support for a trigger based on economic activity. One interviewee also supported a price trend trigger as it builds on an existing EU ETS measure, but all expressed concerns about the political feasibility of a price corridor. Nonetheless, setting the trigger thresholds will be a challenging exercise for all trigger types as the thresholds would be designed to only act in extraordinary circumstances. Importantly, the threshold levels also need political agreement, although this may be easier for trigger types that are more politically accepted.

3.4.2 Volume-based mechanism

A volume-based trigger mechanism in the EU ETS uses the surplus in the system as a parameter to determine intervention by the MSR. The surplus quantity can be used as an indicator of the market imbalance (see section 3.1.1).

Rather than using absolute terms to determine the corridor within which the surplus can move, relative terms could be used e.g. the change of surplus compared to the previous year (European Commission, 2014b). Crossing an upper or lower value of annual change of the surplus would then result in allowances being moved from or to the MSR. Using a relative approach may not necessarily improve the market balance in absolute terms and therefore this study only focusses on an absolute surplus trigger design.

3.4.2.1 Surplus

An MSR triggered through surplus works as follows:

- When the surplus is higher than the upper bound threshold for allowance surpluses, allowances are moved from the market to the reserve.
- When the surplus is lower than the lower bound threshold for allowance surpluses, allowances are injected from the reserve back into the market.

Trigger design
The surplus in the EU ETS can be defined in different ways (see section 3.1). According to the EC's definition, the surplus in any year is the difference between the total allowances issued and the total emissions accumulated from 2008 to that year, taking into account any international credits that were used or put into the MSR in the meantime.

This would be different from looking at the surplus as the difference between the supply in the market, i.e. allowances that have been issued so far, and the verified emissions (IETA, 2013). The EC's definition of the surplus provides a consistent timeframe between the supply and emissions (see Box 3 for the differences between approaches). In this study the definition for surplus of the EC is used.

Impact on the market and behaviour of market participants
A surplus-triggered reserve may introduce more price volatility as the liquidity in the market is reduced by putting allowances in the reserve without any restraint on price (as would be the case with a price corridor). On this basis, one interviewed party was not convinced that a surplus-triggered mechanism would have a positive effect on the market.

Given the increasingly stringent cap, market participants may anticipate that the allowances in the reserve will always return to the market at some point in time. As it is uncertain what the impact of these allowances will be on the market, market participants may rather wait until the reserve is exhausted before abating. Participants may prefer to take on higher compliance costs for a few years, because the business case related to investing in abatement measures is seen as less certain than the return of allowances?. Private sector banking activity can influence whether or not allowance will actually return to the market, though. When significant private banking occurs and as a result a level of surplus in the market is maintained this could prevent injections into the market for some time.

The surplus might also not be the right indicator for the state of the market. The market could be very tight with a high surplus if market participants are sufficiently forward-looking, i.e. market participants may not be willing to sell their banked allowances in anticipation of future scarcity and fewer allowances are available for purchase on the market. If firms decide it is cheaper to abate earlier in order to reduce their current compliance costs and bank allowances for later use, this would increase the surplus and the MSR would be triggered to withhold allowances.

Other market behaviour impacts common to all triggers are described in section 3.4.1.

Market manipulation risks
Opportunities for gaming under a surplus trigger are very limited in the EC's definition of the surplus. The surplus is the total allowances that have not been used to cover emissions, so the only way market participants can trigger the release of allowances in the market is to increase their emissions and forfeit their own allowances through surrendering for compliance. This would only be possible by players with large quantities and there is no financial rationale to do this.

Table 3 Summary of the pros and cons of a surplus-triggered reserve

Key features	Pros	Cons
ETS fundamentals	Maintains the EU ETS's key characteristic of being quantity-driven. Supply and demand continue to determine the price. Steers the market onto the cost-optimal pathway if firms are too short-sighted while allowing for price discovery.	A surplus-triggered reserve may merely mimic the private banking function and might even be triggered by desired investments in abatement activity meant for banking (see section 3.1.2) Given the limited foresight of most firms and reluctance to investment in abatement measures to hedge against future carbon exposure (Ecofys and OEA, 2014), this seems unlikely though.
System responsiveness	The impact of a range of unforeseeable events that lead to a market imbalance will be addressed, as it translates to a change in the surplus. It is also able to address the current large surplus.	The MSR can only respond once a year as relevant data for a whole year only becomes available from May of the following year. This implies a time lag between the accumulation of surplus allowances to the trigger level, and an actual trigger event. Although unlikely, intervention may come at a time when the market has balanced itself again, unintentionally causing some degree of imbalance. Generally, this frequency is likely to be acceptable for a system designed to capture extremes, not regular changes.
Data	While the methodology for determining the upper and lower thresholds needs to be carefully defined, the underlying data are publicly available and transparent as they are based on verified information from the registry.	Limited to annual data frequency (see System responsiveness)
Predictability	Surplus trigger levels set in advance allows the market to predict when, and to what extent intervention would occur. Possibilities to influence the surplus level to trigger the MSR are very limited.	The exact impact on the allowance prices is difficult to predict other than that prices will go up or down. However market participants will have clear visibility on the volume of allowances available at auction.
Feasibility	The EC's analysis of stakeholder input shows that a surplus-based intervention mechanism is widely acceptable to market participants and may be less politically contentious. This corresponds to comments by most of the interviewed stakeholders in this study.	The EC and some interviewees indicated that the hedging requirements could be used as an indicator to set thresholds. The hedging requirement changes over time though, meaning setting the thresholds remains a challenging exercise.

Table 4 Assessment of a surplus-triggered reserve against the key criteria

Criteria	Criteria largely met?	Clarification
Stable price signal	Limited	No explicit price signal is provided by a surplus trigger and allowances can return from the reserve at any price.
Shock resilience	Yes	A surplus trigger is able to respond to allowance demand shocks that would cause an imbalance to the market as long as the trigger threshold for injection is set appropriately low to maintain sufficient allowances in the reserve and only addresses shocks.
Adjustment certainty	Yes	All parameters can be set in advance and timing of intervention is fixed, allowing the market to anticipate interventions.
Balanced market	Yes	Assuming thresholds and restrictions on allowances to return to the market have been set appropriately, market imbalance is prevented.
System integrity	Yes	No financial incentive for gaming provided by a surplus-based trigger.

3.4.3 Price-based mechanism

Many papers on price-based triggered reserve mechanisms focus on a reserve in combination with a price floor and/or ceiling, i.e. an MSR with a price trigger (Murray et al., 2008; Grüll and Taschini, 2011; Fell and Morgenstern, 2010; Fankhauser and Hepburn, 2010). This could be established by creating an ETS reserve with an upper and lower price threshold (price corridor) as a trigger, taking advantage of some of the economic efficiency of a tax with the assurance of the environmental outcome of an ETS; this design would at least have the lowest economic efficiency loss of whichever of the ETS and the price corridor were set at the most optimal level (see section 1 for an explanation of the relative economic efficiencies of tax vs. ETS). In the European context a price corridor is politically difficult as it poses challenges to the fiscal sovereignty of Member States, so others have looked at using price trends as a trigger instead (Taschini et al., 2014).

The main difference between the price trend and corridor approaches is that the price corridor corrects prices that are deemed too high and low, while a price trend trigger dampens strong price changes. Other distinct features are discussed below.

3.4.3.1 Price corridor

A price corridor withholds allowances when the price drops below a predetermined lower price threshold (price floor) and injects allowances when the price rises above the predetermined upper price threshold. The price used to initiate intervention by the MSR can be either the average price over a period, the price being continuously higher than the ceiling or lower than the floor over a certain period or a minimum auction price for ordinary allowances (floor) and for allowances in the reserve (ceiling).

Price corridors have been included in a number of other ETSs, although not for the purpose of market stability, but explicitly for price containment.

Such an approach entails the definition of a price ceiling, the maximum price that is politically desired as cost of carbon, and a price floor, the minimum cost of carbon which is seen as desirable to induce emission reductions and to internalise the social cost of climate change. Lessons to be learned for the MSR in the EU ETS are therefore limited as the purpose of the reserve mechanism is different.

Box 5 Cost containment mechanism design in the California Cap and Trade programme

Cost containment mechanism in California

The California Cap and Trade programme includes a cost containment mechanism which relies on a rising minimum auction price and a cost containment reserve that will be auctioned at three price levels, (US$40, US$45 and US$50). This approach was designed collaboratively as part of the Western Climate Initiative (WCI) and, therefore, together with other states and provinces considering setting up an ETS. In this context, no alternative triggers were considered, prices were the only options. The price level for the containment reserve was determined based on the British Columbia (BC) tax, such that the lowest tier was higher than the BC carbon tax. Thus far, no entities have participated in a reserve auction. Use of allowances from the reserve auctions is restricted to compliance entities only and, once purchased, allowances go into these entities compliance accounts and cannot be resold. The intention is for the reserve to act as a pool of allowances of last resort to enable compliance.

Trigger design

A price corridor used as trigger for an MSR is a soft collar, because the price can still rise beyond or fall below the corridor (Murray et al., 2008). The corridor is only defined to determine if and when allowances are moved into or out of the reserve. If the market is still short while the reserve is empty the price will rise above the ceiling price. Market imbalance will be avoided as the equilibrium will always be defined by matching demand with the supply not being distorted by a fixed price.

Given the longer term perspective of the EU ETS the price corridor could be designed in a dynamic way by adjusting it to factors such as historic price trends or inflation. Similar to the surplus threshold trigger, the corridor should be defined as wide enough to only intervene in exceptional circumstances and allow for the market to work efficiently within that range (Stranlund and Moffitt, 2011).

Impact on the market and behaviour of market participants

A price-triggered mechanism would change the dynamics of the EU ETS as it moves the mechanism away from a pure quantity-based instrument, in particular if the price corridor is defined too narrowly.

A price corridor could lead to firms deviating from their cost-optimal pathway if the trigger threshold levels are set wrong. A price ceiling trigger against unexpected price rises could have an unintended dampening effect on allowance prices. This would discourage market participants from investing in abatement as the expected return of investment becomes lower (Burtraw et al., 2009). On the other hand, it could put firms back onto the cost-optimal pathway when firms are too short-sighted or a shock has taken place. A price floor would not only increase the allowance price itself, but also reduces the risk associated with banking of allowances (CBO, 2010).

Abatement investments would require a lower rate of return and firms would bank more allowances for future use or selling. This impact will be larger as the price floor increases.

Other market behaviour impacts common to all triggers are described in section 3.4.1.

Market manipulation risks

An increasing price floor also provides firms with arbitrage opportunities, in particular if the price floor is known to increase faster than the interest rate (Fell and Morgenstern, 2010). Firms would have more incentive to buy and bank allowances, selling it in when the price floor guarantees a higher price and earning a return above interest rate. However, if firms do not think the price floor can be maintained politically, firms may sell their banked allowances sooner than later, leading to a price crash (Ecofys and OEA, 2014; CBO, 2010).

The arbitrage opportunities increase if the future price floor would be higher than the past price ceiling when allowances are available in the reserve (Fell and Morgenstern, 2010). Traders could create a temporary shortage on the market, spiking prices and trigger a release from the reserve. Although this would depend on how long the price needs to be above the ceiling and in any case some interviewees indicated they thought there was insufficient cooperation in the market to enable this. The release would quickly depress the price and provide market participants with more allowances to buy from auctions at low prices and bank for future sales. If the future price floor increases beyond the price ceiling used for manipulation, it essentially guarantees a minimum return for traders. Even though a price corridor may provide more price certainty in the future, these possibilities of gaming could lead to higher price volatility within the corridor as one interviewee pointed out. The manipulation of the price ceiling also reduces the quantity that can be used by the reserve against future imbalances. This disadvantage was highlighted by one of the interviewees.

Table 5 Summary of the pros and cons of a reserve with a price corridor

Key features	Pros	Cons
ETS fundamentals	This mechanism can induce private sector banking, which could limit intervention by the MSR to unexpected shocks, but would go some way to achieving the objective. Some interviewed stakeholders acknowledged that this type of intervention would provide more certainty for investment decisions through clear and long-term pricing signal and remove extreme downside price risk. This would be required to put the market on the cost-optimal pathway considering the myopia of firms.	The price corridor approach does not fully preserve the price discovery principle of the EU ETS. The EU ETS further away from a quantity-based instrument by introducing price-based mechanism.
System responsiveness	Would be able to address all market imbalances due to unexpected shocks if the effect is propagated to the allowance price. Would also be able to address the current surplus as it has resulted in low allowance prices.	If a technology shock results in the allowance price moving beyond the price corridor as the cost of abatement changes, but required abatement remains unchanged and the shock does not cause a market imbalance, which is possible given the uncertain nature of technology change, intervention by the MSR would cause a market imbalance.
Data	Allowance price data is readily available with a resolution smaller than a day.	None
Predictability	Using a carbon price that is imposed externally has an advantage as it, by definition, prevents emissions price volatility outside the specified range. By specifying the price collar in advance, the market can make decisions based the price levels at which interventions occur.	A price-based trigger is more vulnerable to market manipulation due to the fact prices are determined by a smaller trading volume i.e. the marginal demand and supply rather than the total quantity of allowances. The price within the price corridor may therefore be more volatile and unpredictable. Some interviewees, however, believe that there is insufficient cooperation in the market for this purpose.
Feasibility	Although for slightly different purposes, other ETS in the world such as California, Québec or RGGI have a price-based reserve in place. Matching the MSR design to their reserve could facilitate future linking.	In the European context the price corridor approach is politically difficult as it poses challenges to the fiscal sovereignty of Member States, which was also why many interviewees did not prefer or look into this option. Choosing the price levels is likely to be politically difficult.

Table 6 Assessment of a reserve with a price corridor against the key criteria

Criteria	Criteria largely met?	Clarification
Stable price signal	Yes	Price corridor levels provide a price signal to the market. Anticipation of intervention could maintain the price within the corridor without actually intervening.
Shock resilience	Yes	Able to respond to almost all variations of shocks that would cause an imbalance to the market and propagate into the price.
Adjustment certainty	Yes	All parameters can be set in advance and timing of intervention can be fixed, allowing the market to anticipate interventions.
Balanced market	Limited	Addressing the market imbalance based on the price level may not always result in a balanced market.
System integrity	Limited	Prone to market manipulation. This risk can be limited by avoiding a rising price floor and having a sufficiently long assessment period to trigger to MSR.

3.4.3.2 Price trend

A price-based trigger mechanism can also be based on price trends. The withdrawal and the injection of allowances is caused by the fall or rise of the allowance price over a specified period compared to a defined reference period. The price used to determine whether the MSR is triggered can be either the average price or continuous price over that period.

Trigger design
An MSR using a price trend trigger would be similar to the mechanism already in place in the EU ETS under Article 29a of the EU ETS Directive. This enables the injection of allowances from future auctions if for six consecutive months the allowance price has remained three times higher than the average price in the two preceding years. A price trend trigger to withhold allowances could mirror the Article 29a. The evaluation period is therefore six months and the reference period the preceding two years, with an intervention threshold of three times the reference price. By changing the assessment period, reference period and threshold, the frequency of intervention changes significantly.

The intervention thresholds results in a certain price bandwidth, and as long as the price moves within that bandwidth no intervention will occur. Compared to the trigger based on a price corridor, however, this bandwidth is moving and adapts according to past price developments (Taschini et al., 2014). The bandwidth should be sufficiently large so the MSR is only triggered under exceptional circumstances.

A price trend trigger would not be able to address the market imbalances that occurred before the introduction of the trigger, such as the current surplus in the EU ETS. The price trend trigger would need to be combined with another measure to specifically address the current market imbalance in the EU ETS.

Impact on the market and behaviour of market participants
The impact of the price trend trigger on the market is heavily dependent on the assessment period, reference period and intervention threshold.

If the intervention level under a price trend trigger is too weak to address the unexpected shock, eventually no intervention would occur as the reference period moves to cover the period of the shock and the MSR becomes ineffective. It may even be the case that the market manages to restore itself from the shock. But under a two-sided price trend trigger the shock determines the price trigger, the MSR becomes counterproductive and intervenes when the market imbalance has been corrected. This will very much depend on the length of the reference and assessment period. If these are set too long or too short, it may cause firms to deviate from the cost-optimal pathway.

Other market behaviour impacts common to all triggers are described in section 3.4.1.

Market manipulation risks

If the reference period is too long it may include past shocks in the trigger price, and if the assessment period is too long intervention may occur too late unless a rolling assessment period is used. If the reference and assessment period is too short, the mechanism would be more susceptible to gaming as temporary price spikes could trigger intervention. Since there are more factors to consider with a price trend trigger compared to other trigger options and the price trigger levels are only revealed over time, the majority of the interviewees commented that a price trend trigger would be considered too complex and intervention not very predictable.

Table 7 Summary of the pros and cons of a price trend-triggered reserve

Key features	Pros	Cons
ETS fundamentals	This mechanism can induce private sector banking, which could limit intervention by the MSR to unexpected shocks. The mechanism is triggered based on the price, but still allows price discovery as the price bandwidth moves.	If the intervention is too weak to address the unexpected shock, eventually no intervention or incorrect intervention would occur as the shock becomes the reference for intervention and the MSR becomes ineffective.
System responsiveness	Demand shocks with various causes could be addressed through this approach as long as it leads to a change in the allowance price. Most market and political shocks such as the economic crisis and the energy efficiency directive are propagated to the allowance price.	This trigger is not able to respond to the current surplus, only certain types of future market imbalances. The market could still move to an imbalanced state with a stable high or stable low price, but could reach it in a way that did not trigger the price trend. It may also not respond properly to shocks such as technology shocks that do not cause a market imbalance and intervention by the MSR may actually cause firms to deviate from the cost-optimal pathway.
Data	Allowance price data is readily available with a resolution smaller than a day.	None

Key features	Pros	Cons
Predictability	For the short term good predictability as information on the price development is publically available and market participants can predict when the MSR will intervene in the market. It is less likely to be subject to market manipulation than an absolute price trigger but market participants, who see opportunities for market manipulation as well as speculation, expressed that this strongly depends on the chosen period of measurement.	Some interviewees commented that predictability of this trigger is poor because it is unknown what the trigger levels for intervention will be beyond the period defined for assessing the trigger. Compliance entities were also concerned that prices are heavily influenced by financial players making fluctuations hard to predict. There is also the risk of gaming if the price trend period is taken too short. Some interviewees, however, believe that there is insufficient cooperation in the market for this purpose.
Feasibility	This trigger is similar to the mechanism already in place in the EU ETS and can build on Article 29a of the EU ETS Directive. It is also does not specify an upper or lower price threshold which could be politically sensitive and could be seen as ruling out or a preference for certain abatement technologies.	Many interviewees did not prefer this option as it was seen as too complex and adding more uncertainty to the system. Although perhaps less challenging than setting the price corridor, the tolerances would still need to be set politically.

Table 8 Assessment of a price trend-triggered reserve against the key criteria

Criteria	Criteria largely met?	Clarification
Stable price signal	Limited	Limited capability of providing a stable price signal under a strong shock and weak intervention. No explicit absolute price signal and allowances can return from the reserve at any price, but behaviour to limit intervention could lead to less volatile prices
Shock resilience	**Yes**	Able to respond to almost all variations of shocks that would cause an imbalance to the market and propagate into sudden price changes.
Adjustment certainty	Limited	There is certainty of adjustment within the assessment period of the trigger, but unknown when adjustments occur beyond that period, even though adjustments are rule-based.
Balanced market	Limited	Only capable of addressing future market imbalances and not the current surplus.
System integrity	**Yes**	If the reference and assessment period of the trigger is selected over a sufficiently long period, market manipulation becomes more difficult.

3.4.4 Hybrid surplus/price mechanism

Under the hybrid approach, two different types of triggers are used. The hybrid design in this study is limited to using a surplus trigger for withholding and a price trigger for inject. This allows the hybrid trigger to capture the benefits of both trigger types.

Trigger design

Allowances are transferred to the reserve once the volume of the surplus exceeds an upper bound threshold and the price determines when allowances are returned to the market. The price trigger can be set up in two ways:

- As a *price ceiling*, i.e. if the price was above a specified price for a certain period then allowances in the reserved would be auctioned (DECC, 2014a), or
- As a *price rise trigger* where the price then functions as a trigger if the price of a given period increased by a certain percentage compared to the average price over a previous period (SSE, 2013).

The prices can be either an average price or a continuous price over a certain period. In the first case the mechanism intervenes when prices become higher than anticipated and in the second case when prices increase too quickly. The surplus trigger would only intervene in the market when the market appears to be in an excessive oversupply.

Impact on the market and behaviour of market participants

By using a hybrid trigger, the advantages of both a supply adjustment and price adjustment to regulate abatement could be captured. Maeda (2012) argues that if the future emissions to abate are very uncertain, an adjustment to the trigger price would have a larger impact on abatement. When future emissions are relatively certain, an adjustment of the supply would be more effective. See box in section 1.2 on price versus quantity instrument discussion for further details. These observations are true for both a hard and soft price ceiling but would not be valid for a price trend-trigger as it varies with the market price.

While a hybrid trigger captures many positive impacts of the different triggers, the surplus and price are not perfectly correlated; the relationship between the surplus-trigger and the price-trigger can change over time and respond differently to shocks. Changes to the hedging demand or expectations of the market could change the interaction between the surplus and allowance price, which has also been discussed in sections 3.1.1 and 3.4.2. The surplus and price would respond differently to technology shocks. If the technology shock causes abatement costs to decrease or increase, the price would move in the same direction, but the surplus would not change if the abatement undertaken within the foresight window remains unchanged. Other factors could also alter the relation between surplus and price e.g. significant changes in energy costs. This asymmetry could possibly lead to both triggers being met simultaneously, or the triggers consecutively triggering in opposite directions. The market can suddenly become tight even though the surplus is very large. If the foresight window changes to include a very large future scarcity, e.g. if the market becomes more certain about the future, compliance entities may not want to sell any excess allowances, reducing market supply, and may even increase their demand. Traders may also not want to sell in expectance of higher future prices.

In theory the surplus could be very large while the volume available on the market is very small. In this situation the surplus trigger level might not reflect the right state of the market anymore or the price jump is a temporary response to new information without need for intervention. The reverse is also possible where the surplus is very small, but market participants expect that future targets can be met with ease, leading to low prices. At the moment this is not the case of the EU ETS as the surplus is large and prices are low.

However, careful threshold setting and review of the relation between the surplus and price would be required to prevent clashes between the triggers in the future, possibly more often than with non-hybrid designs given the risk of trigger clashes that could lead to continued intervention by the MSR. More regular reviews would increase the uncertainty for the market participants as adjustments change their future expectations of the market.

Other impacts of the hybrid approach are similar to a surplus trigger when withholding allowances and a price-based trigger for injecting allowances. More information about the impact of the individual triggers can be found in sections 3.4.2 (surplus), 3.4.3(absolute price) and 3.4.3.2 (price trend). Other market behaviour impacts common to all triggers are described in section 3.4.1.

Market manipulation risks
Using a hybrid approach does not provide arbitrage opportunities associated with using a price floor to withhold allowances or the incapability of a price trend trigger to address an existing surplus. For injection of allowances a price ceiling might be susceptible to gaming and withholding allowances might trip the price trend trigger, in both cases depending on design, but there is less financial incentive for traders to game the reserve compared to a price corridor design[22]. The price ceiling provides a more predictable price at which the allowances enter the market from the reserve than price trend does.

[22] Compliance buyers would only have an incentive if their demand is larger than the increase in demand required to trigger the ceiling and it will result in lower costs by triggering the ceiling. For traders triggering the ceiling could be beneficial through short selling or with put options but the financial risk is larger than trades required to profit from some price corridor designs.

Table 9 Summary of the pros and cons of a reserve with a hybrid trigger

Key features	Pros	Cons
ETS fundamentals	By using a hybrid trigger, abatement incentives can be provided to market participants with different business models, while at the same time still allowing for price discovery below the price ceiling when the reserve is not empty.	The asymmetric response between the surplus and the price could potentially cause both triggers to be met at the same time or consecutively trigger intervention, causing the mechanism to become ineffective.
System responsiveness	Would be able to address all market imbalances due to unexpected shocks leading to an oversupplied market, and imbalances leading to a tight market if the effect is propagated to the allowance price. Would also be able to address the current surplus has resulted in low allowance prices.	The responsiveness of the mechanism is determined by data on the surplus, which only becomes available from May of the following year, limiting the intervention frequency to maximum once a year. This causes a time lag between the price increase to the trigger level, and an actual trigger event, unless the price trigger responds independently of the surplus trigger through e.g. amendments to the auction regulations, increasing the chances of trigger clashes.
Data	The surplus data is publicly available and transparent as they are based on verified information from the registry. Allowance price data is readily available with a resolution smaller than a day.	Limited to annual data frequency (see System responsiveness)
Predictability	With the trigger thresholds set in advance, when interventions occur, these are predictable to the market. Only under a price trend trigger interventions are less predictable over the long term. Without guarantee of the minimum price, arbitrage opportunities are significantly less than under a price corridor.	Due to a price to release allowances the mechanism might be prone to market manipulation, depending on design. Temporary price spikes could be created with the intention to lower the cost of compliance. Some interviewees, however, believe that there is insufficient cooperation in the market for this purpose.
Feasibility	Surplus element is widely acceptable to stakeholders. A price rise trigger is already taken up in Article 29 of the EU ETS Directive. A price ceiling may be less politically contentious than setting a price floor and could be seen as similar to the penalty for non-compliance in place as it implies a maximum price on allowances.	There is no consensus among the interviewees on the preference for the hybrid trigger. Some commented that this trigger type is politically unfeasible as price levels need to be agreed upon or due to complexity, while one preferred the price trend trigger version and another saw the merits in having an absolute price ceiling combination. Nonetheless, the political challenges of setting the trigger thresholds remain.

Table 10 Assessment of a reserve with a hybrid trigger against the key criteria

Criteria	Criteria largely met?	Clarification
Stable price signal	Limited	Price ceiling provides price signalling to the market, while the surplus trigger prevents low prices due to market imbalance. Sudden decreases in price due technology shocks are still possible.
Shock resilience	**Yes**	Able to respond to almost all variations of shocks that would cause an imbalance to the market.
Adjustment certainty	**Yes**	All parameters can be set in advance of the intervention, although there is more adjustment certainty with a price ceiling.
Balanced market	**Yes**	The surplus trigger prevents an oversupplied market while the price trigger can largely address a market that is too tight.
System integrity	**Yes**	Arbitrage opportunities are limited to the price-based trigger, which would only inject allowances that were in the system in the first place. Whilst price trend and ceiling are somewhat open to gaming, other factors such as the higher financial risk associated limit this.

3.4.5 Economic activity-based mechanism

The fundamental economic principle underlying the EU ETS implies that increasing economic activity causes higher demand for industrial goods and increased electricity consumption, which may lead to increased carbon prices if the increase is stronger than efficiency improvements.

In order to take account of the fact that some industries covered by the EU ETS are not proportionally affected by GDP changes or affected only with a delay, the trigger could be tailored to indicators mapping industry or electricity production activities (European Commission, 2014b). There are a number of variables other than GDP that can be used to develop such a production activity-based trigger, including primary energy demand, fossil fuel prices and even financial market indicators depicting the developments on the equity market (Newell and Pizer, 2008; Aatola et al., 2013; Battles et al., 2013; Hintermann, 2010).

While some of these indicators are available on a day-to-day basis, such as stock market indices, the intention of the MSR is not to respond to normal economic movements; only extreme developments should be counteracted that affect the underlying cost-efficiency of the EU ETS by fundamentally disturbing the supply and demand balance (DIW Berlin, 2013). The evaluated trigger designs based on economic activity are therefore limited to macroeconomic activity such as GDP and changes in production.

3.4.5.1 Macroeconomic activity

With macroeconomic activity indicators as a trigger, such as changes to the gross domestic product (GDP), an MSR is fed with allowances if economic activity is found to decrease and allowances are released again to the market if the chosen indicator picks up. This would make the EU ETS lean towards an emission intensity-based system (CEZ group, 2013). Research has been able to verify this underlying economic reasoning of both CO_2 emissions and prices rising as economic activity increases (Chevallier, 2013).

Trigger design
In practice a trigger based on economic activity could mean that if the GDP is found to have fallen by a specific percentage over a given year compared to a previous period, then allowances are withdrawn from the market. If the GDP trend moves too far in the other direction, allowances are injected.

This trigger can also be designed based on economic forecasts, or at least take these into account as they are implicit when the cap is set. Significant changes in respect to economic forecasts would then constitute as an unexpected shock. Economic forecasts can also be used to allow for pre-emptive action by the MSR before the market becomes imbalanced, avoiding the delay of the measure. However, if the forecast is wrong the intervention may cause more imbalance in the market.

Impact on the market and behaviour of market participants
There are conflicting views in literature over whether flexibility of the supply is desirable in times of recession or whether a rigid cap during times of economic booms provides the necessary stability through preventing excessive growth of high carbon production (DIW Berlin, 2013).

The more reactive the MSR is to economic activity the more flexible the supply will be. This approach will therefore move the EU ETS from a fixed cap system towards an intensity-based cap system (CEZ group, 2013). However, the underlying principle that only what is in the MSR can also move out of the MSR still applies and therefore assures that overall reduction targets of the EU ETS still have to be achieved. The degree to which this trigger option can mimic an intensity-based cap will therefore always be limited by the amount of allowances in the MSR.

Other market behaviour impacts common to all triggers are described in section 3.4.1.

Market manipulation risks
For the market participants there are practically no opportunities for gaming if a macro-economic indicator such as the GDP is chosen as the trigger. These indicators cannot be simply influenced by market participants looking for an arbitrage opportunity as it depends on the performance of the whole economy.

Table 11 Summary of the pros and cons of a reserve with a trigger based on economic conditions

Key features	Pros	Cons
ETS fundamentals	The trigger allows the EU ETS to remain a quantity-based instrument with most of its current features while adjusting for one of the main causes of the current surplus.	The trigger moves the EU ETS towards an intensity-based cap, which does not fit with the overarching aims to support the economy in decoupling growth from carbon emissions.
System responsiveness	Economic forecasts are more widely available have a significant historical experience to build upon compared to projections of carbon prices and surplus, giving them the greater perceived reliability. By including forecasts in the trigger, e.g. such from the European Economic Forecast, the MSR could to some extent increase inter-temporal efficiency by predicting major economic events and counteracting their impacts more quickly.	This approach only captures market balance changes due to the economic driver, not the political or technology drivers, so the MSR would not be able to responds to all potential shocks to the system. It would also not be able address the current surplus. The trigger could be too broad as GDP is also driven by sectors not involved in the EU ETS. This could lead to intervention at a time when there has not been a shock in the EU ETS, but only to other parts of the economy.
Data	Changes in GDP are measurable and a relevant indicator for economic activity. Since it is based on existing and publically available data using it as a trigger for an MSR would provide confidence to market participants that it is not subject to political considerations, while also providing the necessary level of transparency.	While data availability for GDP is, in general, good, various sources exist, e.g. GDP Eurostat reports, and would need to be tested according to their appropriateness. Corrections to GDP data are not uncommon though, sometimes even a long time after the initial release.
Predictability	Possibilities to influence GDP level to trigger the MSR are very limited and it would be based on objective economic indicators that are visible and have proven to show relevant correlation to the carbon market.	The exact impact on the allowance prices cannot be predicted other than that prices will go up or down. Clear visibility on the volume of allowances available at auction can be provided under a rule-based system.
Feasibility	Due to the limited political interference and extensive history of using macro-economic indicators to form policies, this trigger might be easier to agree upon than the others. It would also address future market imbalances due to the economic crisis, which is regarded by many as the main cause of the current market imbalance.	GDP or other economic indicators are largely based on national policies, while the EU ETS is EU-wide. Therefore a choice would be needed about which GDP figures to use for determining the trigger as in the past has shown that Member States are not synchronised in terms of their economic cycles. Similar to other triggers, selecting the threshold level for economic indicators is also considered difficult as determining deviation from the 'expected level' is rather subjective.

Table 12 Assessment of a reserve based on economic conditions against the key criteria

Criteria	Criteria largely met?	Clarification
Stable price signal	Limited	Only changes in prices due to changes in economic conditions can be addressed.
Shock resilience	Limited	Only able to respond the economic shocks.
Adjustment certainty	Yes	By setting a baseline and thresholds for deviation in expected economic, all parameters can be set in advance and timing of intervention can be fixed, allowing the market to anticipate interventions.
Balanced market	No	As emissions are to decouple from economic indicators, it may not reflect the market balance. It is also not able to address the current surplus.
System integrity	Yes	Economic indicators cannot be significantly influenced by market participants as they depend on the performance of the whole economy.

3.4.5.2 Changes in production

Research has confirmed the existing link between industrial production and carbon prices (Chevallier, 2013). Allowances would be withheld from auctions if the production activity decreases below the threshold, and injected into the market from the reserve if production activity increases above the threshold.

Trigger design

While the general link has been confirmed between the macroeconomic activity depicted by aggregated industrial production and the carbon price has been shown, additional empirical research identified three EU ETS sectors that drive this correlation. Both the changes to the production level production and the compliance positions of the EU ETS sectors combustion (incl. power sector), paper and steel, have significantly impacted changes of the carbon price (Chevallier, 2011; Alberola et al., 2008). The link between production and emissions should hold as long as there is no significant energy efficiency gain or increased use of renewable energy in these sectors; this would again reduce emissions and would dampen the increase in carbon prices during economic upturns (Chevallier, 2013). However, in order to reach the 2050 GHG emission reduction targets, significant increases in energy efficiency and renewable energy are required as well (European Commission, 2011), making this type of trigger out of sync with the objective of the EU ETS. Further analysis would be required to confirm that this relationship still holds true for the previously identified sectors combustion, paper and steel.

A trigger based on production changes of EU ETS sectors would require the calculation of an index, mapping the changes in production of the sectors having the largest impact on the market balance. Existing industrial production indices can be used but, due to the availability of the production data, a substantial time lag would exist between the causes of the market imbalance and the triggered intervention.

Box 6 Difference between an MSR and dynamic allocation reserve

The difference between a reserve mechanism for dynamic allocation and an MSR is that the MSR intervenes in the market through adjustment of the auctioning supply and dynamic allocation through adjusting free allocation. The MSR has a primary purpose of reducing the current surplus and preventing future market imbalances, which is the focus of this study. The primary purpose of a dynamic allocation reserve is preventing carbon leakage by adjusting allocation of free allowance to actual production, by lowering the actual carbon costs of compliance entities as long as the reserve is not empty (Ecofys, 2014). Some of the broad impacts of the different reserves on the market balance may be similar. However, adjustments to the approaches taken to free allocation is not the focus of this study and observations made in the context of an MSR are therefore not directly applicable to the dynamic allocation reserve.

Impact on the market and behaviour of market participants

The impact of a mechanism triggered by changes in production would be similar to changes in economic conditions, with the main difference being that changes in production capture the market shocks to the EU ETS more precisely than a broader measure of changes in economic conditions, provided that production included all ETS participants i.e. industrials and utilities. Using changes in economic conditions would also include changes to sectors not in the EU ETS which therefore do not affect the allowance market; trigger based on changes in production narrows the trigger scope to sectors in the EU ETS.

Other market behaviour impacts common to all triggers are described in section 3.4.1.

Market manipulation risks

In theory it is possible for market participants to manipulate the MSR by changing their production or reporting false production values, but this would have to be done collectively by all EU ETS participants. Furthermore, carbon costs are only a small part of the total production costs, so there is little incentive to doing so.

Table 13 Summary of the pros and cons of a reserve with a trigger based on production changes

Key features	Pros	Cons
ETS fundamentals	The trigger allows the EU ETS to remain a pure quantity-based instrument with most of its current features while adjusting for one of the main causes of the current surplus.	The trigger moves the EU ETS towards an intensity-based cap and linking production to emissions does not fit with the overarching aims to support the economy in decoupling growth from carbon emissions.
System responsiveness	There is evidence that demand for allowances is correlated with production, which could therefore ensure that the MSR is likely to be effective in coping with market shocks.	This approach does not capture the political or technology drivers that do not affect the production, which also means that the MSR would not be able to responds to all potential shocks to the system. Furthermore, it also does not take structural changes or efficiency improvements into account, e.g. a switch in products could mean increase in production, but emissions may not change.
Data	Industrial production indices are publicly available and more recent data on industrial production can be collected as part of the yearly EU ETS monitoring requirements of firms.	Publicly available data on industrial production is generally published with a two year delay due to competitiveness concerns and time required to confirm the reliability of the data. In order to rule out potential data manipulation by industry to induce injection by the MSR to lower carbon costs, complex competitiveness sensitive data would need to be analysed. Generally carbon costs are only a small part of the total production costs though, so the benefits of data manipulation are small.
Predictability	Stakeholders have expressed that basing the trigger on actual production data is perceived as objective and not being subject to government interference.	Using production will provide limited visibility to market participants of when the trigger might be reached and what the impact on the allowance price is, potentially adding some instability to the market.
Feasibility	This trigger is desired by many industrial participants as it would address future market imbalances due to the economic crisis to production, which is regarded by many as the main cause of the current market imbalance.	Selecting the threshold level for unexpected production changes is considered difficult as with all the other triggers. In particular, stakeholders fear that this MSR would be triggered more often than just for 'extreme' cases or for other purposes than intended such as competiveness concerns if trigger thresholds are set in a way to accommodate these concerns.

Table 14 Assessment of a reserve based on production changes against the key criteria

Criteria	Criteria largely met?	Clarification
Stable price signal	Limited	Only changes in prices due to changes in production can be addressed.
Shock resilience	Limited	Only able to respond production-related market shocks.
Adjustment certainty	Limited	Using production will provide limited visibility to market participants of when the trigger might be reached and adjustment occurs.
Balanced market	**No**	As emissions are to decouple from production, it may not reflect the market balance. It is also not able to address the current surplus.
System integrity	**Yes**	There would be little benefits to market manipulation as it would require manipulation of total production of which carbon cost is only a small part.

3.4.6 Other trigger options

There are a variety of other trigger options that have been identified, but these options would not allow the MSR to meet its objective to address the current surplus and future market imbalance:

- ***Development of renewable energy -*** Having identified overlapping policies as one of the driving forces behind the surpluses accumulated in the EU ETS, the increasing use of renewable energy could cause a market imbalance. Marginal abatement costs for users of renewable energy fall which free up allowances for emitters facing higher marginal abatement costs (DIW Berlin, 2013).
- ***Implementation of energy efficiency measures -*** A similar effect can be seen between policies on energy efficiency affecting the EU ETS sectors.
- ***Changes in fossil fuel prices –*** Changes in fossil fuel prices could lead to changes in emissions through fuel switching. If coal becomes more expensive than natural gas, firms are inclined to switch to using natural gas, reducing emissions and changing the balance on the carbon market.

These suggestions all have the dual advantage and disadvantage of being tailored to only one of the causes of the problem. Such targeting enables an appropriately precise response, but would not be robust in the face of other shocks. To address other shocks, different triggers would be required, making the MSR overly complicated.

3.5 Evaluating design options against the market stability reserve criteria

In section 3.4 each trigger option has been evaluated against the key criteria specified in section 3.3 in a qualitative manner. A summary of the assessment is provided in Table 15.

Table 15 Summary of the assessment for each trigger option against the key criteria

Trigger type	Stable price signal	Shock resilience	Adjustment certainty	Balanced market	System integrity
Surplus	Limited	**Yes**	**Yes**	**Yes**	**Yes**
Price corridor	**Yes**	**Yes**	**Yes**	Limited	Limited
Price trend	Limited	**Yes**	Limited	Limited	**Yes**
Hybrid surplus/price	Limited	**Yes**	**Yes**	**Yes**	**Yes**
Change in economic conditions	Limited	Limited	**Yes**	**No**	**Yes**
Production change	Limited	Limited	Limited	**No**	**Yes**

The trigger sets that appear most promising, according to the criteria, are the hybrid surplus/price approach, surplus approach and price corridor. The price trend trigger also performs relatively well under certain conditions; but it can only address future imbalances and the intervention must be sufficiently strong to address the shock before the shock becomes part of the price trend dictating intervention. These are also the triggers that are inherent to the system, whereas changes in economic conditions and production are mainly external factors and not primarily driven by the EU ETS. As the overarching purpose of climate policy is to decouple emissions from economic activity, changes in economic activity such as GDP or production will not necessarily reflect a change in the market balance. These trigger types are therefore not selected for further investigation.

Nonetheless, the ability of these triggers to meet these criteria and the way in which they will perform depends heavily on the detail of their final design. In chapter 4 of this report we examine some examples of more detailed designs for selected triggers, in order to allow some modelling to test their resilience in the face of unexpected shocks in chapter 5, and to try and assess how these designs will really interact with market behaviour. Based on the assessment in Table 15, modelling results are expected to show that all selected trigger options are able to address unexpected shocks, but the surplus and hybrid trigger would perform best in balancing the market onto the cost-optimal pathway.

4 Designing market stability reserve mechanisms

Any MSR mechanism consists of many different design elements that need to be taken into consideration. These design elements will determine the effectiveness, credibility and feasibility of the MSR. In section 3.5, various trigger options and their impacts have been compared to and evaluated against the key criteria set out by DECC in section 3.3.

This resulted in three different triggers to investigate:

- Trigger type 1: Surplus
- Trigger type 2: Absolute price
- Trigger type 3: Price trend

These triggers options can be combined in various ways having different impacts on the market, e.g. the hybrid surplus/price options combine trigger type 1 to withhold allowances with trigger type 2 or 3 for the injection of allowances. The EC's proposal is a combination of trigger type 1 to withhold and inject allowances and trigger type 2 to inject allowances.

Other design elements, independent of the trigger types, have also been investigated:

- Reserve size
- Expiration of allowances in the reserve
- Reserve holders
- Executive authority
- Credibility
- Review points

The purpose of this section is to provide an overview of what has been found in literature to enable an informed decision-making process. While some interviewees did have a preference for some design options, often it is a trade-off between flexibility and complexity.

4.1 Trigger-specific design details: threshold, intervention level and timing

The next step would be to investigate when intervention should occur and to what extent. As current prices are determined by expectations of the future supply and demand, the appropriate level for the thresholds depends on how far into the future the regulators believe the market is looking, and in the case of prices, how risky it is to abate instead of buy allowances. As Weitzman (1974) pointed out, firms are only aware of their own abatement cost structure and how far they look ahead (Maeda, 2012). And when deciding on the threshold levels, there is a significant level of information asymmetry between what firms know of themselves and what is available to the regulators (Newell and Pizer, 2008). In addition, thresholds should also reflect the benefits of emission reductions, both wider social benefits, and the specific benefits that accrue to investors.

The literature is very limited on what the appropriate threshold levels could be. This section gives an overview of the available information on how trigger thresholds, intervention level and timing could be set for the selected trigger types.

4.1.1 Trigger type 1: Surplus

Trigger thresholds can be set as an absolute value or a percentage of the cap. Various thresholds have been proposed to the EC. The hedging demand by market participants has been used as a basis to set trigger level for the surplus based on input from expert meetings held by the EC and public consultation (European Commission, 2014b):

- Bloomberg New Energy Finance mentioned a range of 1.2-1.3 billion allowances in the expert meeting;
- ENEL proposed a surplus range of 762-956 million allowances in the same meeting, which is based on 80–100% of the expected 2014 auction volume;
- Fortum proposes a range between 40-50% of the following years cap (i.e. 810-1013 allowances at the start of phase 3 declining to 704-880 allowances at the start of phase 4) based on assessment using Pöyry's Carbon Model (Pöyry, 2013);
- Dong Energy estimate hedging volumes of around 500 million in 2017;

A survey by Bloomberg New Energy Finance on the impact of backloading further reveals that among the 25 respondents almost all believe that the hedging demand of power companies is more than 900 million allowances, with more than half estimating a demand between 1100 and 1500 million allowances. Although it is not clear how much of this would be met through financial contracts and whether this necessitates a corresponding level of surplus.

In the EC proposal for the MSR, the optimal bandwidth of surplus has been set as 400–833 million allowances (European Commission, 2014c). While the upper limit is within the range of hedging demand proposed by some stakeholders, it is unclear how the lower limit has been set. Interviewees in this study also expressed a view that the thresholds were set in a non-transparent manner. While one interviewee believed the upper threshold was in the right ballpark and the lower threshold was on the high side, most of the interviewees did not have an opinion on whether the proposed levels were right or not. Some interviewees agreed that the hedging demand plus banked allowances by industry for future compliance is a good proxy to use for setting threshold levels. All interviewees called for more analysis of the impact of the thresholds.

One interviewee argued that the EC's MSR proposal is looking at the problem from the wrong angle, and the surplus thresholds should not be based on hedging demand. As discussed in section 3.1.1 the surplus is used for hedging because there is a surplus, but that does not necessarily equate to the surplus being necessary to be able to hedge, as futures contracts for allowances can be used for this purpose. The surplus should only exist to address unexpected shocks to demand, which could be in the range of 10–15% in the period for forward power hedging. This would be equivalent to approximately 200–300 million based on the Phase III cap.

The advantage of using a percentage of the cap as a trigger, rather than an absolute value, is that the trigger level changes as the cap changes. This accords with the logic of hedging, as it is also expected that hedging demand changes with a changing cap. Carbon-intensity is expected to gradually reduce with a tighter cap, reducing the need for hedging. For utilities hedging demand depends, amongst other things, on their current and future generation portfolio. As discussed in section 3.1.1, how hedging volumes will change over time remains uncertain to some extent as there are numerous other factors that could change the hedging demand.

Banking for future use may also increase as allowance prices are expected to increase in the future. In this case using a fixed percentage of the cap as a trigger would be less appropriate as the cap decreases over time. There are many factors that contribute to hedging needs and these are complex and change over time. The complexity of these factors contributed to the uncertainty of the interviewees when asked whether the threshold levels proposed by the EC were optimal and acceptable. It is unclear whether a surplus-triggered reserve would only respond to unexpected shocks as intended or also to normal developments in the EU ETS such as tightening of the cap.

Similarly to the trigger thresholds, interviewees also commented that it was not clear where the intervention levels of 100 million allowances (injection) and 12% (removal) of the surplus come from. In general the level of intervention that is required is a trade-off between the responsiveness of the system and the impact on the price. The intervention level can be an absolute number of allowances or relative to the surplus in the system. While setting an absolute intervention level provides more predictability to the market, a percentage would allow the corrective action to reflect the scale of the imbalance. By acting in a proportionate manner, the action is more likely to solve the imbalance. In the EC's proposal withholding allowances as a percentage of the surplus can also provide a degree of predictability once the existing surplus has been reduced to the upper threshold level. Many interviewees commented that 12% per year is not fast enough to address the current surplus and it would take almost the whole of Phase IV to balance the market.

It is notable that under the current proposal the actions in the case of under and over-supply are not the same and would only be more equal once the market was in balance. In the short-term action is skewed in favour of keeping allowances in the reserve, given the large surplus in the market.

Another major disadvantage of a surplus trigger is the speed at which it can respond to the market imbalance as highlighted in section 3.4.2. The surplus can only be determined once a year when the compliance entities report their emissions and surrender their allowances. This limits the intervention frequency to once a year, which might be sufficient for a mechanisms designed to respond to extraordinary circumstances, but this would need to be tested in the actual market. As the required data is published from May of the following year, the EC proposed intervention by the MSR from the beginning of the calendar year after, putting at least one year between the occurrence of the unanticipated shock and intervention. To smooth the price impact, the intervention can be spread over the entire year.

The injection as well as the removal would be managed through adding or subtracting allowances from upcoming auctions respectively, allowing for an appropriate notice period for the market to adapt.

4.1.2 Trigger type 2: Absolute price

Choosing the level of a price trigger is difficult as it may result in de facto preferential treatment for technologies above (floor) or below (ceiling) that price. Analysis to consider the marginal abatement cost that is required to meet long term emissions reductions targets could act as a starting point in selecting price triggers. Other considerations include which timeframe of emissions reduction target should be chosen, how far into the future the price should be set in relation to this to remain on the cost-optimal pathway and what assumptions should be made when determining this marginal abatement cost.

Maeda (2012) finds that the price ceiling should be set at twice the expected marginal abatement costs as this relates to the probability that the trigger price would be reached. Other reference points for a price trigger that have been suggested include consistency with other floor and ceiling levels in other schemes, the economic consequences of the chosen trigger levels and the expected environmental cost of emissions (IETA, 2013). However, referencing prices in other schemes may not be appropriate as the sectoral coverage and the abatement costs are different in the other schemes and often in the final decision-making process these price thresholds are determined politically.

The interviews also did not reveal much more concrete information on how the price floor or ceilings should be set. All interviewees were conscious of the political challenges of agreeing absolute price triggers. As a result, some interviewees disregarded the absolute price triggers completely as politically unfeasible, and had done little or no analysis on this option, while others only briefly looked into preferred absolute price levels. Some interviewed utilities mentioned that the UK carbon price floor could be used as a starting point for the price floor. Another interviewee mentioned that from experience they see that firms do not plan to take significant abatement measures as long as the price is below 20 €/tCO_2. When discussing price ceiling levels, interviewees mentioned the abatement cost of carbon capture and storage (CCS) as a potential price ceiling; some mentioned that it could be in the range of 50–60 €/tCO_2. Setting the price at this level, rather than above it, would only be an appropriate level if policy-makers are in agreement that CCS constitutes a measure to be taken under exceptional circumstances in the short-term, and if there is agreement about the marginal abatement cost of this measure. These levels also depend on how far ahead in the future the market should be balanced as the marginal costs of abatement to meet decreasing cap increases over time. Given the limited foresight of the market, this would mean that the price floor and ceiling should increase over time as well.

As regards the intervention level, as with a surplus-triggered system, intervention can be a specified quantity (i.e. absolute value or percentage of surplus) or a flexible quantity as long as the price remains below or above the trigger or, in case of injection into the market, the reserve runs out. In the EU ETS, however, it is more difficult to allow a flexible quantity to be auctioned as the amounts to be auctioned must be spread across different Member States' auctioning platforms and auction calendars. Measures that prescribe exactly when and how Member States must auction their allowances would pose significant challenges to fiscal sovereignty. The most feasible option would to change the auction volume by a specified amount when the price threshold has been breached or for each Member State to hold fixed volume auctions where allowances from the reserve are sold, but only above the ceiling price.

The downside of the first option is that there is no guarantee that intervention will bring the price within the desired price corridor (European Commission, 2014b).

Since the action of the MSR is implemented through auctioning calendars, the frequency is governed by practicalities around setting the auctioning calendars. This may still allow relatively frequent assessments of the price situation but would be limited by the additional administrative burden it creates and fiscal consequences for the Member States of changes to auction volumes and hence in revenues within a year. While frequent intervention would increase the probability of keeping the price within the corridor, provided the reserve is not empty, it provides more opportunities for gaming, in particular if the price is only assessed over a short period of time. This is illustrated in Figure 9 where it can be seen that short-term average prices are much more prone to volatility. On the other hand, if the time between assessments is too long, intervention is delayed or may not even occur. There is not a trade-off between frequency and the average chosen as a rolling average price could be chosen to assess, but both factors are important when deciding on the frequency that the assessment will be made.

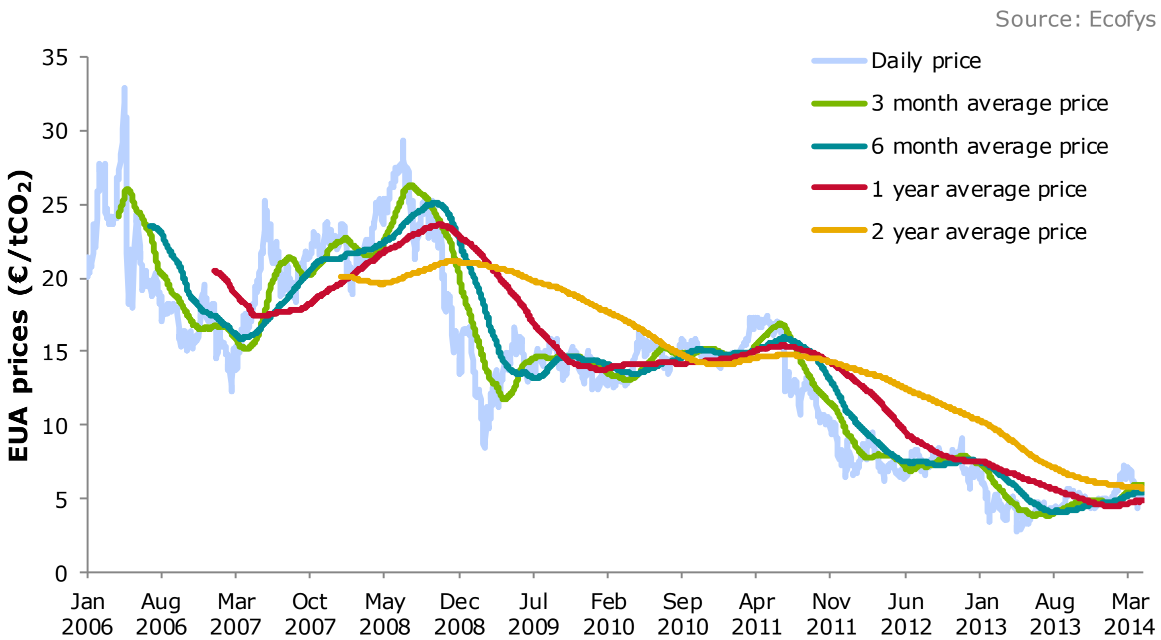


Figure 9 Assessment of the price averaged over different periods starting from January 2006. December contract prices are shown and pre-2008 prices are 2008 December contract prices. Source of prices: Thomson Reuters Point Carbon.

Although many alternative options in other ETS and literature would be very difficult to implement in the current state of the EU ETS, these following options could improve the responsiveness of the system:

- An auctioning reserve price could be implemented for the price floor and a fixed amount of allowances from the reserve could be offered at a fixed price as a price ceiling. This would be similar to the ETS implemented in California and Québec.
- Instead of auctioning, allowances in the reserve could be sold at a fixed price (CBO, 2010). This would be similar to the ETS in New Zealand.

- Active buyback by the regulator or an independent entity when the price drops below the price ceiling and selling at the price ceiling. This could create more arbitrage opportunities in particular when the price floor is set to increase (Fell and Morgenstern, 2010; Fankhauser and Hepburn, 2010) and is similar to the planned cost containment approach in the Kazakhstan ETS.

4.1.3 Trigger type 3: Price trend

The price trend trigger looks at the historical price development and compares it with the recent price development. Intervention depends on what period is used to evaluate historical price, the reference period, and what period for the recent price development, the assessment period.

Literature on this type of trigger is very scarce and available literature suggests basing the reference and assessment period on the existing Article 29a of the EU ETS Directive to determine over what period the price should be assessed (Taschini et al., 2014; SSE, 2013). This would mean that the prices for the past six months are compared to the prices of the preceding two years. Article 29a also specifies that intervention would occur when prices in the assessment period are three times higher than the average price in the reference period. No indication has been found about how the levels mentioned in the Directive were chosen to be the trigger level.

Without further detailed work, it is difficult to determine whether the price of three times higher would constitute an unexpected shock and what level would be appropriate.

4.2 Trigger-independent design details

4.2.1 Reserve size

In many reserve designs the reserve size is central to the effectiveness of the mechanism. This is the case where a reserve has a primarily purpose to inject allowances in the case of shortage, similar to the reserves investigated in relation to commodities. This type of reserve is asymmetrical if there is no mechanism to withhold allowances from the market, such as in RGGI, and the size would need to be determined ex-ante. The size of the reserve required to ensure effectiveness depends the size of the market i.e. the total emissions covered by the system (Fell et al, 2012). In principle, it would not make sense to have a reserve larger than the cumulative cap and highest business-as-usual emissions forecast (Murray et al., 2008).

In a symmetrical reserve design such as the MSR under investigation in this study, the consideration of the size of the reserve has more than one function. On the one hand, the reserve should be sufficiently large to inject allowances in the case of shortage under unexpected circumstances. On the other hand, a limit on the size of the reserve could be used to highlight extraordinarily exceptional circumstances where the market stability mechanism cannot cope with the excess, and further action e.g. cancellation, might be required.

Some stakeholders might consider it being important for the reserve to have a minimum size to be able to remain credible as an instrument to address unexpected shocks, and even be replenished in certain circumstances (even if this means endangering the cap). Too large a reserve could undermine the confidence in the market though. If the reserve becomes too large it may be seen as holding a too great a power to influence the market. There is also a risk that holding a very large reserve may not be politically feasible anymore and the allowances may be released back into the market much earlier or more rapidly than anticipated flooding the market and sending the allowance price crashing down lower than if no reserve was implemented (Ecofys and OEA, 2014). This risk would be present in both an asymmetrical and a symmetrical reserve. Interviewees did express some concerns that if the reserve becomes too large it may lead to political intervention.

Capping the reserve could mean two things (European Commission, 2014b):

- Excess allowances will remain on or enter the market, reducing the effectiveness of the reserve but maintaining the total supply of the system, limiting the reserve to what is deemed absolute necessary to restore market balance and reducing impact on the banking ability of participants
- Excess allowances are cancelled, creating a market signal for steeper emissions reductions than would have otherwise been the case.

The question here is, within the discussions about an MSR in the EU ETS, what is the role of the reserve itself – a repository or a safeguard. Under current circumstances the reserve would act as a repository for the current large surplus and a safeguard against future imbalances.

4.2.2 Expiration of allowances in the reserve

Various studies and position papers propose the implementation of a sunset clause or expiration date on allowance in the reserve to prevent it growing too large and politically difficult to maintain (e.g. CMIA, 2012). Cancelling allowances in the reserve can also help mitigate the concern that storing allowances in the reserve alone will not actually impact the prices in the system, because they can be returned at any point, and the market knows this. By introducing expiration dates on the allowances in the reserve it cannot become too large, because at some point the reserve will decrease in size when the allowances expire. Most interviewees showed an interest in this option or even mentioned that they have proposed this before.

In the event that the reserve runs out and prices are excessively high, the reserve holder could consider filling the reserve by borrowing allowances from the future or buying offsets to transform these into allowances into the system (Stavins, 2008). In the latter the central authority would purchase offsets to retire them and in return generate additional allowances (CBO, 2010). This way the central authority controls how many offsets could enter the system, which if done in a clear, predetermined and transparent way could act as an additional stabilisation mechanism without the integrity of the system being undermined. This option was also preferred by one of the interviewees, which highlighted that these offsets would need to be actual emissions reductions achieved in contrast to allowances to emit that are used to fill the reserve at the moment.

4.2.3 Reserve holders and Executive authority

The reserve can either be held by a central authority or firms. While holding the reserve by the central authority is mostly proposed in literature, if firms hold the reserve the response to the triggering of the MSR can be faster. This firm-based approach could be implemented in the same way that banks are required to maintain a certain amount of assets (Newell et al., 2005). In practice this would be difficult to implement as it would require firms to buy allowances if they did not hold sufficient allowances when the limit is changed. It would also be difficult to enforce.

Currently a decision to adjust the market volume must go through a lengthy legislative process at the EU level, which is subject to political lobbying. Many studies propose the formation of an independent authority such as a central carbon bank and delegation of decision-making power to this independent authority (Grosjean et al., 2014; DIW Berlin 2013; Clò et al., 2013). Studies argue that an independent authority would also improve the credibility of the MSR by limiting the possibilities for lobbying and insulating decision-making from short-term political concerns (Brunner et al., 2012).This corresponds to the responses of the interviewees that feel the credibility of an MSR would improve significantly if it would not be influenced by the Member States. They expressed concerns regarding the decision-making power of setting and reviewing the triggers being in the hands of politicians. However, under the current MSR proposals, and according to the criteria outlined in section 3.3, a system that works according to pre-determined rules would have more limited ability to benefit from a central decision-making body.

In any case, under the institutional setup of the EU it is very difficult to delegate the decision-making power to an independent body such as a central carbon bank. At most this independent body would be able to provide advice when rules were set or reviewed and perform administrative duties to maintain the MSR. The latter would be in line on the proposal by the EC for the European Investment Bank to act as a reserve-keeper (European Commission, 2014b). The reserve-keeper would maintain the reserve and auction the allowances according to the rules of the MSR that have been set in advance. An independent body providing advice on rules would be akin to the UK Committee on Climate Change.

4.2.4 Credibility

Various ways have been suggested in literature to improve the credibility of the reserve. These can be divided into three types (Brunner et al., 2011):

- Legislation: putting the establishment of an MSR into legislation. The more details that are put into legislation, the more certainty it provides to the market. It should leave some flexibility for unforeseen circumstances though. Interviewees indicated that the general framework of the MSR should be put into legislation before the market would actually respond to it and see it as credible. They did support the idea of reviewing the MSR threshold and intervention levels, which corresponds to one of the lessons learnt from other markets where regular review was required to maintain the credibility of the rules (see section 3.2)

- Delegation: delegating various responsibilities to an independent entity that is not influenced by politics or lobbying (see section 4.2.3). This could be in an advisory role, implementing role or decision-making role. In the EU it is very difficult to delegate decision-making powers to an independent entity, and may not be necessary if the rules are sufficiently automated.
- Securitisation: selling call and put options and future contracts for allowances by the MSR (Murray et al., 2008). These financial instruments would provide more certainty for long-term investments as it enables market participants to hedge against unexpected circumstances where the MSR would act. This would also enhance the credibility of the MSR as the contracts ensure the access to the allowances in the MSR by market participants when conditions to release allowances have been met.

The general lack of transparency in setting the thresholds and intervention levels in the MSR and uncertainty in what form the MSR will be adopted in legislation was mentioned by the interviewees as undermining the credibility of the MSR currently and as proposed. For this reason most interviewees see practically no impact of the MSR on the current allowance market. They expect that the MSR will only start to have an impact when it has been adopted in legislation or the implementation date is coming closer.

4.2.5 Review points

Review points should be positioned so that they are frequent enough to ensure that the MSR is operating effectively, but not so often that the reviews undermine the credibility of the MSR. Reviews can be set according to a fixed period or triggered by certain events. A periodic review is seen to provide more stability to the market as it reassures the market that no more regulatory changes related to the MSR would occur between the review points (IETA, 2013). In the latter case more flexibility allows for a quick fix if the MSR parameters have been set at the wrong levels. The trigger points for review must then be clearly defined to prevent political intervention at any discretion.

In the current EC’s proposal the review date has been set by the end of 2026. Some interviewees had some doubts whether that was too early as the surplus may still be above the upper threshold proposed by the EC, but the majority agreed that review was necessary and a period of approximately every five years would be acceptable. They reiterated that review should not occur too often, as that would cause more uncertainty in the market. It was also emphasised that when reviewing the MSR, it should be limited to the threshold and intervention levels and the choice of triggers should remain intact.

5 Assessing market stability reserve designs

The quantitative analysis is conducted using the Kollenberg and Taschini (2014) Model (KT Model) and the DECC Carbon Price Model (DCPM). The KT Model characterises an emissions trading system where price-taking entities must comply with regulations by perfectly offsetting their emissions within the compliance period. In doing so, firms decide whether to abate or trade (buy and sell) allowances. Companies adapt their abatement and trading behaviour, depending on the expectations about the relative cost difference between abatement and acquiring allowances and the resulting allowance price.

The KT model provides explicit outputs including abatement, reserve levels and carbon prices and can therefore demonstrate how market players may respond to different designs of an MSR. As discussed below, the results reinforce the critical role played by market expectations in influencing future cumulated abatement effort and its perceived costs. A comprehensive description of how the KT model works, its assumptions and properties can be found in Annex III.1 and III.2.

The KT model allows us to test the performance of different MSR designs. These designs can be compared, using the model under:

a. different states of the world or so-called shock scenarios, e.g. a strong or weak state of the economy, and
b. different trigger levels, also referred to as sensitivity analysis.[23]

Firstly, the key model inputs: the time horizon, the marginal abatement cost parameter, the trading cost parameter, and the annual price increase equivalent to a risk-adjusted interest rate of 4.8%[24] were set, together with DECC (see Annex III.3). Finally, the allowance allocation schedule (CAP) and the business-as-usual (BAU) emissions are selected from the inputs variables used in the DCPM. These figures are used to quantify the cumulated abatement effort given the stipulated foresight (more on this below). They capture market expectations about the future cumulated abatement efforts, e.g. the difference between expected total cap and expected total emissions. (See Annex III.4).

Second, acknowledging the outcomes of the research in the first part of this study, an assumption was added to the model that companies only consider their expected abatement effort within the next five years. This five-year foresight is referred to sometimes as myopia, as it deviates from the theoretical perfect foresight that would look forward to 2050, in this policy context. Under perfect foresight there is no uncertainty about current and future marginal abatement cost curves, emissions and caps. Abatement and trading strategies are based on this set of information. Under limited foresight, when making decisions about abatement and trading of allowances, market participants consider the information about abatement efforts only up to five years in the future.

[23] The selection of the trigger levels was part of the sensitivity analysis, e.g. selecting trigger levels was an iterative process. We would like to stress the fact that exact levels do not matter that much; it is the market response relative to different design choices that we are exploring in this study.
[24] Derived using market prices of EUA futures contracts.

Firms consider only banking of allowances for five years and thus do not consider the impact of long-term scarcity on allowance price or for abatement decisions. While hedging behaviour is not explicitly modelled, it is included as part of the trading strategies (see Box 7).

Box 7 Hedging in the K&T model

How is hedging behaviour being considered in the K&T model? The K&T model does not make any specific assumptions about the hedging behaviours of individual market participants and therefore the hedging behaviour of compliance entities is not explicitly modelled or estimated. Rather, the hedging demand is considered as part of the overall demand for emission allowances and impact of trading strategies in the model. Under limited foresight, the demand for emission allowances is the expected emissions within the foresight window — 5 years — minus the expected abatement, implicitly taking into account hedging or industrial banking that takes place within this timeframe (see section 3.1.1). Speculative demand is not included in the model. Hedging is only omitted from this approach when the hedging window is longer than the foresight window. This mismatch is unlikely as hedging windows are understood to be limited to 3 to 4 years (Neuhoff et al., 2012).

As the cap becomes increasingly stringent and more abatement measures are taken, emissions and associated allowance demand, including hedging, decreases over time. In the model the number of allowances in circulation, which includes any banked or hedged allowances, decreases over time. This means that even changes in hedging behaviour are implicitly reflected in abatement and trading decisions under limited foresight, together with any other demand for emission allowances.

However, the impact of hedging on the prices is not included in the model. The K&T model assumes an annual price increase of 4.8%. Changes to the allowances in circulation in relation to the hedging requirements could change this annual price increase rate as described in section 3.1.1. This would result in a variable annual price increase, which is beyond the scope of the model.

In this model a five-year foresight window was used. If the foresight window were longer, then abatement would be spread out more evenly over time, with more early abatement and permits savings in response to future larger scarcity. Consequently, the MSR would store less allowances. If the foresight window were shorter, then abatement decisions would be based on a shorter time frame: in the presence of high level of permits savings abatement will be delayed even further. Consequently, the MSR would store more allowances. Because of the five-year foresight window, and also an assumption that all abatement is resolved by 2050, results towards the end of the horizon i.e. after 2045 should be treated with caution.

The objective of this modelling exercise is to test the various MSR design options under investigation in relation to one another and against future unanticipated variations in the allowance demand. To do so, different states of the world (henceforth called '*shocks*') are used. The sensitivity of the MSRs is tested by implementing an artificial unanticipated economic recession, i.e. a persistent decrease of emissions, and an artificial unanticipated economic boom, i.e. persistent increase of emissions. These shocks may also been seen to represent technology advancement and implementation of new complementary policies.

These shocks affect future emissions compared to the business-as-usual scenario and thus the future demand for allowances. In the model the emissions after application of the shocks are referred to as 'post-shock BAU emissions'. In this study we consider two possible scenarios:

a. a 10% reduction every year for six consecutive years, from 2023 to 2029;
b. and a 10% increase every year for six consecutive years, from 2023 to 2029 or from 2029 to 2035.[25]

The following sections describe the scenarios tested, and outline the results and key findings.

5.1 Market stability reserve design alternatives

While there are broad range of options for the design of an MSR, assessment exercise described in this chapter focuses on three types of MSRs following the evaluation of trigger designs in section 3.5:

- volume-based mechanisms
- price-based mechanisms, and
- a combination of the two dimensions, henceforth hybrid mechanisms.

The table below describes the withholding and injection conditions (trigger levels and withholding and injection quantities) of the three types of MSR under investigation: European Commission MSR proposal (EC); hybrid MSR (hybrid mean price, HM) and price-based mechanisms (absolute price, AP, and mean price, MP). The table below offers a summary of the MSR sub-cases listing their trigger levels (upper volume threshold, and lower volume threshold, respectively; and upper price threshold, and lower price threshold, respectively), and withholding and injection quantities (withholding quantity, and injection quantity, respectively). The complete catalogue of all implemented MSR sub-cases and graphical representations of all model runs can be found in Annex IV.

Table 16 Overview of all MSR sub-cases and their key characteristics

MSR sub-case	Start year	Shock*	Withholding threshold	Injection threshold	Withdrawal quantity	Injection quantity
EC 1.1 (surplus)	2021	-	833 Mt	400 Mt	12% of surplus	100 Mt
EC 1.2 (surplus)	2021	-10% in 2023–2029	833 Mt	400 Mt	12% of surplus	100 Mt
EC 1.3 (surplus)	2017	-10% in 2023–2029	833 Mt	400 Mt	12% of surplus	100 Mt
EC 1.4 (surplus)	2021	-10% in 2023–2029	1000 Mt	200 Mt	12% of surplus	100 Mt
EC 1.5 (surplus)	2021	-10% in 2023–2029	833 Mt	200 Mt	12% of surplus	100 Mt
EC 1.6 (surplus)	2021	-10% in 2023–2029	Step-wise threshold	Step-wise threshold	12% of surplus	100 Mt
EC 1.7 (surplus)	2021	+10% in 2023–2029	833 Mt	200 Mt	12% of surplus	100 Mt
EC 1.8 (surplus)	2021	+10% in 2023–2029	Step-wise threshold	Step-wise threshold	12% of surplus	100 Mt

[25] The selection of these two scenarios is based on a comparison of pre- and post-recession BAU emissions projections over the period 2013-2020, which indicates that there has been an annual reduction of about 10-13% in each year.

MSR sub-case	Start year	Shock*	Withholding threshold	Injection threshold	Withdrawal quantity	Injection quantity
Hybrid HM 2.1 (absolute price)	2021	-	833 Mt	60 €/tCO_2 (4.8%/a increase)	12% of surplus	100 Mt
Hybrid HM 2.2 (absolute price)	2021	-10% in 2023–2029	833 Mt	60 €/tCO_2 (4.8%/a increase)	12% of surplus	100 Mt
Hybrid HM 2.3 (absolute price)	2017	-10% in 2023–2029	833 Mt	60 €/tCO_2 (4.8%/a increase)	12% of surplus	100 Mt
Hybrid HM 2.4 (absolute price)	2021	-10% in 2023–2029	833 Mt	15 €/tCO_2 (4.8%/a increase)	12% of surplus	100 Mt
Hybrid HM 2.5 (absolute price)	2021	-	833 Mt	20 €/tCO_2 (no increase)	12% of surplus	100 Mt
Hybrid HM 2.6 (absolute price)	2021	+10% in 2029–2035	833 Mt	20 €/tCO_2 (no increase)	12% of surplus	100 Mt
Hybrid HM 2.7 (absolute price)	2021	+10% in 2029–2035	833 Mt	Step-wise threshold	12% of surplus	100 Mt
AP 3.1 (absolute price)	2021	-	8 €/tCO_2 (4.8%/a increase)	60 €/tCO_2 (4.8%/a increase)	200 Mt	100 Mt
AP 3.2 (absolute price)	2021	-10% in 2023–2029	8 €/tCO_2 (4.8%/a increase)	60 €/tCO_2 (4.8%/a increase)	200 Mt	100 Mt
AP 3.3 (absolute price)	2017	-10% in 2023–2029	8 €/tCO_2 (4.8%/a increase)	60 €/tCO_2 (4.8%/a increase)	200 Mt	100 Mt
AP 3.4 (absolute price)	2021	-10% in 2023–2029	8 €/tCO_2 (4.8%/a increase)	60 €/tCO_2 (4.8%/a increase)	100 Mt	100 Mt
AP 3.5 (absolute price)	2021	-10% in 2023–2029	Step-wise threshold	Step-wise threshold	200 Mt	100 Mt
AP 3.6 (absolute price)	2021	+10% in 2029–2035	8 €/tCO_2 (4.8%/a increase)	60 €/tCO_2 (4.8%/a increase)	200 Mt	100 Mt
MP 4.1 (mean price)	2021	-	8 €/tCO_2 (4.8%/a increase)	60 €/tCO_2 (4.8%/a increase)	200 Mt	100 Mt
MP 4.2 (mean price)	2021	-10% in 2023–2029	8 €/tCO_2 (4.8%/a increase)	60 €/tCO_2 (4.8%/a increase)	200 Mt	100 Mt

* This is a shock to the level of BAU emissions; -10% represents an economic recession and +10% represents an economic boom

5.2 Description of the outputs

Given the selected model inputs, the KT model produces the following outputs (also see Annex III.4):

a. Post-shock BAU emissions - yearly emission level after the shock occurred;
b. Allocated allowances - yearly cap, including back-loaded allowances (without smoothing effect)[26] and international credits, minus auction adjustments. This represents the total number of allowances auctioned each year;
c. Emission abatement - yearly emission abatement;
d. Total number of allowances in circulation (TNA): defined as initial surplus of allowances plus past and present allocated allowances minus past and present post-shock BAU emissions, plus past and present emission abatement (see also Box 3). In the modelling results TNA is used instead of surplus, since the TNA can be positive or negative while surplus generally refers to a positive TNA;

[26] The smoothing mechanism in the EC's MSR proposal was not applied to ensure only the impact of the MSR is modelled and does not include any additional impact of the smoothing mechanism; scenario without an MSR, the baseline scenarios, do not include a smoothing mechanism. Regardless, this choice has negligible impact on the MSRs that start in 2021.

e. The allowance reserve level;
f. Allowance price.

While the KT model produces allowance prices, it is important to reiterate that these are not price projections. The absolute price levels are a function of the assumption and model inputs and as a standalone output no meaningful conclusions can be drawn from the allowance price graphs. It is the relative price performance of different MSR designs that is of interest. The price performance of the MSR designs is assessed by comparing the price trajectories and final aggregated compliance costs of the designs with each other and the status quo.

Please see Annex III Kollenberg and Taschini (2014) model for a detailed description of the model assumptions and model inputs. Figures will offer a graphical presentation of the evolution of most relevant model outputs from 2013 to 2050.

5.3 Discussion of the model results

In the previous chapters we argued that the large oversupply of allowances due to the economic recession has distorted the current incentive for businesses to reduce emissions.

The important impact of perfect foresight

Decisions taken on emissions abatement are closely related to past and future expected emissions and past and future expected allocations of allowance. In a theoretical economist's model, compliance entities have perfect foresight and perfect policy certainty. As such, there is full certainty about current and future allowance supply and emissions. Firms can make their trading and abatement decisions based on perfect information and spread their abatement yearly efforts equally across the compliance phase (top-right diagram in Figure 10). The equalisation of abatement across time represents the cost-optimal abatement pathway. As such, under perfect foresight and perfect policy certainty the presence of a large surplus in the system — approximately 1.8 Gt — is not a problem. The optimal allocation of abatement efforts across the next 37 years makes the surplus of 1.8 billion allowances rather small when compared to the total (available) allowances to 2050 of around 50 billion.[27] Hence, under perfect foresight the current surplus is small compared to total future cap (top-left diagram in Figure 10) and does not generate short-term excessive market imbalance. The top-left diagram of Figure 10 provides an illustration of the supply of allowances up to 2050 with back-loading (more details on the impact of back-loading is provided below). Back-loading reduces the auctioned volumes by 400, 300 and 200 million allowances in 2014, 2015 and 2016 respectively. These allowances return to the market later, increasing the auctioning amounts by 300 and 600 million allowances in 2019 and 2020 respectively.

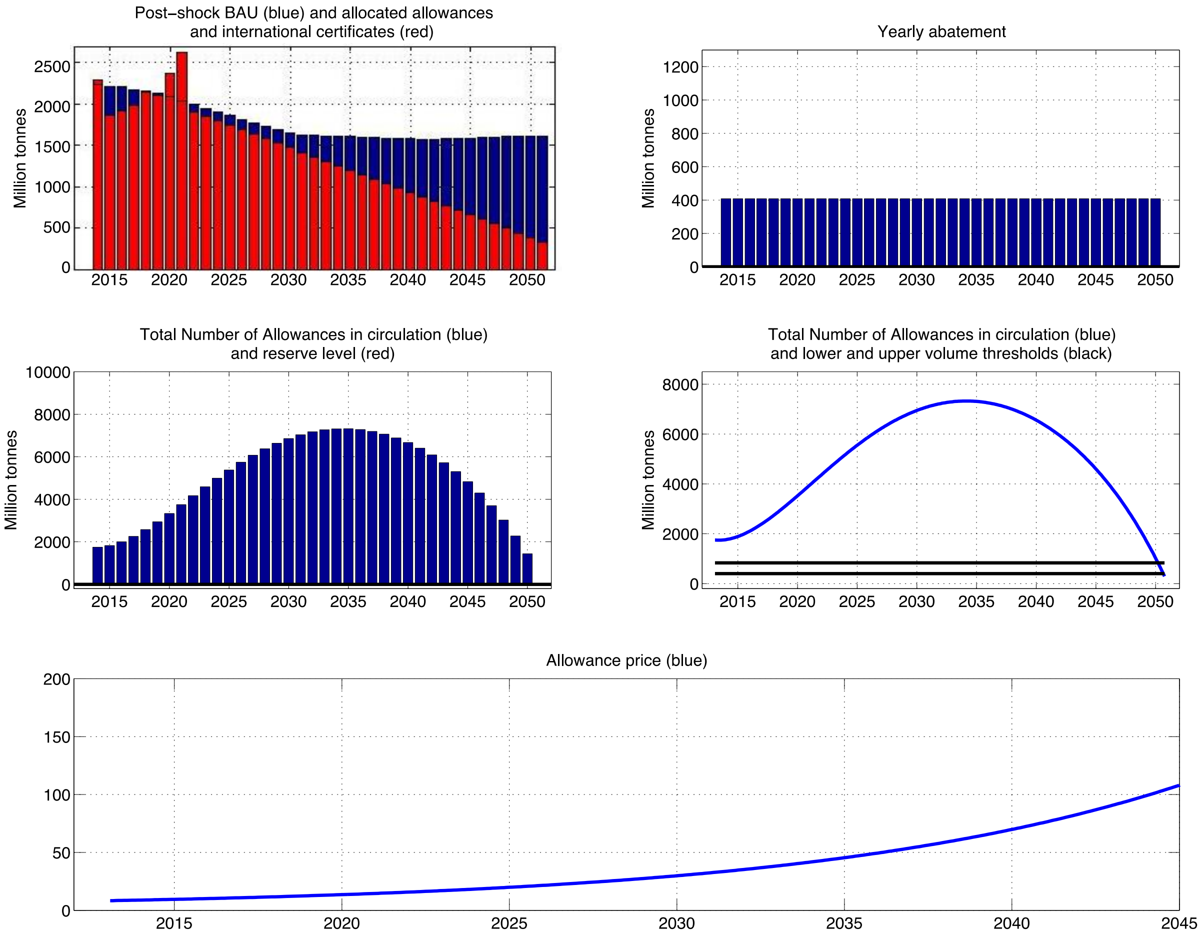


Figure 10 Perfect foresight and no MSR – Evolution of the yearly abatement, the total number of allowances in circulation and the allowance price in the absence of a market stability reserve

Also, when considering one of the objectives of a supply management mechanism – to tackle future unanticipated variations in allowance demand – the design of the EC MSR and, in particular, the definition of the TNA, renders the mechanism ineffective under perfect foresight. Emission abatement is evenly spread in the case of perfect foresight, as shown in the graphs in Figure 10. Because of the high levels of emission abatement large numbers of allowances are not used for compliance and instead create a very high TNA. As such a surplus-based MSR is triggered every year, and so the mechanism withholds a significant amount of allowances. The resulting perverse outcome of running the EC MSR under perfect foresight, as discussed in sections 3.1.2 and 3.4.2.1, is visible in the graph below: the reserve continuously grows (mid-left diagram in Figure 11) causing a significantly higher, unnecessary abatement response (top-right diagram in Figure 11).

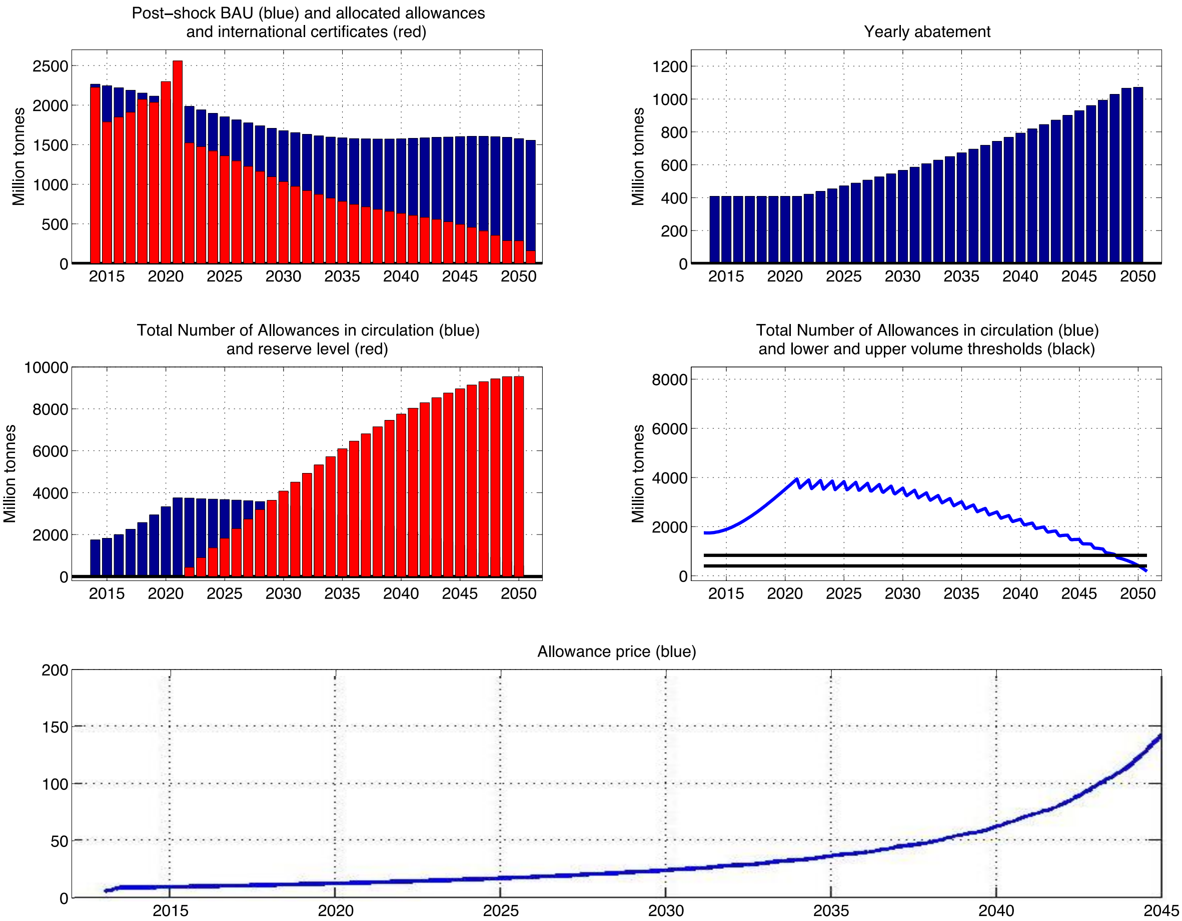


Figure 11 Perfect foresight and EC MSR – Evolution of the yearly abatement, the total number of allowances in circulation and the allowance price in the presence of a market stability reserve

Conversely, the presence of a large surplus in the system may blunt abatement incentives when businesses have limited foresight (see section 1.1). An expected large surplus of allowances reduces the inter-temporal efficiency of the ETS because businesses prefer to postpone emission abatement.[28] Costs of emission reductions are expected to be lower, the earlier emission abatement takes place. Hence, delaying emission abatement increases overall costs when considered over the longer periods. If allowances are not scarce over the limited foresight horizon, prices are low and abatement is not incentivised. The shorter the foresight, the stronger the effect. In principle, under limited foresight an MSR should result in earlier emission abatement and, ideally, lower abatement costs.

Back-loading reinstates incentive to abate, but only for a very short period of time
As a short-term measure to mitigate the effects of the large surplus, the Commission is back-loading the auctioning of 900 million allowances from the beginning of Phase III.

[28] The inter-temporal decisions of how many allowances to trade matters for economic efficiency as measured by the optimal scheduling of abatement efforts across time.

With a five-year foresight, Figure 12 shows that back-loading re-establishes an incentive to abate emissions. However, this effect is only temporary - from 2014 to 2015 (top-right diagram in Figure 12). As back-loading leads to a rebound in the surplus in 2019 and 2020 (mid-right diagram in Figure 12), shortly after 2016 when the return of allowances comes within the modelled foresight of participants the incentive to abate emissions vanishes. Only in 2024, when the market-wide perception of an excessive oversupplied EU ETS changes, does the yearly abatement becomes positive again (top-right diagram in Figure 12).

If no action is taken, abatement costs will grow dramatically

Under perfect foresight, businesses smooth their volume of abatement and their (discounted) costs of abatement. The limited foresight results in a dramatic deviation of the abatement pathway from the optimal outcome in the model, which is constant abatement (see Figure 12). Almost no mitigation is pursued before 2025, resulting in the need for a rapid ramp up of abatement toward the end of the modelling period (top-right diagram). Due to the surplus (positive TNA) in the system up to the late 2030s in combination with limited foresight, abatement by firms in the model is reduced. This results in a weaker increase in abatement over the years relative to the increasingly stringent cap. The surplus is gradually reduced until it becomes negative, representing firms borrowing allowances (also see Box 3). Since in the model the demand and supply have to be in balance in 2050, the abatement effort increases in the late 2040s and becomes positive again.

In the model, abatement cost increases with successive increase in abatement. This means that it costs a lot more to reduce the last unit of pollution than the first. Later emission reduction increases the total cost of emission abatement. This also increases the aggregated costs of the system (see Section 5.4).

In practice it could also bring into question the likelihood of firms being able to achieve the very high levels of abatement required in the future given that this would be very costly, thus jeopardising the emission reduction target.

The expectation of a low allowance price may also discourage investments in low carbon technologies, exacerbating the lock-in effect of investments in high carbon technologies, particularly in the energy sector (see section 1.1)

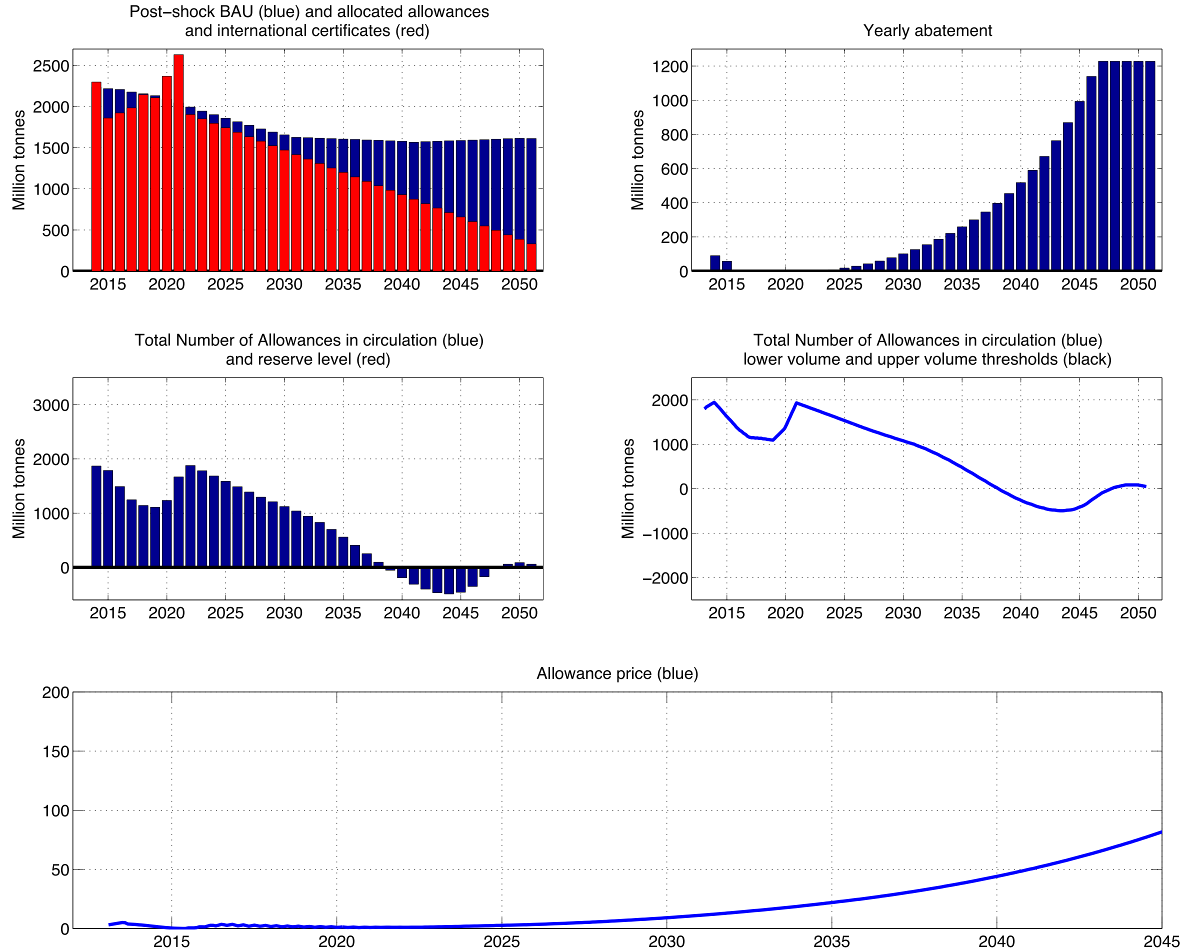


Figure 12 Status quo – Evolution of the yearly abatement, the total number of allowances in circulation and the allowance price in the absence of a market stability reserve

MSR results in earlier emission abatement and lower abatement costs

When the MSR is triggered, allowances are withheld from auction and placed into the reserve. This reduces the availability of allowances and increases the required abatement effort. Since costs of emission reductions are lower when emission abatement takes place earlier, bringing the start of the MSR forward reduces abatement costs. In other words, the allowance reserve drives firms to anticipate emission abatement ultimately decreasing overall costs when considered over the longer term. The MSRs start in 2021 in all sub-cases except four. These four cases show the lowest abatement cost levels (see Figure 21 below). In fact, an earlier implementation of the MSR is the policy design option that delivers the most significant reduction of abatement costs. This occurs as allowance prices increase earlier, stimulating earlier abatement and, consequently, requiring firms to do less (expensive) abatement later. Thus, earlier emission reductions decrease the total cost of emission abatement. It is important to note that the abatement path profile is still very different from the optimal outcome: constant abatement levels over time. This suggests that an earlier implementation of the MSR alone is not sufficient to replicate the cost-optimal pathway. That said, subject to the model assumption that market participants do not have perfect foresight and thus are reluctant to bank allowances beyond five year time horizons, the result that earlier implementation reduces aggregate compliance costs appears to be a sensible conclusion that deserves careful attention.

The performance of the European Commission's proposed MSR

First we describe the case where there are no future unanticipated variations in the allowance demand, i.e. no shocks. The EC MSR is immediately triggered in 2021 – allowances are withheld from auction and placed into the reserve over the course of 2021. Withholding continues until the TNA falls below the upper volume threshold. When the TNA falls below the lower volume threshold, the mechanism starts using the allowances in the reserve until it is entirely deployed as shown in Figure 13.

By reducing the availability of allowances the EC MSR increases the required abatement effort starting from 2022. Compared to the situation where there is no MSR, the status quo, the earlier emission reductions induced by the EC MSR result in a lower total cost of emission abatement.

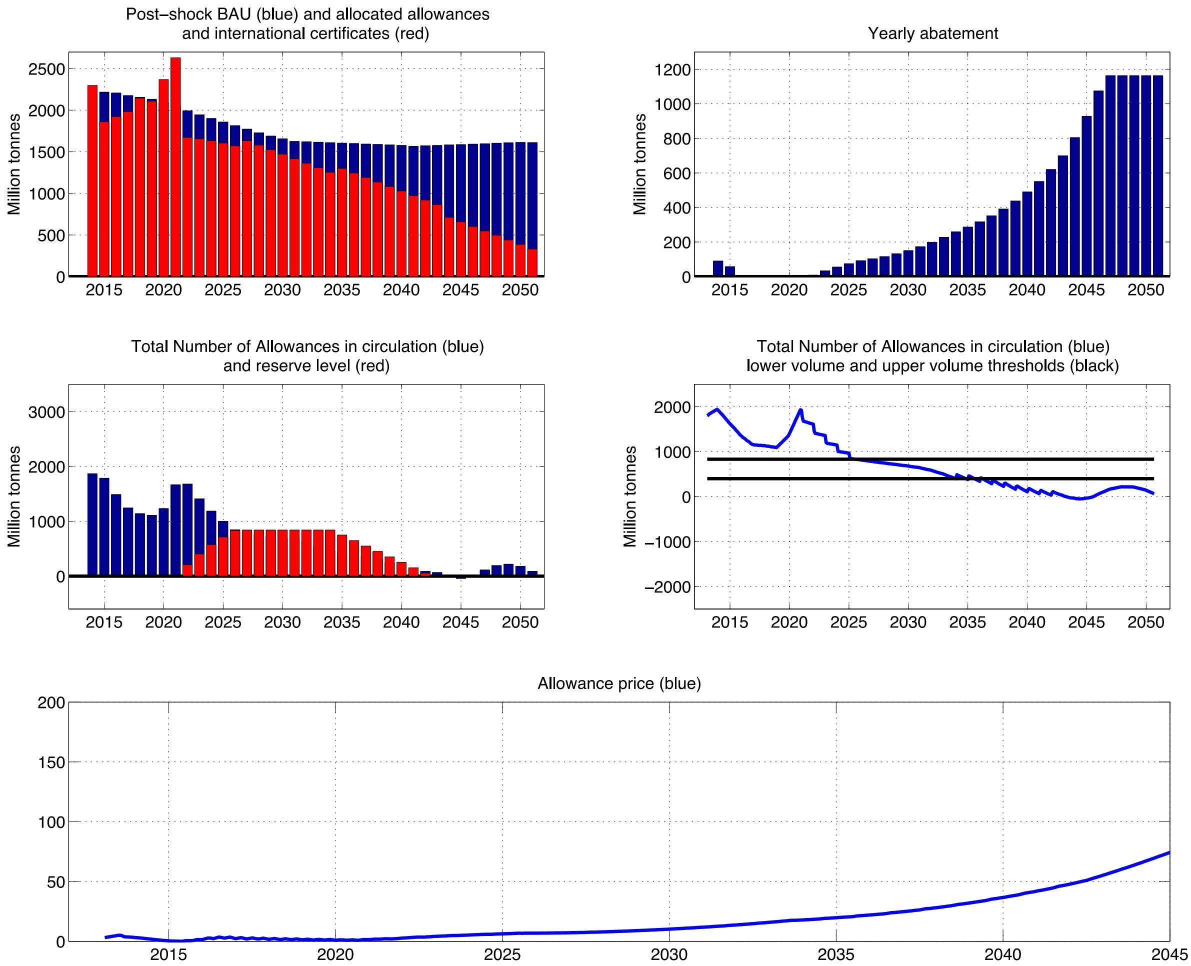


Figure 13 EC sub-case 1.1 – Evolution of the yearly abatement, the total number of allowances in circulation and the allowance price without a shock and with the EC market stability reserve with its original trigger thresholds and withholding/injection quantities.

By withholding or injecting allowances, the MSR redistributes abatement efforts across the modelling horizon and thus help reduce total costs from the otherwise delayed abatement. It improves the economic efficiency of the system and brings it closer to the cost-optimal pathway, represented by equal abatement effort over time as shown in the top diagram in Figure 14. With an MSR the annual abatement moves closer to annual abatement under perfect foresight compared to the status quo. The cost of emission abatement can be lowered further by implementing the MSR earlier, i.e. 2017 in the model, spreading annual abatement more equally. The bottom diagram in Figure 14 shows that the MSR also allows the TNA to reduce and abatement increase in a more gradual manner, which leads to a more gradual price increase, which is further elaborated in Figure 20). An early implementation of the MSR leads to an even more gradual reduction of the TNA.

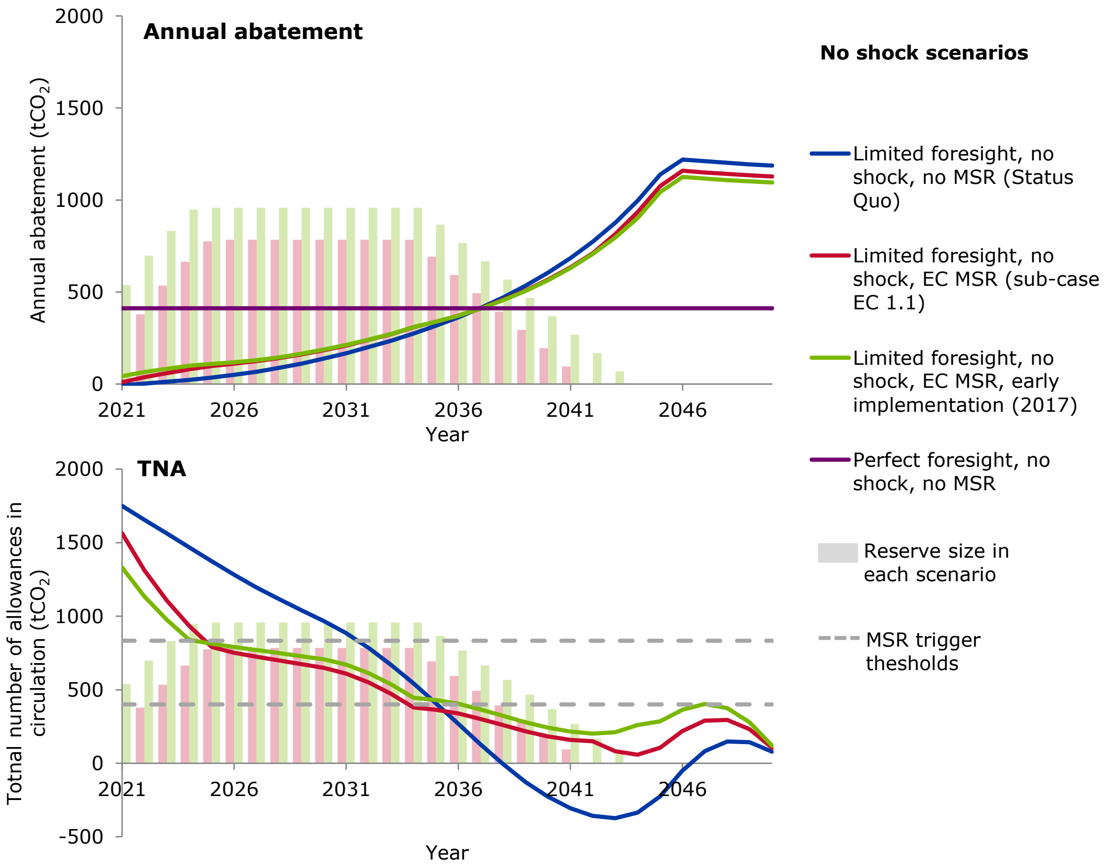


Figure 14 The annual abatement (top) and total number of allowances in circulation (bottom) with the reserve size in each scenario for the status quo and the EC MSR with different starting dates, and annual abatement under perfect foresight

The response of EC MSR to economic shocks

As mentioned above, the objective of this modelling exercise is to test the various MSR design options against future unanticipated variations in the allowance demand. To do so, different shocks are used. These shocks affect future emissions compared to the business-as-usual scenario and thus the future demand for allowances. In particular, we consider a persistent decrease of BAU emissions and a persistent increase of BAU emissions. These are, respectively

a. a 10% reduction every year for six consecutive years, from 2023 to 2029;

b. and a 10% increase every year for six consecutive years, from 2023 to 2029 or from 2029 to 2035.

In the model the emissions after application of the shocks are referred to as 'post-shock BAU emissions'.

Post-shock BAU emissions (blue bars, top-left diagrams) represent emissions after the shock occur. Depending on the type and timing of the shock, post-shock BAU emissions may differ from one sub-case to the other. Conversely, every MSR tested uses the same initial annual allocation (the cap) – this incorporates back-loading and future availability of international credits but no smoothing mechanism.

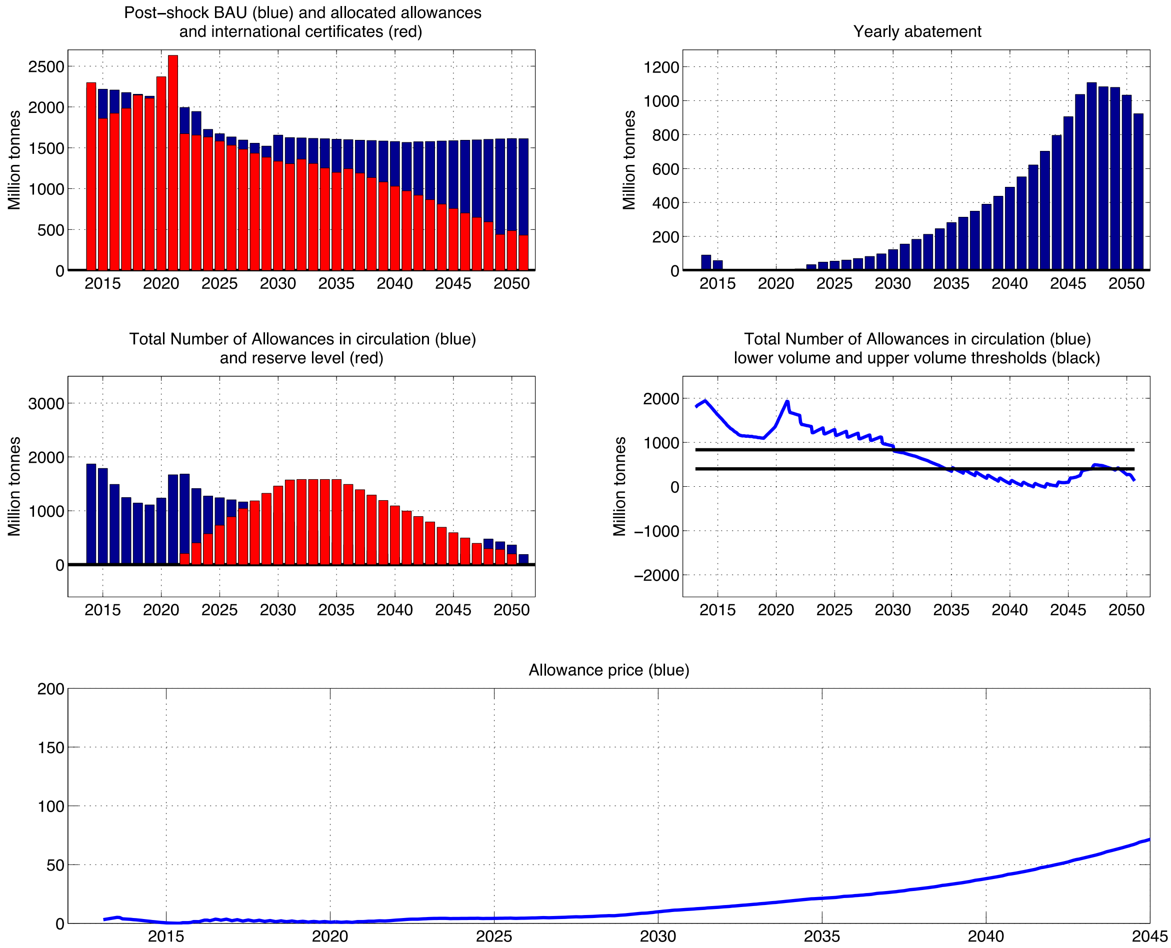


Figure 15 EC sub-case 1.2 – Evolution of the yearly abatement, the total number of allowances in circulation and the allowance price in the presence of a negative shock (reduced emissions) and with the EC market stability reserve with its original trigger thresholds and withholding/injection quantities

A 10% reduction in BAU emissions every year from 2023 to 2029 (blue bars, top-left diagram in Figure 15) results in a higher surplus (mid-right diagram in Figure 15) than would have been the case without this shock. The reserve absorbs part of the larger surplus by withholding more allowances so that the reserve level at its peak is higher (red bars, mid-left diagram in Figure 15) than the reserve without shock. Moreover, the reserve is not entirely deployed by 2050.

When considering a positive shock, a 10% increase every year from 2023 to 2029, the higher allowance demand and lower TNA are reflected in a lower reserve volume than would otherwise have been the case. However, the reserve is deployed much earlier, leaving no allowances in the reserve to be used after 2035 to address possible shocks after this time (red bars, mid-left diagram in Figure 16). The EC MSR has sufficient allowances to deal with the selected positive shock but may remain vulnerable to a further positive shock after 2035.

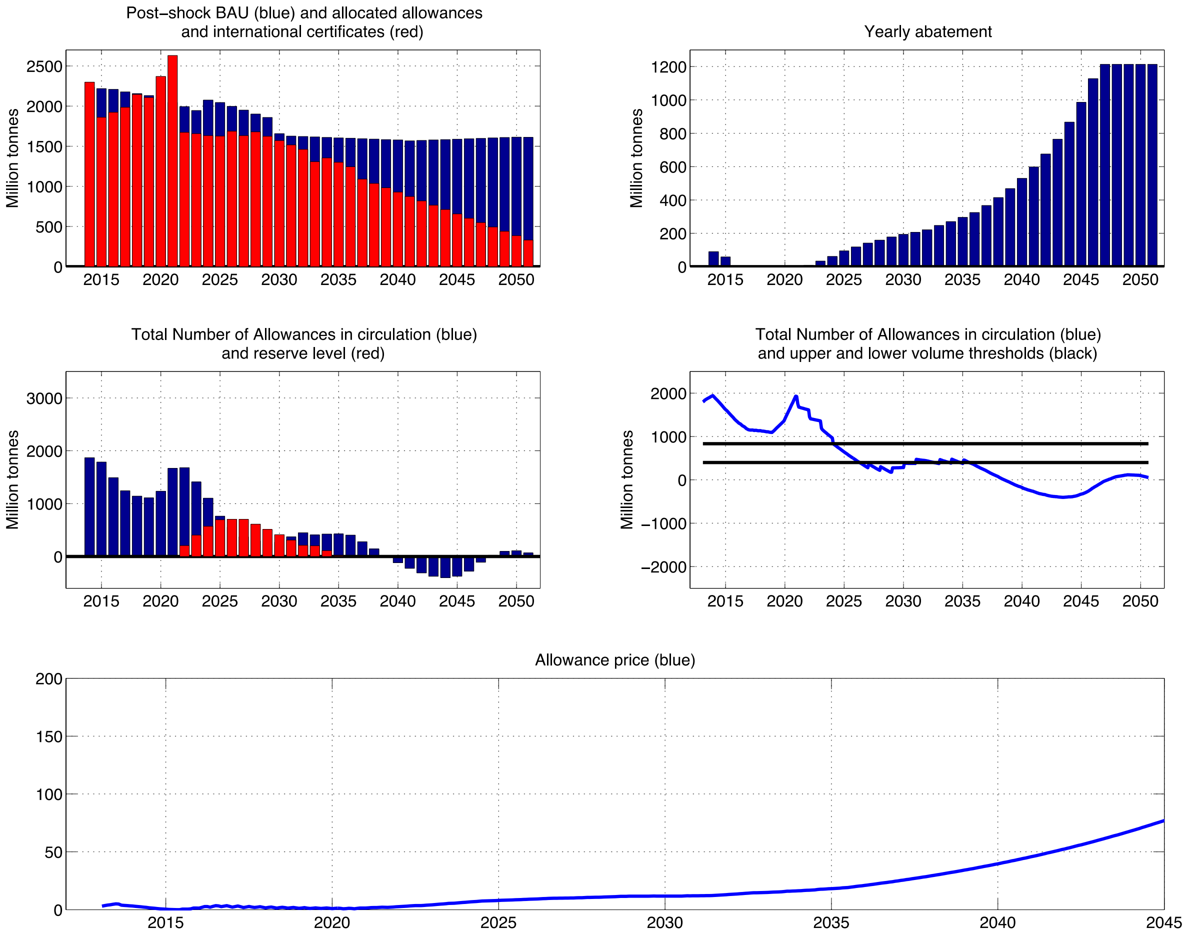


Figure 16 EC sub-case 1.7 – Evolution of the yearly abatement, the total number of allowances in circulation and the allowance price in the presence of a positive shock and with the EC market stability reserve with its original trigger thresholds and withholding/injection quantities

By withholding or injecting allowances, the MSR can redistribute abatement efforts across the compliance phase responding to shocks and thus help reduce total costs. The response of the EC proposed MSR has been summarised in Figure 17.

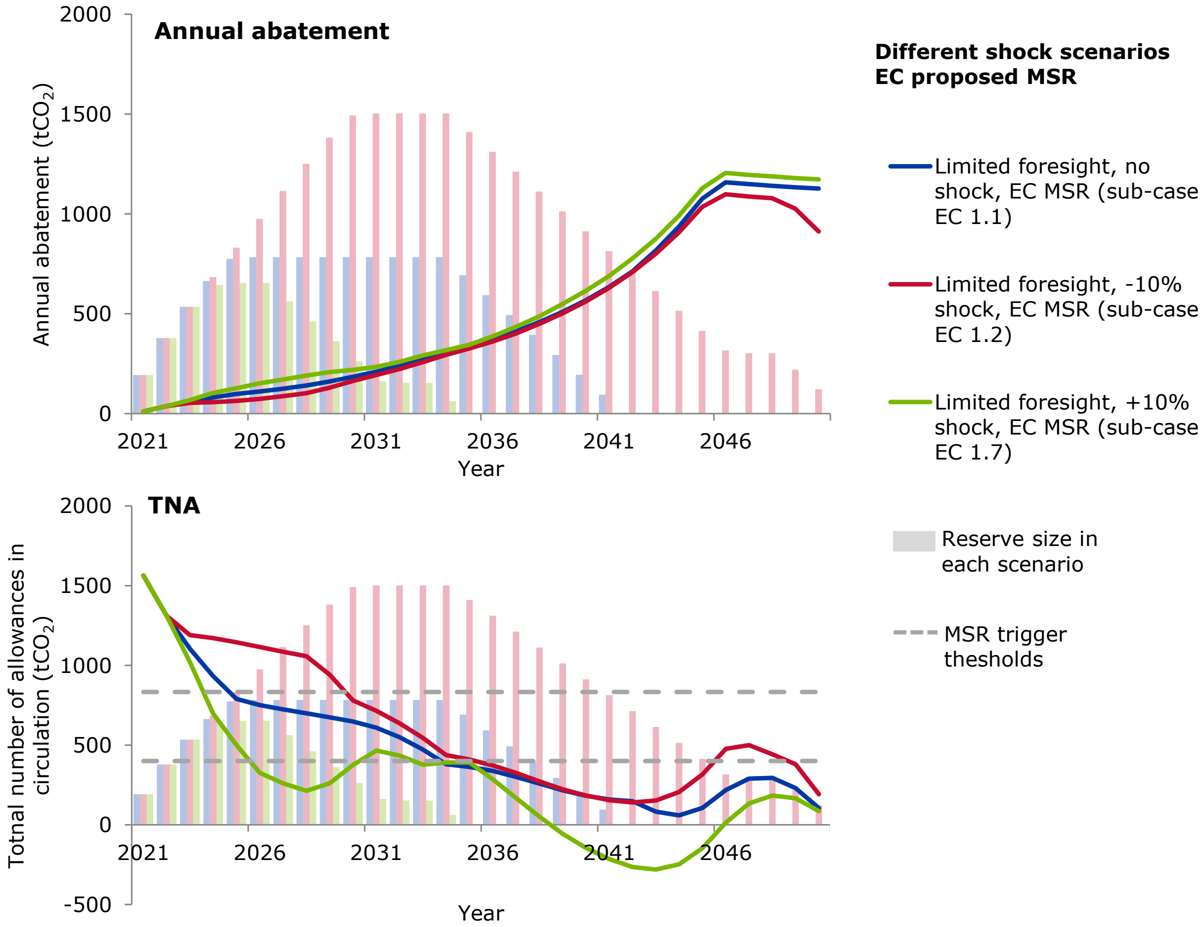


Figure 17 The response of the MSR under different shocks compared to no shock in terms of annual abatement (top) and TNA (bottom) including the reserve size

Broadly speaking, in the presence of a positive shock, the selected injection quantity is such that the reserve is not immediately or instantaneously deployed. In all of the cases assessed the reserve acts for a reasonable duration, however, here only one type of shock at a certain level has been tested. More frequent or forceful shocks may have a different effect. In the presence of a negative shock, the selected withholding quantity is such that the reserve does not "explode". The reserve does not quickly grow to potentially unsustainable levels.

Hybrid design may permanently remove allowances from circulation

The hybrid MSR is a hybrid volume-price mechanism. In the model, a pre-defined volume of allowances is automatically withheld and placed into the reserve when the TNA is larger than a given threshold. A pre-defined volume of allowances is automatically removed from the reserve and auctioned into the market when for more than six consecutive months, the average price of allowances is higher than a given price reference.

In the hybrid mechanism, as in the EC MSR cases, the mechanism is immediately triggered when it is introduced in 2021. Allowances are withheld from auction and placed into the reserve over the course of 2021 (red bars, mid-left diagram in Figure 18). In the presence of a negative shock, 10% reduction every year from 2023 to 2029, withholding stops in 2030 when the TNA crosses the 833 Mt upper volume threshold (mid-right diagram in Figure 18). In the presence of a positive shock, where emissions are increased by 10% each year from 2029 to 2035, withholding stops earlier, in 2025.

It is interesting to observe the impact of the upper price threshold. If the allowance price does not exceed this threshold, allowances in the reserve are not injected back into the market and the level of the reserve remains at its maximum peak. In the model it is as if allowances are permanently removed from the market over the modelled period. This is what we observe when the upper price threshold is assumed to start at €60 and increases with an assumed 4.8% rate of annual increase[29] (red bars, mid-left diagram in Figure 18). The size of the reserve ranges from 1,500 Mt to 2,000 Mt depending on the MSR starting date, 2021 and 2017 respectively. By selecting a lower starting price threshold, for instance €20 without an annual increase, the reserve is completely deployed. As in the EC MSR cases, first allowances are withheld and put in to the reserve and later, depending on when the allowance price crosses the price threshold, allowances are injected back in to the market. Please see Annex IV for graphical representations of all hybrid MSR model runs.

Figure 18 shows the results for the hybrid mechanism. These show important considerations in selecting the appropriate price and trend thresholds. If the threshold to return allowances is designed so that the MSR is triggered in response to unexpected shocks, sufficient allowances remain in the reserve to address any potential positive shocks in future. However, if the threshold is such that allowances are not returned to the market even after a positive shock has occurred, it increases the overall costs of the system as the abatement is larger than required by the original cap. The benefits from this increased abatement will also be larger, although these are not modelled here.

[29] Derived using market prices of EUA futures contracts

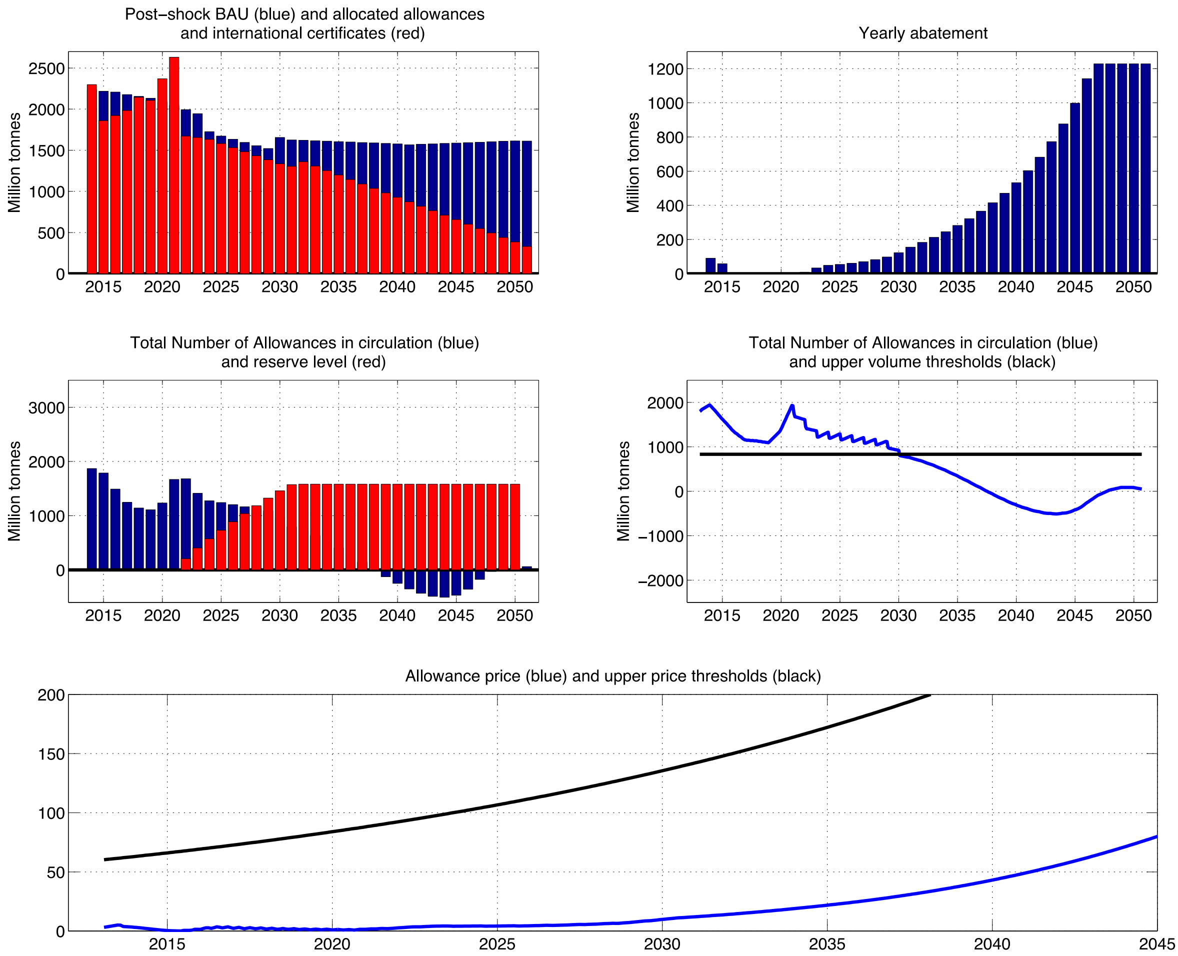


Figure 18 Hybrid sub-case 2.2 – Evolution of the yearly abatement, the total number of allowances in circulation and the allowance price in the presence of a negative shock and with the hybrid market stability reserve in place

The price-based approach: finding the proper price levels

The third type of MSR explored was the price-based MSR: absolute and mean-price mechanisms. Under both type of mechanisms, a pre-defined volume of allowances is automatically withheld and placed into the reserve when the absolute or the mean allowance price, respectively, is lower than a given reference price – the lower price threshold. Hence, as long as the allowance price is lower than the lower threshold, the reserve will continue to grow – it ranges from 1,000 Mt to 2,500 Mt with 2021 as MSR starting year and approximately 3,200 Mt with 2017 as MSR starting year. As in the hybrid case, when the upper price threshold is around €60 and increases with a 4.8% annual rate of increase, allowances in the reserve are not injected back into the market and the level of the reserve ends at its maximum peak (red bars, mid-left diagram in Figure 19).

The result that injection is not triggered demonstrates the difficulty in calibrating both price thresholds and the rate of annual increase of the threshold around values that create an adequate reserve and enable its appropriate deployment in response to a positive shock. The hurdle of the selection of the proper rate of annual increase of the threshold may be removed by implementing absolute price thresholds that evolve in a stepped manner. Yet, model results show that while it is possible that the price thresholds selected could create an adequate reserve and, later, deploy it as needed there is no guarantee that this will occur. Please see Annex IV.8 for a graphical representation of the results, specifically sub cases 2.6 and 2.7.

Interestingly, the chosen absolute and mean-price mechanisms generate similar results: comparable reserve levels and compliance costs. Under price-based MSRs in the model, the (absolute or mean) price is measured across six consecutive months and compared to the price in the reference period to determine whether allowances are withheld or injected. Given the rate of annual increase of the price thresholds assumed and the selected time window — six consecutive months is a sufficiently long time window to absorb any price spikes — the absolute-price MSR does not differ too much from the mean-price MSR. At the same time, the quantity of allowances withheld in a given year under both mechanisms is not sufficiently large to generate sizeable price variations. Significant differences may emerge when using larger withholding quantities and, for the absolute-price mechanism, a shorter time window. In reality, an absolute-price MSR would be more susceptible to market manipulation if time windows are short as discussed in section 3.4.3. Speculators can temporarily create price spikes or dips to either trigger intervention by the reserve. With long time windows the absolute-price could be less susceptible to manipulation to trigger the intervention as the price would need to continuously meet the threshold. However, this also means that speculators can prevent the MSR from triggering by temporary causing the price not to pass the threshold. Since the model only models the behaviour of compliance entities and not speculative trades, market manipulation cannot be captured in the modelling results.

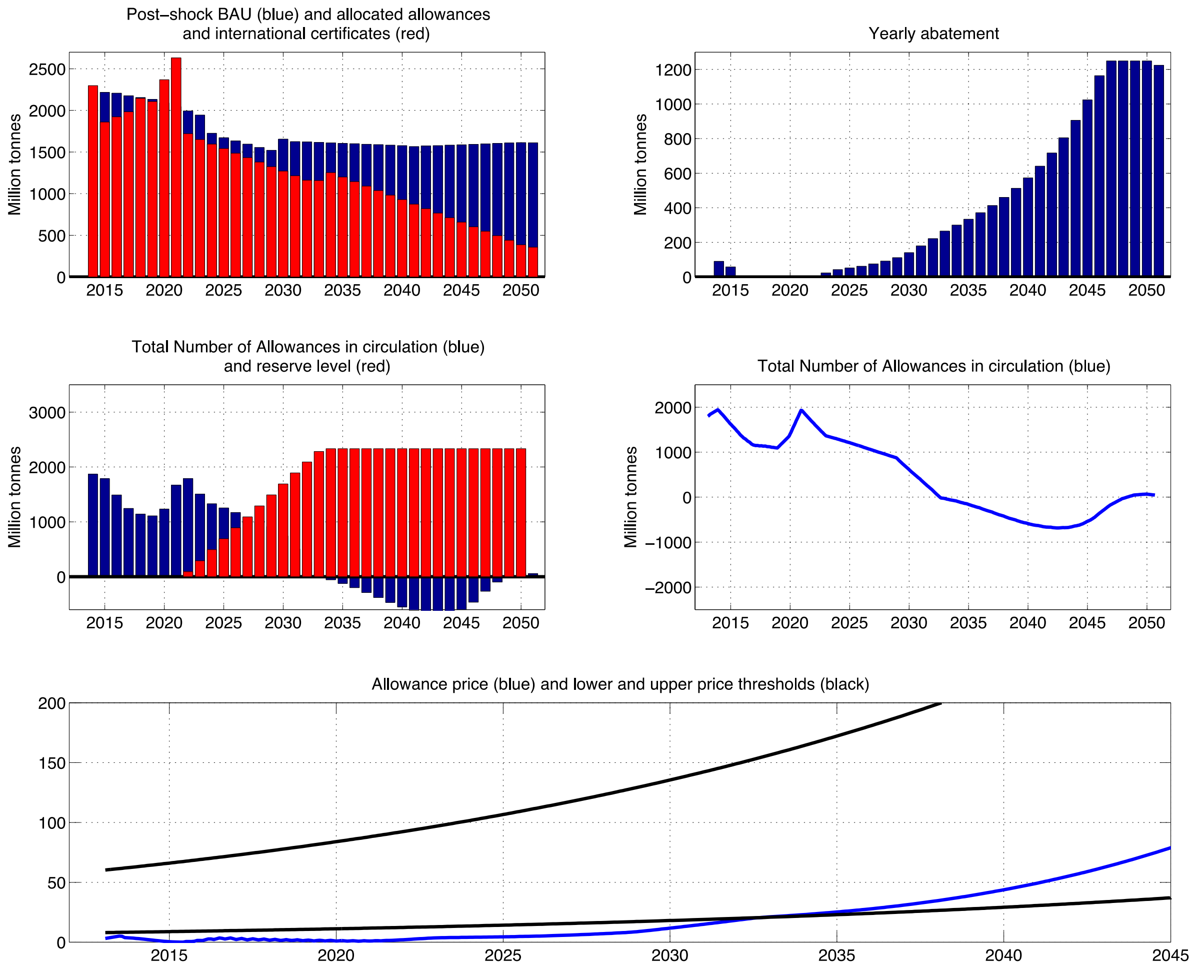


Figure 19 Absolute price sub-case 3.2 – Evolution of the yearly abatement, the total number of allowances in circulation and the allowance price in the presence of a negative shock and with the absolute-price market stability reserve mechanism in place

Relative price performance of different MSR designs

Figure 20 graphically represents the impact of the MSR on the allowance price in the absence of a shock (upper diagram) and in the presence of a negative shock, a 10% reduction every year for six consecutive years, from 2023 to 2029 (lower diagram).

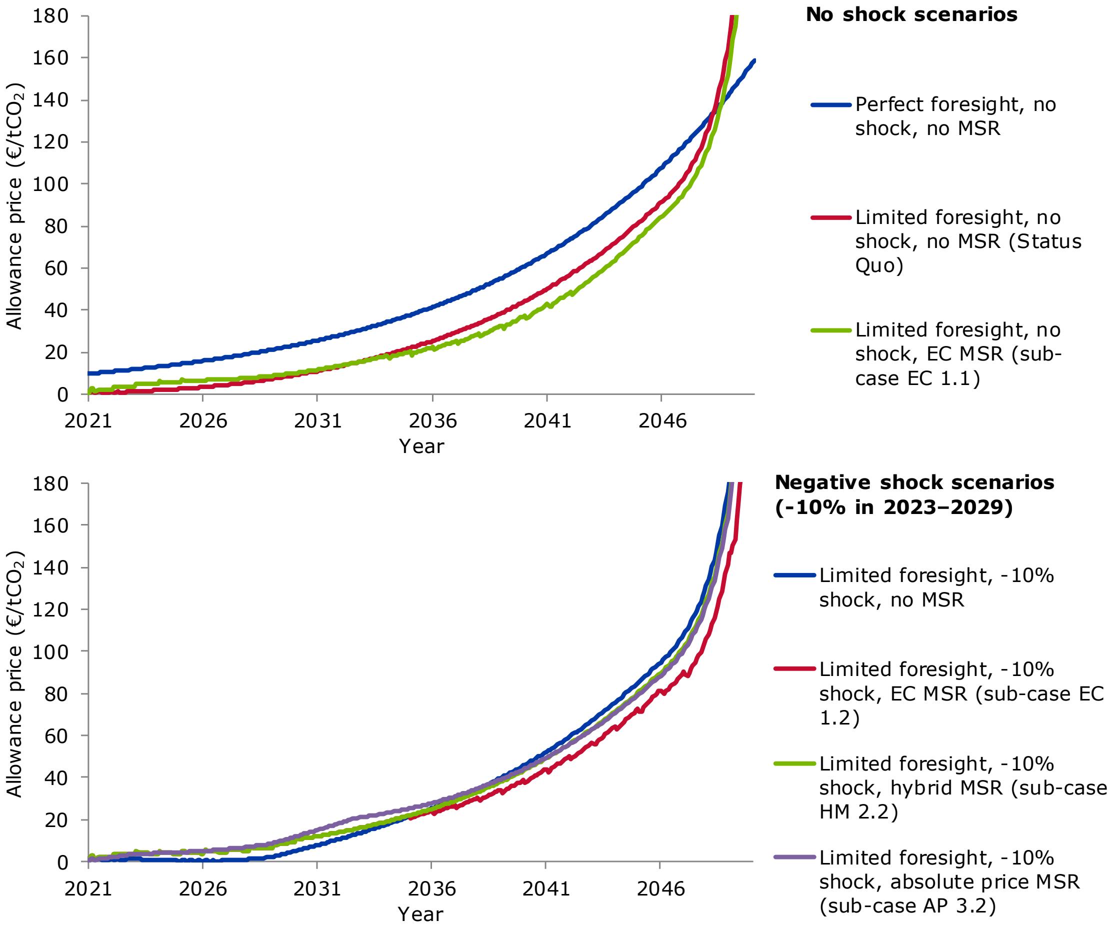


Figure 20 Comparison of allowance price development over the years for MSR designs without a shock (upper diagram) and with a negative shock (lower diagram)

Under perfect foresight we obtain the optimal outcome: constant abatement volume across all years and constant discounted allowance price - given the assumption about percentage annual increase of the price. Limited foresight results in a dramatic deviation of the abatement pathway and the allowance price from the optimal outcomes - see the upper diagram. In particular, the allowance price under limited foresight (red and green lines) are significantly lower when there is perfect foresight (the blue line) in 2020-2030 and significantly higher than perfect foresight after 2048, when the required abatement effort is at its maximum. The objective of the MSR is to re-distribute abatement efforts across years, ultimately improving economic efficiency. This is what we observe when comparing the no MSR (red) and MSR (green) scenarios, which translates into a smoother price curve over the years. The MSR increases abatement, and consequently the allowance price, in 2020-2030. When the reserve is deployed, starting from 2035, the MSR reduces the pressure on abatement and causing the allowance price to rise less rapidly.

More importantly, the MSR should improve policy resilience by allowing the system to respond, in a timely and predictable manner, to unanticipated shocks. The lower diagram shows that a negative shock, an economic recession for example, could depress significantly the allowance price in the baseline scenario (blue line). By withholding allowances from the market, the MSR generates the required scarcity and maintain a steady increase in allowance prices (red, green and purple lines), i.e. higher than the allowance price without MSR (blue line). It also mitigates the price swing due to the price shock, resulting in a more gradually increasing future price profile. Because the EC MSR and the hybrid MSR implement the same withholding mechanism, they overlap until 2035 red and green lines). In 2035 the EC MSR injection mechanism kicks in and the two allowance price paths diverge.

In the hybrid MSR and absolute price MSR presented here, the reserve is not deployed before 2050, which has the same effect as allowances being permanently retired. The result is that during this later period the same level of abatement effort is required as cases with no MSR, this is reflected in a more rapid allowance price increase when compared with the EC MSR case.

5.4 The sensitivity analysis

Varying volume trigger thresholds of EC MSRs has a marginal effect on the aggregate compliance cost when most of the allowances are injected back into the system.

MSR designs can lower or increase the total aggregate abatement costs compared to the status quo

The optimal outcome given the assumptions on rate of annual increase and abatement cost curve would be constant abatement volume across all years. This is what we obtain under perfect foresight. Under limited foresight the total abatement effort is not optimally distributed across the compliance years (2013-2050). Compared to the optimal cost-effective solution, limited foresight leads to higher total abatement costs. By withholding allowances, the MSR forces firms to anticipate emission abatement ultimately approaching the optimal abatement path. This is what we observe when comparing the sub-case without MSR, the status quo, to the sub-cases with MSR, EC1.1 and HM2.1 in Figure 21. The abatement effort is reduced when allowances are injected back in to the system. However, if the reserve is not deployed over the modelling horizon, the resulting additional abatement effort increases the compliance costs.

It is important to note that, as with prices, the absolute values of aggregated costs from this model are not a meaningful output in themselves, however, a comparison of relative costs across different scenarios can highlight the impacts of different MSR designs.

Different reserve approaches incur different cost changes in the system

As expected, the larger the level of the reserve in a given year, the larger the required abatement effort in that year. As a sensitivity analysis, we test different trigger levels for the EC MSR. We observe that by decreasing the upper volume threshold or increasing the lower volume threshold the reserve size is larger and, consequently, the per-year required abatement effort is increased.

However, the different trigger levels we selected do not have a material impact on the aggregated compliance costs for participants under the EC MSR because they do not significantly change the size of the reserve. Compare the EC 1.2 bar (EC MSR proposal in the presence of a negative shock) in Figure 21 with the EC 1.4, EC 1.5 and EC 1.6 bars (variations of the EC MSR proposal in the presence of a negative shock). Put differently, increasing the upper volume threshold from 833 Mt. to 1,000 Mt. or decreasing the lower volume threshold from 400 Mt. to 200 Mt. has only a small impact on the redistribution of the yearly abatement effort and therefore overall aggregate compliance costs.

Varying price trigger thresholds of hybrid MSRs has a less clear effect on the aggregate compliance cost than for a volume-based MSR. Under both hybrid types, allowances are removed from circulation to 2050. When compared to the EC MSR sub-cases (second diagram vs. first diagram in Figure 21), this removal of allowances has two inter-related effects: it increases yearly abatement and the associated final abatement costs. As in the EC MSR, within the same type of mechanism the lowest cost is achieved when the mechanism is introduced earlier (HM 2.3 bar in the second diagram in Figure 21).

However, if the price trigger thresholds are set in a way that the allowances in the reserve are eventually injected the aggregated compliance costs can be lower than the status quo, even under a positive shock which would otherwise increase costs. This is shown by HM 2.6 and HM 2.7.

Changing re-injection amounts has a limited impact on price, but alters reserve levels significantly, influencing total aggregate abatement costs

As a sensitivity analysis, we tested different withholding and injection quantities. We observe that by doubling the withholding quantity (from 100 Mt. to 200 Mt.) under price-based design options, the reserve reaches its peak only one year earlier, 2034. Hence, the impact on the allowance price is marginal. The reserve levels, however, are significantly different: peak levels are 1,200 Mt and 2,200 Mt, respectively. Since allowances in the reserve are not injected back into the market before 2050, aggregated abatement costs are also different, higher when the withholding quantity is greater (compare AP 3.2 and AP 3.4 bar in the third diagram in Figure 21). Similarly, since injection does not occur, varying the quantity of allowances injected has no impact.

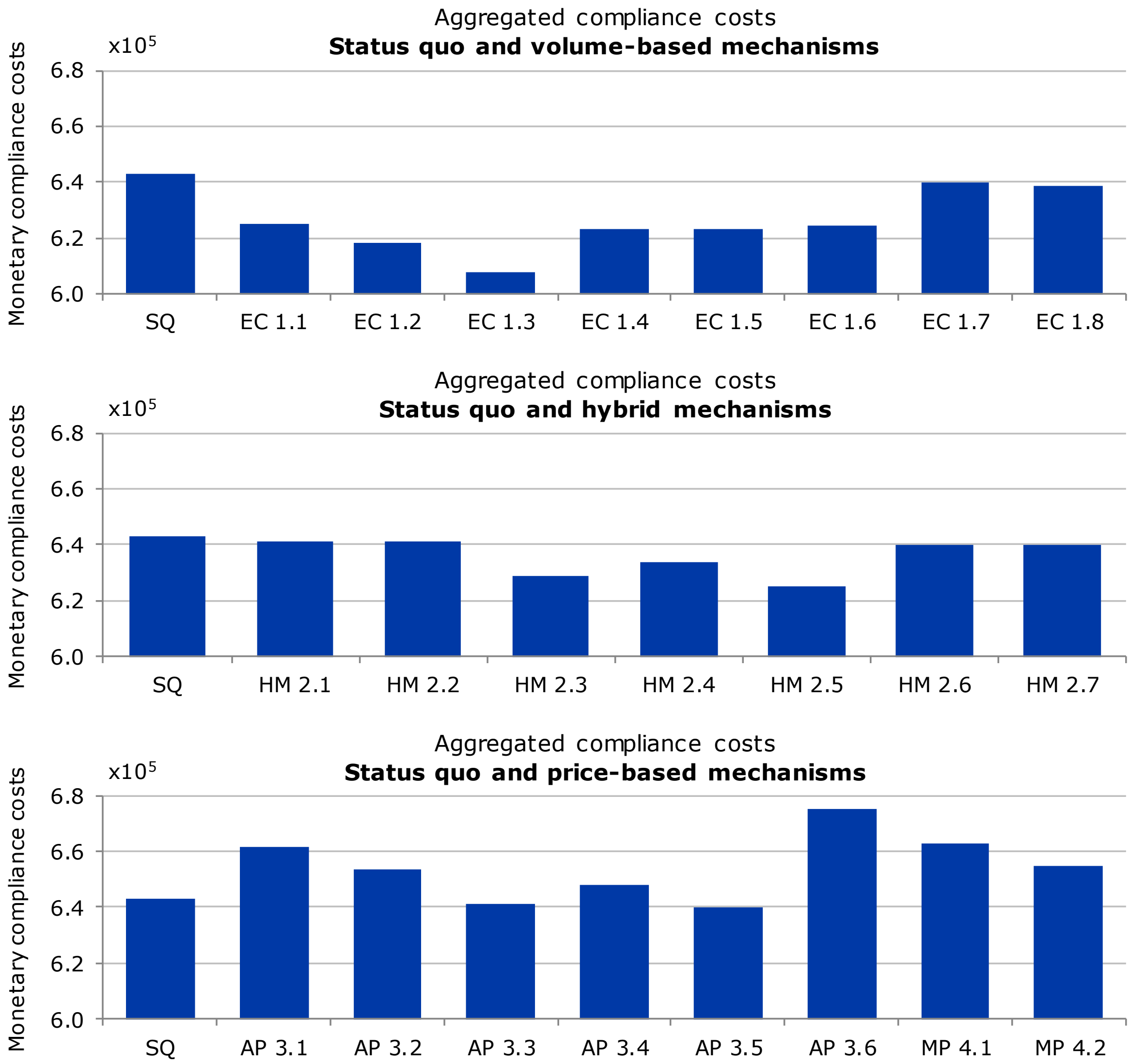


Figure 21 Aggregate compliance cost – Aggregate compliance costs for each sub-case under investigation: first diagram represents the European Commission MSR; second diagram represents the hybrid mechanisms; the third diagram represents the price-based mechanism; an overview of the abbreviations and scenarios can be found in Table 16

The impact of different types of shocks

Unexpected shocks such as technology change or overlapping mitigation policies could fundamentally change allowance demand and are perhaps more likely to result in excessive over-supply of allowances. As such, most of the scenarios described here consider negative rather than positive shocks to emissions. However, the change in emissions from shocks is likely to be broadly symmetric.

5.5 Summary of key findings

The modelling exercise highlights several key findings. It is important to note that, as with any modelling exercise, the results are heavily influenced by the input assumptions. It is for this reason that the outcomes, in quantitative terms will differ from other similar studies into the MSR, such as those carried out by the EC.

However, this modelling exercise can be used nonetheless to draw out some valuable key findings and these are listed below:

1. Changing the starting date of the MSR has the largest material impact, of any design feature modelled, on aggregate abatement costs.
2. MSRs all respond to shocks, but to a differing degree. Volume-based MSRs that use the TNA as a target dimension respond to shocks to emissions. Given the rate of annual increase of the price thresholds assumed in most scenarios and the selected time window, the response of price trend-based MSRs to shocks to emissions is less apparent since these shocks are not immediately transferred to price trends.
3. Reserves are completely deployed within the modelling horizon (up to 2050) in most of the volume based MSR sub-cases whereas in the hybrid and price-based mechanisms – given the selected injection thresholds – at least some allowances remain in the reserve.
4. Reserves that are not fully deployed within the modelled horizon have an equivalent impact in the model to permanently retired allowances or a lower cap. The greater the number of allowances held in the reserve in 2050, the higher the aggregated compliance costs. Ordering the MSR design options with respect to increasing aggregate compliance costs, we have: volume MSR, hybrid and price-based mechanisms although this order may be different under different thresholds. If allowances are withheld in the short-term without being injected back into the system in the long-term, compliance costs increase in the short-term, but the amount that needs to be abated, and the associated costs, in the long-term remain unchanged, increasing aggregated compliance costs. It is, however, important to note that co-benefits from GHG mitigation and early abatement are not taken into consideration. The gains in net benefits of extra abatement may actually outweigh the rise in total compliance costs, bringing the system closer to the cost-optimal pathway, but this is beyond the scope of the model.
5. All MSR designs are capable of re-distributing abatement efforts over time, ultimately reducing total compliance costs. Compared to a situation without an MSR, the allowance price rises faster in the earlier years through withholding and less rapidly in the later years, leading to a smoother price curve over the years. However, if the reserve is not completely deployed within the modelling horizon, prices will rise more rapidly in the later years, leading to higher prices and higher aggregated costs at the end of the modelling horizon.
6. Varying the volume trigger thresholds (EC MSR and hybrid MSR) varies the size and duration of the reserve. Consequently, it varies the per-year required abatement effort. The effect on the aggregated compliance costs, however, is negligible.

7. Varying the withholding and injection quantities of the price-based mechanisms (hybrid MSR and pure price-based mechanisms) significantly varies the size of the reserve. These quantities seem to be able to maintain sufficient allowances in the reserve to respond to the selected positive shocks (+0% BAU variation) and not reach unsustainable high levels under selected negative shocks (-10% BAU variation). The effect on the allowance price and, consequently, on the aggregated compliance costs is marginal.
8. The EC MSR mechanism does not achieve its intended aim if participants exhibit perfect foresight.
9. Under limited foresight, back-loading temporarily mitigates the effects of the large surplus.

In the following section, these key findings are combined with the information in the rest of the report to make some conclusions about the use of an MSR in the EU ETS.

6 Conclusions

Reforming the EU ETS is necessary to absorb shocks and deal with myopia of firms

The theory presented in this report argues that a case can be made for reform in the EU ETS, on the basis that the current inflexible supply is not responding to fundamental changes in the allowance demand, pushing regulated firms away from the cost-optimal pathway to reaching 2050 targets. As a result, these targets may be met at higher cost, both for society and for firms themselves, than would otherwise be the case.

The purpose of a reform or role of a market stability mechanism would be to improve the system responsiveness of the EU ETS in the event of significant, unexpected changes in circumstance, in order to restore the balance of the system such that participants are sent the right signal to make decisions that set the economy onto a cost-optimal emissions reduction pathway.

If reform is chosen, it is important that the measure operates according to a pre-defined and predictable set of rules, to limit any increase in uncertainty that the changes could have on participants. Uncertainty can have a negative impact on abatement investment decisions within the EU ETS, because of the increased risk this brings. In addition, the reform itself has to be justified clearly to limit concerns amongst participants that it could occur more often.

The use of an MSR as such an intervention has been questioned. This is because, theoretically, if participants have perfect foresight of price developments and behave accordingly, the MSR will have no impact on the overall price signal. Shocks would have a minor impact in the overall pathway towards a low-carbon economy, so participants would only change their abatement strategy slightly. An MSR will do nothing more than mimic a private sector banking function. In fact, evidence from the modelling exercise showed that, when perfect foresight is assumed, an MSR increases the complexity of the ETS and does not achieve its goals to reduce GHG emissions in a cost-effective and economically efficient manner. There would be no need for an MSR if market participants had perfect foresight and certainty about the future cap in reality.

However, discussions with participants, and evidence in the literature, and in participants' behaviour in reaction to the recession, indicate that participants in the market do not look far ahead to the future, and certainly not to 2050, but demonstrate a degree of myopia, making abatement investment decisions on the basis of a 3-5 year outlook for industry, and possibly further for utilities. Furthermore, policy to 2050 is not perfectly certain, despite political signals around goals to reduce EU emissions by 80–95% over 2005 levels, making investment decisions that are dependent on this long term view more risky. Limited foresight results in a dramatic deviation of the abatement pathway from the theoretically optimal outcome: constant abatement volume across all years. As a result, an MSR could have an impact on market participants by altering the supply of allowances to send a stronger signal to abate, more in line with long term goals, than market participants would perceive otherwise. When a five-year myopia was used in the modelling exercise, an MSR showed an impact on abatement activity. The MSR acts to re-distribute abatement efforts, ultimately reducing total compliance costs. The actual impact of an MSR is therefore likely to be heavily dependent on the real outlook of participants (as an aggregated group).

When the MSR was tested against the current surplus situation in the EU ETS, the modelled designs all began withdrawing allowances soon as they were introduced, and impacted market behaviour in some way. The simulation of both positive and negative shocks in the modelling exercise showed that an MSR is capable of correctly responding to shocks to emissions, provided that the thresholds are set at the right level. Under an economic boom the MSR injects allowances and when an economic recession occurs allowances are withheld. The modelling results show that an MSR mitigates price swings due to shocks, leading to more gradually increasing future price profiles. In reality the behaviour of market participants may lead to more volatile short term prices, depending on the MSR design, as the market reacts to changes in supply.

Other commodity markets show that reserves can be successful in addressing market imbalances

Reserves have been used in many markets to smooth price shocks in the short term, and have also been used in food and currency markets to smooth long-term price changes, e.g. currency reserves used in China to manage currency appreciation in a way that benefitted economic growth. Evidence from food markets also show that using reserves to reduce supply (restriction/storage) in times of oversupply helps to reduce price falls, a good parallel with the current surplus in the EU ETS. In these cases the size of the reserve also had a bearing on their impact, with larger reserves typically providing a greater stabilising impact against higher prices. Their impact in the case of low prices is dependent on the mechanism, but can both stabilise/reverse or sustain the trend.

The EU ETS has the benefit over commodity markets that policy can directly control supply and that storage has virtually no costs. Nonetheless, as in all commodity markets decisions are inevitably political to some extent. Even if the MSR is created as a politically-independent and rule-based predictable system, it is likely that any design will still have, and need, political involvement, e.g. review periods. The commodity market shows that price triggered reserve mechanisms can be vulnerable to external actors and shocks, in particular speculation.

This vulnerability was an important reason for the failure of a number of reserve / price fixing mechanisms, where there were insufficient resources, credibility and/or willpower to address the problems. Any MSR created for the EU ETS has to consider carefully the potential role of speculators and the ways in which the mechanism can itself be vulnerable to shocks.

There is no perfect MSR design to continuously keep the market on the cost-optimal pathway

An MSR could be designed in numerous ways in terms of the choice of trigger type, as well as trigger levels. The six key trigger-types that have been judged against key criteria developed in conjunction with DECC show that a trade-off in performance would have to be made.

Trigger type	Stable price signal	Shock resilience	Adjustment certainty	Balanced market	System integrity
Surplus	Limited	**Yes**	**Yes**	**Yes**	**Yes**
Price corridor	**Yes**	**Yes**	**Yes**	Limited	Limited
Price trend	Limited	**Yes**	Limited	Limited	**Yes**
Hybrid surplus/price	Limited	**Yes**	**Yes**	**Yes**	**Yes**
Change in economic conditions	Limited	Limited	**Yes**	**No**	**Yes**
Production change	Limited	Limited	Limited	**No**	**Yes**

The literature indicates that a price corridor approach could be the most cost-effective and capture the economic efficiency of both a carbon tax and ETS, provided that the corridor and the reserve thresholds were set appropriately. It is also capable of providing a clear price signal as market participants know the price bounds and can observe prices on a continuous basis adjusting their behaviour accordingly. This transparency could help ensure that the MSR only intervenes under exceptional circumstances. It also offers investors certainty, to some degree, about the price of carbon that they can use in making investment decisions. On the other hand, the delineation of a strict price corridor and behaviour as described above may limit discovery of the cost-optimal pathway should this be outside the price corridor. The self-same transparency of price that enables a more certain price signal also provides more opportunity for gaming the MSR, although specific rules can limit manipulation. Using price trends as a trigger instead of an absolute price would be harder to manipulate, but this gain comes at the expense of less certainty about when intervention would occur and how this might relate to price or surplus.

A surplus-based trigger is in keeping with the EU ETS's quantity-based character and potentially enables increase economic efficiency as it would enable quantity (cap) to be adjusted as new information is revealed, if thresholds are set correctly but there is limited literature about what the suitable trigger volumes should be. Unlike price based mechanisms, it is less prone to gaming. Only market participants that can change their emissions in large quantities would be able to influence the MSR trigger, and there is no financial rationale in doing so. Furthermore, the surplus is determined once a year, making it more difficult to actually manipulate the system. The trade-off is an increased risk of short-term volatile prices around the intervention date as the behaviour of market participants could amplify the impact of the intervention on prices.

In the bigger picture, the trigger should limit potential price swings due to the shock, despite some volatility observed around the time of the intervention. This trade-off between stable short term prices and system integrity also applies to triggers based on changes in economic activity. It is important to note, however, that some market participants will continue to try and maximise their profits, through some types of speculation, even where the potential for market manipulation is limited. These efforts could lead to forms of undesirable behaviour and market manipulation, even where it seems unlikely.

For the potential benefits of a reserve to be maximised thresholds must be set within the correct range.

The right level of surplus could serve as the threshold

There is limited literature about what the suitable surplus thresholds should be. The EC proposal and others have argued that thresholds under a quantity-based MSR have and should be established with hedging as the starting point. Consideration is also needed of industrial banked allowances as the market does not always consider these as active trading volume that can meet hedging demand, since most industrial participants only buy allowances in case of shortage and do not sell when in surplus. Investigation of the current surplus in the EU ETS indicates that a large portion is used for hedging, especially for utilities, with estimates ranging from 500 million to 1.5 billion.

However, it is not clear that a surplus is fully necessary for hedging. Some stakeholders argue that the surplus is only used for hedging because there is a surplus at the moment, and without such supply available the market will find other means to hedge. There is little evidence for the exact hedging demand under supply that is constraining emissions because at current prices hedging demand is satisfied by allowances, and therefore there is insufficient scarcity to trigger abatement. Even without a surplus, firms can borrow one year’s worth of free allocation plus four months of auctioning, equating to 1 billion EUAs for the 2013 compliance year. Forward contracts can also be used to hedge without being covered by a physical emission allowance, albeit at higher prices and risk. As industrial firms and utilities are generally more risk-averse, this is where the financial sector can play an important role.

Others argue that the surplus is needed for hedging and that there is a relationship between the right level of surplus and a stable market. If the surplus is reduced beyond the level of hedging demand plus industrial banking, there is a risk that firms reduce their emissions beyond what is cost-optimal in order to stick to their hedging strategy. However, setting a fixed level is challenging as hedging demand changes over time. Hedging demand is expected to decrease over time as emissions reduce but other factors could also increase or decrease hedging volumes. They could, in principle, increase with an economic boom or decreasing free allocation for industry, although it is not clear whether or not this will prompt industry to hedge. Hedging could also decrease with renewable energy and energy efficiency developments or restructuring of the European power market. A fixed surplus threshold may therefore only be appropriate for a limited amount of time, and interviewees supported a periodic evaluation of the thresholds. These reviews would provide a good sense-check for the levels that seem appropriate now, whilst we are in a period of time with ample surplus available.

Price-based thresholds are more difficult to choose
A price corridor is likely to be difficult politically as it ignites concerns about fiscal sovereignty at the European level. However, in common with other price based approaches, it offers an opportunity to assess the trigger point continuously, in contrast to a surplus-based system where assessment is only possible once a year, and therefore respond more quickly after an unexpected shock. The few firms interviewed for this study that did look at price thresholds, maintain that firms do not plan to take significant abatement measures at prices below 20 €/tCO_2. When discussing price ceiling levels, some mentioned the abatement cost of carbon capture and storage (CCS), in the range of 50–60 €/tCO_2, as a potential price ceiling in relation to prices today.

While politically less contentious, selecting appropriate price trend triggers would also be challenging.

Early introduction lower overall compliance costs much more than threshold choices
The literature and discussions with stakeholders implied that the choice of trigger levels can have a big impact on the extent to which an MSR actually returns participants onto the cost-optimal pathway. However, the modelling of the different types of MSRs showed that the choice of threshold levels, within the range tested, had an impact on the duration and size of the reserve but a relatively minor impact on the aggregated costs of compliance. The same was true when the reinjection volume was modified. The exception was the choice of price thresholds to inject allowances that were high enough that they prevented allowances returning from the reserve, even under a positive shock, in some of the modelled scenarios.

In the modelling exercise, by selecting a relatively high price ceiling for injection, the hybrid system, and other price-based approaches withheld allowances to 2050. This approach results in higher overall total compliance costs over the modelling horizon. This is because scenarios that do not completely disburse all allowances require firms to make additional early abatement without changes to the required future abatement that keep the overall abatement in line with the total cap. The cap is effectively made smaller. The MSR should ensure a lower availability of allowances initially to increase early abatement, ultimately reducing abatement costs if allowances in the reserve return into the system in the future. It is important to note that co-benefits from GHG mitigation and early abatement are not taken into consideration in the model. The gains in net benefits of extra abatement may actually outweigh the rise in total compliance costs when allowances are withheld in the MSR for a longer period of time.

Based on the evidence gathered as part of this study, the technical arguments for modifying the trigger points as defined by the Commission are few, and furthermore, any discussions about the trigger type and threshold level will most likely a lengthy negotiation process and in the end a political choice. Therefore if the current approach appears palatable there is little to be gained from opening this debate.

More importantly, timing was the single biggest factor in lowering compliance costs overall as this had the biggest impact on bringing abatement forward. In all MSR designs bringing them into operation earlier than 2020 reduced aggregate costs and would have the added benefit of bringing greater certainty to participants, who are now expecting an intervention anyway.[30] Instead of tweaking the thresholds, introducing the MSR in 2017 would have the largest impact on lowering the aggregated costs faced by compliance entities.

There are certain assumptions that affect some of the results

The results of the modelling exercise, and overall conclusions, need to be considered in the light of the assumptions and limitations in the model.

The assumed degree of foresight in the model dictates businesses' abatement and trading strategies. Under the limited foresight chosen in this model, market participants consider the information about abatement efforts only up to five years in the future. Five years is considered a reasonable average, based on our understanding of market participants. In reality, the level of foresight varies between different market players, and so the estimate used in any model will only approximate behaviour. This allows market participants to differ in their reactions to the introduction of an MSR, and indeed any change in carbon price. Ultimately this can and should lead to different competitive advantages between companies in the same sector, and also may manifest itself as different impacts on some sectors versus others e.g. electricity sector which has more foresight versus industrial participants which may use a shorter time horizon.

The model also includes an assumption about the risk-adjusted interest rate. The risk-adjusted interest rate determines the rate of increase of the carbon price in the model, apart from changes in price due to abatement and participant behaviour. This interest rate had an important impact on the likelihood of the price ceiling being reached in all MSRs with a price-based trigger. In a related design choice, the price floor and ceiling were chosen to increase over time in line with this interest rate. This increase in the price floor, when carbon prices also remained low, could mean that the market is not allowed to find the lowest cost pathway to achieving the cap.

The modelling exercise displayed lower carbon prices than could have been expected, under all MSR design options. However, these low prices are the result of the assumptions used as inputs to the model like business as usual emissions projections and marginal abatement costs, combined with assumptions foresight and the risk-adjusted interest rate. The allowance prices are therefore meaningless as a standalone result but can be used to compare results across the different scenarios considered in this study.

[30] Given the existing evidence on the benefits of early action to reduce emissions, early abatement is likely to cheaper than delaying abatement and buying allowances as the stringency of the cap continuous to increase (see e.g. Stern, 2006),

The theory did not indicate that the MSR would hold the allowances for such a long time, allowances would have been expected to return later in the modelling period when more abatement was needed to meet the 2050 targets. While this occurred in some cases, particularly those with a surplus trigger, the modelling showed that allowances were, in fact, withheld for a long time in many cases. This result was, in part, due to design choices such as the number of allowances re-injected at any one time, as well as the choice of thresholds for the modelling exercise, especially the price ceiling. In addition, no scenarios included more than one shock, which could have stimulated a further reinjection of allowances.

The model includes an assumption of perfect compliance. As a result, market participants are assumed to offset all their emissions by the end of the compliance horizon of 2050. In calculating the aggregated costs we assume that allowances cannot be used after this date (allowances become worthless). Conclusions on the MSR performance should therefore not be based on the end-of-modelling period.

Taken together these findings indicate that:

The EC's proposal seems like a sensible political compromise, but there are a number of risks...

The surplus-based trigger, as proposed by the EC, seems to be a sensible political compromise for an intervention. A surplus-based measure comes out favourably from the literature and theoretical discussion, as well as from the modelling exercise and political considerations. The MSR is a patch that is intended to fix the perceived market imbalance in the EU ETS over the entirety of the period from now to 2050 to put the system back on the cost-optimal pathway and keep it there by addressing future shocks. Given the large overhang of surplus in the market, not implementing reforms would mean that the EU ETS would remain on a non-cost-optimal pathway for decades from the time that the economic shock in 2008 occurred. Therefore, it is important to consider an early implementation of the MSR or faster withholding of allowances, as suggested by several interviewees, to address the surplus more quickly and reduce the risk of lock-in of carbon-intensive technology. Furthermore, a mechanism that is designed now should be tested relatively soon or, as suggested by some stakeholders, the thresholds should be re-examined periodically.

The purpose of the MSR is to not only move the current market, with a huge surplus, closer to the cost-optimal pathway and correct for myopia, but also to provide the system with responsiveness to deviations from the cost-optimal pathway when this changes due to unexpected shocks. The EC's proposal has the potential to do this, however, the exact response of such an MSR to shocks is unknown and would have to, to a certain extent, be discovered by the market; modelling can only provide a limited understanding of the possible market responses to an MSR. The ability for the proposed MSR to respond appropriately to such shocks will depend on whether the trigger and intervention levels are set appropriately. In the current design the intervention levels have been set to withhold allowances faster in the current circumstance of high surplus. Levels for withholding and injecting will be more equal when the market is in balance. This accommodates the dual objectives of the MSR. There is a risk that the MSR may actually respond too slowly to the current imbalance to prevent lock-in of carbon-intensive technology, but on the other hand there is also a risk it responds too strongly to address future imbalances: a sub-optimal measure to address either of the problems although no evidence for this was found in this study.

Lessons from other commodity markets have shown that reform is a continuous learning experience, the impact may be different than intended, and decisions on policy settings are inevitably political to some extent. The assessment planned for 2026 will tell how successful the MSR is.

Some important indicators of failure would be if there was evidence of gaming, if the MSR was triggered too often, or if a shock occurred that was widely understood to have impacted the cost-optimal pathway, and there was no response. Metrics such as price or the number of allowances in the reserve will not provide an adequate measure of the MSR’s success alone. Other potential indicators of success are investments in low-carbon measures in the EU ETS compliance sectors or the number of new low-carbon patents.

7 References

Aatola, P., Ollikainen, M. and Toppinen, A. (2013), "Price determination in the EU ETS market: Theory and econometric analysis with market fundamentals", Energy Economics vol. 36, March 2013, pp. 380-395.

Alberola, E., Chevallier, J. and Cheze, B. (2008), "The EU Emissions Trading Scheme: The effects of industrial production and CO_2 emissions on carbon prices", International Economics, no. 116, issue 4 2008, pp. 93-126.

Analysis Group (2010), "Next Steps for California Climate Policy II: Moving Ahead under Uncertain Circumstances", April 2010.

Battles, S., Clò, S. and Zoppoli, P. (2013), "Policy Options to Support the Carbon Price within the European Emissions Trading System:Framework for a Comparative Analysis", Italian Ministry of Economy and Finance, Department of the Treasury, Working paper no.1, January 2013.

BNEF (2014), "Impact of backloading", survey by Bloomberg New Energy Finance (BNEF), February 2014.

Brunner, S., Flachsland, C. and Marschinski R. (2011), "Credible commitment in carbon policy", Climate policy, vol. 12, issue 2, pp. 255-271.

Brunner, S., Flachsland, C., Marschinski, R. (2012), "Credible commitment in carbon policy", Climate Policy, vol. 12 issue 2, pp. 255-271.

Burtraw, D., Palmer, K. and Kahn, D. (2009), "A Symmetric Safety Valve", Resource for the Future (RFF) Discussion paper 09-06, February 2009.

CBO (2010), "Managing Allowance Prices in a Cap-and-Trade Program", Congress of the United States Congressional Budget Office (CBO), November 2010.

CDC Climate (2014), "Tendances Carbone n°92 « Les marchés du carbone et l'accord post-2020 »", June 2014.

CEZ Group (2013), "Flexible cap-and-trade – proposal for an intensity-based supply adjustment mechanism", September 2013.

Chevallier, J. (2011), "A model of carbon price interactions with macroeconomic and energy dynamics", Journal of Energy Economics vol. 33, issue 6, November 2011, pp. 1295-1312.

Chevallier, J. (2013), "Understanding the link between aggregated industrial production and the carbon price" The Economics of Green Energy and Efficiency, Eds. Galarraga, I., Gonzalez-Eguino, M., and Ansuategi, A. Editions: Springer, forthcoming.

CMIA (2013), "CMIA structural reform proposal", November 2013.

DECC (2014a), "EU ETS Structural Reform Background Paper", prepared for the DECC stakeholder workshop: 10 January 2014.

DECC (2014b), "EU ETS Structural Reform stakeholder event report: January 2014".

DIW Berlin (2013), "EU Emissions Trading: The Need for Cap Adjustment in Response to External Shocks and Unexpected Developments?", on behalf of the German Federal Environment Agency, February 2013.

Dong Energy (2014)," Hedging requirements and the Market Stability Reserve's surplus ranges", July 2014.

Ecofys (2014), "Dynamic allocation model for the EU ETS", forthcoming.

Egenhofer, C., Marcu, A. and Georgiev, A. (2012), "Reviewing the EU ETS review?", report of the CEPS task force on "Does the ETS market produce the 'right' price signal?", November 2012.

Ellerman, A. and Montero, J. (2007), "The Efficiency and Robustness of Allowance Banking in the U.S. Acid Rain Program", The Energy Journal, Vol. 28, No. 4, pp. 67-91.

European Commission (2008), "Impact assessment accompanying the document Package of Implementation measures for the EU's objectives on climate change and renewable energy for 2020", SEC(2008), 85/3, Brussels, 23 January. 2008.

European Commission (2011), "A Roadmap for moving to a competitive low carbon economy in 2050", COM(2011) 112 final, March 2011.

European Commission (2012), "Proportionate impact assessment accompanying the document Commission Regulation (EU) No .../.. of XXX amending Regulation (EU) No 1031/2010 in particular to determine the volumes of greenhouse gas emission allowances to be auctioned in 2013", available athttp://ec.europa.eu/clima/policies/ets/cap/auctioning/docs/swd_2012_xx2_en.pdf

European Commission (2013), "Options for structural measures to strengthen the EU Emissions Trading System: Main outcomes of the public consultation", October 2013, available at http://ec.europa.eu/clima/consultations/articles/0017/main_outcomes_en.pdf

European Commission (2014a), "Impact assessment accompanying the document Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions A policy framework for climate and energy in the period from 2020 up to 2030", SWD(2014), 15 final, Brussels, 22 January 2014.

European Commission (2014b), "Impact assessment accompanying the document Proposal for a Decision of the European Parliament and of the Council concerning the establishment and operation of a market stability reserve for the Union greenhouse gas emission trading scheme and amending Directive 2003/87/EC", SWD(2014) 17 final, Brussels, 22 January 2014.

European Commission (2014c), "Proposal for a decision of the European Parliament and of the Council concerning the establishment and operation of a market stability reserve for the Union greenhouse gas emission trading scheme and amending Directive 2003/87/EC", COM(2014) 20/2.

European Commission (2014d), "Commission Regulation EU No 176/2014 amending Regulation (EU) No 1031/2010 in particular to determine the volumes of greenhouse gas emission allowances to be auctioned in 2013-2020", Official Journal of the European Union L 56/11, 26 February 2014.

Fankhauser, S. and Hepburn, C. (2010), "The Design of Carbon Markets Part I – Carbon Markets in Time", Fankhauser_and_Hepburn_2010_The Design of Carbon Markets Part I-Carbon Markets in Time.pdf

Fell, H. and Morgenstern, R.D., "Alternative approaches to Cost Containment in a Cap-and-Trade System", Environ Resource Econ (2010) 47, pp. 275–297.

Fell, H., Burtraw, D., Morgenstern R. and Palmer, K. (2012), "Soft and hard price collars in a cap-and-trade system: A comparative analysis", Journal of Environmental Economics and Management vol. 64, 2012, pp. 183-198.

Fell, H., Hintermann, B. and Volleberg H. (2013), "Carbon Content of Electiricity Futures in Phase II of the EU ETS", CESifo Working Paper, no. 4367, August 2013.

Feng, Z., Zou, L. and Wei, Y. (2011), "Carbon price volatility: Evidence from EU ETS", Applied Energy vol. 88, pp. 590-598.

Goulder, L. and Schein, A. (2013), "Carbon taxes vs cap and trade: a critical review", National Bureau of Economic Research Working Paper 19338, August 2013.

Grosjean, G., Acworth, W., Flachsland, C. and Marschinski R. (2014), "After Monetary Policy, Climate Policy: Is Delegation the Key to EU ETS Reform?", Mercator Research Institute on Global Commons and Climate Change (MCC) draft working paper, February 2014.

Grubb, M., Laing, T., Sato, M. and Comberti, C. (2012), "Analyses of the effectiveness of trading in EU ETS", Climate Strategies Working Paper, February 2012.

Grüll, G. and Taschini, L. (2011), "Cap-and-trade properties under different hybrid scheme designs", Journal of Environmental Economics and Management vol. 61, pp. 107-118.

Hermann H. and Matthes F. (2012), "Strengthening the European Union Emissions Trading Scheme and Raising Climate Ambition", report by Öko-Institut for WWF and Greenpeace, June 2012.

Hintermann, B. (2010), "Allowance price drivers in the first phase of the EU ETS", vol. 59, issue 1, January 2010, pp. 43-56.

Hoel, M. and Karp, L. (2001), "Taxes and quotas for a stock pollutant with multiplicative uncertainty", Journal of Public Economics vol. 81, issue 1, October 2001, pp. 91-114.

IETA (2013), "IETA considerations on introducing flexibility in the supply of allowances in the EU ETS", International Emissions Trading Association (IETA), December 2013.

Keohane, N. (2009), "Cap and Trade, Rehabilitated: Using Tradable Permits to Control U.S. Greenhouse Gases", Rev Environ Econ Policy (2009) vol. 3 (1), pp. 42-62.

Maeda, A. (2012), "Setting trigger price in emissions permit markets equipped with a safety valve mechanism", J Regul Econ 2012 vol. 41, pp. 358–379.

Martin, R., Muûls, M. and Wagner, U (2011), "Climate Change, Investment and Carbon Markets and Prices – Evidence from Manager Interviews Carbon Pricing for Low-Carbon Investment Project". Climate Policy Initiative Report, January 2011.

Martin, R., Muûls, M. and Wagner, U. (2013), "Trading Behavior in the EU ETS", available at http://ssrn.com/abstract=2362810

Metcalf, G. (2009), "Designing a Carbon Tax to Reduce U.S. Greenhouse Gas Emissions", Rev Environ Econ Policy (2009) vol. 3 (1), pp. 63-83.

Murray, B., Newell, R. and Pizer, W. (2008), "Balancing cost and emissions certainty: an allowance reserve for cap-and-trade", National Bureau of Economic Research (NBER) Working paper 14258, August 2008.

Neuhoff, K., Schopp, A., Boyd, R., Stelmakh, K. and Vasa A. (2012), "Banking of Surplus Emissions Allowances – Does the Volume matter?", German Institute for Economic Research (DIW), March 2012.

Newell, R. and Pizer, W. (2003), "Regulating stock externalities under uncertainty", Journal of Environmental Economics and Management vol. 45, issue 2, March 2003, pp. 416-432.

Newell, R. and Pizer, W. (2008), "Indexed Regulation", Journal of Environmental Economics and Management vol. 56, pp. 221-233.

Newell, R., Pizer, W. and Zhang, J (2005), "Managing Permit Markets to Stabilize Prices", Environmental & Resource Economics, vol. 31, pp. 433-157.

Parsons, J. and Taschini, L. (2012), "The Role of Stocks and Shocks Concepts in the Debate Over Price Versus Quantity", Environmental and Resource Economics, November 2012.

Piris-Cabezas, P. and Lubowski, R. (2013), "Increasing Demand by Raising Long Term Expectations: the Importance of a 2030 Target for the European Union's Climate Policy", Executive Summary, September 2013.

Pizer, W. (1999), "The optimal choice of policy in the presence of uncertainty", Resource and Energy Economics vol. 21, issues 3-4, August 1999, pp. 255-287.

Pizer, W. (2001), "Prices vs. Quantities Revisited: The Case of Climate Change", Discussion Paper 98-02, Resources for the future, October 1997.

Pizer, W. (2002) "Combining price and quantity controls to mitigate global climate change". Journal of Public Economics vol. 85, pp. 409–434.

Pöyry (2013), "Assessment of the allowance supply adjustment mechanism – Executive summary", a report to Fortum, June 2013.

Roberts, M. J. and Spence, M. (1976), "Effluent charges and licenses under uncertainty", Journal of Environmental Economics and Management vol 5, pp. 193-208.

Rubin, J. (1996), "A model of intertemporal emission trading, banking, and borrowing", Journal of Environmental Economics and Management vol 31, pp. 269-286.

Sandbag (2010), "Cap or trap? How the EU ETS risks locking-in carbon emissions", September 2010.

Schennach, S. (2000), "The economics of pollution permit banking in the context of Title IV of the 1990 Clean Air Act Amendments." Journal of Environmental Economics and Management vo. 40 issue 3, pp. 189-210.

Schopp, A. and Neuhoff, K. (2013), "The Role of Hedging in Carbon Markets", German Institute for Economic Research (DIW), Discussion Paper 1271, March 2013.

SSE (2013), "SSE Discussion Paper on ETS Reform", available at http://news.sse.com/media/68621/ets_summary.pdf.

Stavins, R. (2008), "A meaningful U.S. cap-and-trade system to address climate change", Harvard Economics Law Review vol. 32, pp. 293-371.

Stern, N. (2006), "The Economics of Climate Change: The Stern Review", October 2006.

Stranlund J. and Moffitt, L. (2011), "Enforcement and Price Controls in Emissions Trading", April 2011.

Stranlund, J., Murphy, J. and Spraggon, J. (2014), "Price Controls and Banking in Emissions Trading: An Experimental Evaluation", version January 2014.

Taschini, L., Kollenberg, S. and Duffy, C. (2013), "System responsiveness and the European Union Emissions Trading Scheme", Policy paper Centre for Climate Change Economics and Policy, and Grantham Research Institute on Climate Change and the Environment, November 2013.

Trotignon, R., Gonand, F. and de Perthuis, C. (2014), "EU ETS reform in the Climate-Energy Package 2030: First lessons from the ZEPHYR model", Climate Economics Chair, January 2014.

Tschach Solutions (2013), "Analysing Structural Measures – Building a Structural Reserve to Increase Market Stability in the EU-ETS", October 2013, available at http://ec.europa.eu/clima/policies/ets/reform/docs/20131002_discussion_of_structural_measure_en.pdf

Weitzman, M.L. (1974) "Prices vs. Quantities" The Review of Economic Studies, Vol. 41, No. 4, pp. 477-491.

Annex I Relevant experience from commodity markets: case studies

A range of commodity markets were considered within a framework of objectives and criteria provided by DECC:
UK aims for a supply reserve:

- **Provide a more stable low carbon investment signal by increasing stability of long-term prices;**
- **Improve policy resilience by allowing the EU ETS to respond, in a timely and predictable manner, to unanticipated outside shocks or events;**
- **Increase certainty about how and under what circumstances supply would be adjusted within phases; and**
- **Help address the current surplus and prevent a recurrence of chronic supply-demand imbalance**

Agreed UK criteria for a supply reserve, which a mechanism would have to meet, are:

- Be determined by clear and transparent rules which the market could understand and predict the application of
- **Not provide any discretion to intervene in the market outside these rules and so avoid the possibility of political interference**
- **Preserve the integrity of the system and be robust to a wide range of external circumstances**
- Act to strengthen the investment signal
- Respect Member States' fiscal sovereignty
- Work with the grain of the market to preserve price discovery
- Be supported by clear analysis to demonstrate the proposed design appropriately manages the risks of unintended consequences

The criteria indicated in bold are the criteria provided by DECC to be the focus of this study, which were served as guidance in selecting the commodity markets. The table below provides an overview of the different commodity markets considered in view of these criteria and what lessons could be learned from the markets. The table is followed by a short description of each commodity market.

Table 17 **Overview of selected commodity market characteristics for further evaluation**

Commodity market	Oil	Food crop	Currency	Fish	Gas	Rare Earths	Phosphate Rock	Energy	Aluminium
Name of control mechanism	OPEC	Buffer stocks	Currency pegging (CN, ARG, etc;)	EU Common Fisheries Policy	Producer controls (i.e. Russia)	Chinese export controls	Moroccan export controls	Renewables Obligation (UK)	Warehousing
Type of supply control mechanism:	Reduced / Increased production (supply)	Supply reserve	Supply adjustment – price fix	Quota based supply restriction	Reduced supply (export)	Reduced supply (export)	Reduced supply (export)	Quota-based	Restricted supply volumes / timings
Market type:	Global (exchanges)	Global, regional, national	Currency	Global	Regional / Global	Global (contract)	Global (contract)	National	Global (exchanges)
Objective of the mechanism: (description)	Revenue stability and enhancement for producers	Maintain food security	To maintain target price with peg currency	Sustainable management	Revenue stability and enhancement for producers, geo-politics	Revenue enhancement for producers, strategic industrial policy	Revenue enhancement for producers	Guaranteed supply volume of RE	Rent-seeking
Mechanism targeting price change (increase)	X				X	X	X		X
Reducing price impact of shocks	X	X							
Stability of long term prices	X	X	X					X	
Other (Environmental, Social)		X		X				X	
Operation:									
Clear and consistent rules to alter supply	No, politics, price, events	Yes	Yes	No, science and politics	No, political	No, political	No, political	Yes	No, opaque
Opportunities for political interference	High	Medium	Medium	High	High	High	High	Medium	Low
Supply controllability	Medium	Low	High	High	High	High	High	High	Medium
System robustness	Medium	Medium	Medium	High	Medium	Low	Low	Medium	Medium
Potential Lessons from past:									
Oversupplied market	X	X	X	X					
Undersupplied market	X	X	X		X	X	X		X
Price shocks	X	X	X		X	X	X		
Ineffective mechanism	X	X	X	X			X		

I.1 Commodity markets investigated in detail

Oil

Oil markets have a long price history and clear price responses to changes in supply. The oil market is subject to the OPEC cartel which controls supply for a large share of the market (~40% of global production, ~60% of globally traded oil), and has been shown to have considerable price and market power. Understanding the decisions taken by OPEC, particularly why and when they change supply, and how the market responds, will be illuminating for the EU ETS. Supply responses from OPEC typically involve a consideration of market prices, global events, production capacity, alternative suppliers and, especially, political pressure. Political involvement in decisions is high, any criteria related to prices and production are relatively soft. Oil reserves are maintained by many states and should therefore already be factored into domestic prices. The OPEC system has been sustained for over 50 years and therefore can be regarded as robust, although members have not always abided by controls – it has also experienced and had to respond to a variety of price shocks and under/oversupply.

The high volume of data and wealth of potential lessons to learn for the ETS supply reserve, although The regulatory nature of emission allowances and supply limitations of oil as a commodity are fundamental differences between the EU ETS and the oil market. Nonetheless, the oil markets are an informative market to look at.

Food crops

Maintaining food supplies is one of the basic requirements for modern civilisation. While this is an issue that has declined in relative importance for the developed world in the last decades it remains important globally, with many countries keeping large reserves of basic foodstuffs as buffer stock in case of unexpected circumstances to mitigate potential spikes in food prices due to adverse weather conditions. Often these are foodstuffs that are also subsidised or directly provided by the government. Some producers, i.e. cocoa, also collaborate to manage production and volumes released to market to ensure a desired price, using a supply reserve – both withholding and releasing supply to the market as necessary to boost price stability.

This has many similarities with the type of supply mechanism to be used in ETS and therefore offer interesting lessons on the advantages and disadvantages of such an approach. In particular, buffer stocks are used as an anti-cyclical buyer and seller in markets that are characterized by natural variability of supply and/or by (price-driven) investment cycles, which impacts product prices with a significant time lag.

Currency

Reserves are commonplace in currency markets and are often used to bolster currency values. This occurs most explicitly in the situation where a currency is pegged to another, where its exchange value with the other currency is kept within a specified, usually narrow, range. Many countries take this approach, e.g. China, Argentina; with varying degrees of success. The UK has previously experienced the negative aspects of this through the ERM mechanism. The role of currency reserves in shaping exchange rates (prices) could be instructive in how such a reserve would function in the ETS, although the number of variables to account for will be much higher. Issues such as trigger mechanisms are likely to be clearly delineated, but political interference will also play a large role.

As with oil markets the sheer number and history of such mechanisms makes for potentially interesting lessons.

I.2 Other commodity markets

Fish

The EU Common Fisheries Policy imposes quotas, similar to a cap, on the volumes of fish that can be caught, these quotas are understood to have been over-allocated for many years compared to scientific advice. Analysing the price and market impacts of this system, within the wider global markets, could be instructive for over-supply in the ETS, and an ineffective mechanism. High levels of political interference are also evident in setting the allocation. This could be an interesting example of mechanism failure to take lessons from.

Gas

Closely related to oil markets, but increasingly diverging. These are typically more regional, only in recent years have large quantities been moved globally via LNG trade. Supply restrictions in Europe have resulted in recent years from Russian controls and cuts, as it is a major supplier. While there are price dimensions to these controls they appear to more typically be linked to geo-political issues, with politics being the key determinant. Similar to oil, many countries keep strategic gas supply reserves to hedge against supply risks. Supply control is very high, as alternative gas suppliers and infrastructure are relatively underdeveloped. These controls have led to some price shocks in recent winters.

Rare Earths

A market that has only recently come to full prominence as technological change has created significant new demand. Supply is restricted to only a few suppliers, with over 90% of the market supplied from China enabling the Chinese government to restrict global supply and affect prices. The result has been significant price increases. A direct example of supply restrictions impacting on prices. As with gas, motivations have a price dimension but are more political and related to strategic industrial policy. The market is adapting to this situation with high prices encouraging new production elsewhere, reducing the control and impact of these measures. The measures have caused undersupply and price shocks.

Phosphate Rock

Is also a market that has experienced supply restrictions. With sizable deposits in only a few countries, including Morocco, producers have significant market power. Supply restrictions (taxes) in Morocco in the 1970s led to prices more than tripling. This price shock affected demand, proving ineffective over time, with restrictions being eased and prices falling back towards historic levels.

Energy
The renewables obligation scheme in the UK is a tradable certificate scheme that supports the development of renewable energy. The mechanism is quota-based, like ETS, although the quota was increasing, rather than decreasing each year, towards a target level, the impact on the energy wholesale price and market is likely to be similar to that of the ETS. The functioning of the system was clear and it remained relatively free from political interference, although revisions were made to the scheme. Lessons may already have been absorbed within DECC.

Aluminium
Is a globally traded metal without direct supply restrictions but where supply is subject to speculation and a system of 'warehousing' implemented by major market players which acts to restrict the speed and quantity of supply and can influence prices. Analysis of this market could provide insight into potential market abuse and impacts of delayed supply, equivalent to a reserve, although the situation is not completely analogous.

I.3 Case study: Oil market

Oil is the most important globally traded commodity and is critical to the world economy. It is traded internationally on global exchanges with the New York Mercantile Exchange (NYME) and the Intercontinental Exchange (ICE) among the major hubs and major price indicators being Brent (North Sea), West Texas Intermediate (WTI) and Dubai.

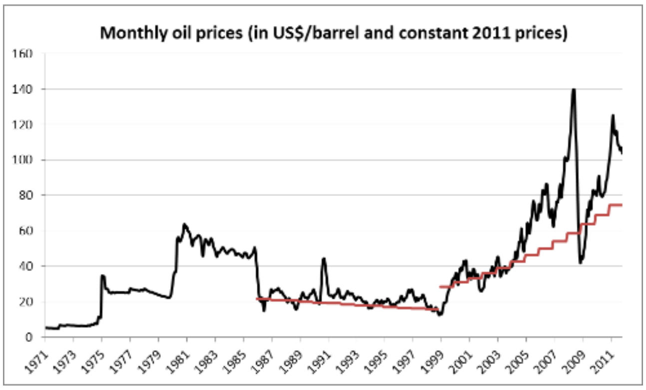
Objective
Oil supply and prices are heavily influenced by the Organisation of Petroleum Exporting Countries (OPEC) cartel. This group of (currently) 12 countries represents around ~40% of total global oil production and ~60% of globally traded oil. As a group they have significant 'swing' power in the market. The stated goals of OPEC are to: 'ensure the stabilization of oil markets in order to secure an efficient, economic and regular supply of petroleum to consumers, a steady income to producers and a fair return on capital for those investing in the petroleum industry.' In practice they seek to maximise the oil price at which demand for oil can still grow, recognising that prices that are too high could reduce demand in the short term through economic slowdown, and in the long term by encouraging fuel switching.

How does it work?
OPEC influences the market by agreeing on an OPEC-wide target oil production total. Decisions on target production are made at bi-annual meetings, or in other extraordinary meetings triggered by OPEC management or a majority of countries supporting such a meeting[31]. Previously, production was managed through country level quotas, which were regularly changed at these meetings, but these have not been issued since 2007. There are no formal rules that trigger OPEC interventions, or decisions on production targets, but members keep in mind target prices, and/or revenues, that they aim for and seek to adjust their production accordingly.

[31] OPEC (2012) Statute

The effectiveness of the decision-making process is debatable, with competing objectives from members often a problem, short-term domestic finance and trade balance issues often dictating positions more than long-term views on price stability. Saudi Arabia is usually one of a group of more stable countries focused on these latter goals, and is more likely to vary its production for these reasons.

Figure 22 Oil prices 1980-2011 red line indicates price trend in period; Source: Ecorys (2012) Mapping resource prices: the past and the future)



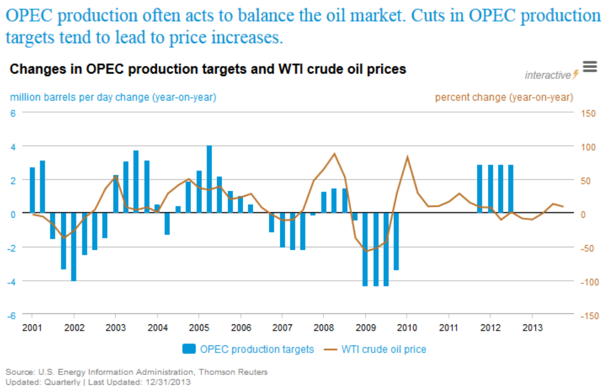
Did it work?

Ignoring the production target (or previously, quotas) reduces its effectiveness, tending to lead to oversupply. The OPEC cartel experienced this as a particular problem in the 1980s, where a more formal OPEC target price regime did exist, but member countries often ignored their quotas. The oversupply this caused, alongside other market developments, led to prices well below target (see Figure 23), indeed the story of the period 1986-1999 is one of relatively stable and low global oil prices. Since 1999 oil prices have risen sharply, from around $20 a barrel, to regularly more than $100 a barrel, driven by increasing global demand and supply disruptions in key producers. Investors see that with prices at current levels OPEC countries are focusing on producing as much as possible to maximise income, rather than working together towards the production target. This is indicative of the OPEC mechanism being more effective in times of falling prices, than in times of rising prices. Indeed, in 2008 as the global financial crisis hit and oil prices plunged, OPEC was able to agree and implement production cuts across its members in 2009[32], with short-term economic and oil market forecasts used to assess the desired reductions in production. Following this decision, and action by members, prices quickly increased again (see Figure 24).

OPEC decisions in the past have been politically motivated, e.g. restrictions in the 1970's in response to the Israeli-Arab conflict (see 1975 in Figure 23), and while this is less the case now, it remains impossible to remove geopolitics from the OPEC decisions. More common now is for OPEC to vary production to stabilise global supply and price volatility, for example to compensate lost production in Libya during the 2011 civil war.

Price discovery is highly efficient in this market with multiple exchange venues and producers, and trade on a rapid, i.e. minute-by-minute, basis, meaning that material changes to supply-demand balances are quickly reflected in prices.

Figure 23 OPEC production change vs oil prices



[32] See 151[st] meeting (extraordinary) of the OPEC conference

The decisions made by OPEC are very closely monitored by the markets and are an important component of oil prices, see Figure 24[33], which presents a US Energy Information Administration analysis of how prices change shortly after OPEC production changes. At the same time, as there is only low certainty on how OPEC members actually work together towards staying within the production target, there is less certainty and predictability to the market, although futures and hedging are widely used by purchasers to smooth the impacts of price changes.

OPEC has been a relatively robust organisation, persisting now for more than 50 years, it has experienced many market disruptions and supply shocks in this time, some of its own making or directly affecting its members. It is difficult to argue oil prices have been stable over this whole period, yet OPEC has been quite successful in its other goal of ensuring revenue for its members. In recent years it is possible to argue that OPEC has played a role in relatively stable (but high) prices, and has played an active role in contributing to this, although it is also hard to disentangle all influences. It is unclear how OPEC will handle a global economic recovery and the expected expansion in the US and Canada (tight-oil), Iraqi (war-recovered capacity) and Iranian (if sanctions are eased) oil production, though these effects are likely to offset each other to some extent, meaning OPEC members may not need to do much more than produce all that they can to maintain their desired price level.

The counterpart to the mechanism – IEA strategic petroleum reserve

The non-OPEC world response to the creation of OPEC and the oil crisis caused by the Israeli-Arab conflict in the 1970s, was to set up the International Energy Agency (IEA) whose primary goal was to help avoid and mitigate against such crises in future. An important part of this decision was the principle that members should maintain oil supply reserves equivalent to 90 days of domestic demand. Member countries introduced policies and agencies to carry this out. In 2009 the EU also introduced a similar 90 days of average net imports reserve requirements for all member states.

In the event of an actual or potential supply disruption, the IEA assess the market impact and the potential need for an IEA-coordinated response in consultation with member countries. If a coordinated response is agreed upon, each member country makes a share of its oil available to the market according to their domestic policy. The share is generally proportional to its total consumption.[34] The IEA strategic petroleum reserve can therefore only address sharp price increases and not a drop in price, the example below in 2011 demonstrates its limited success in this role.

In the US the Strategic Petroleum Reserve was setup and can be used at the discretion of the President to address emergency situations or perceived economic threats. It has been used 3 times, in 1991 to coincide with the first gulf war, in 2005 as an emergency response to Hurricane Katrina, and in 2011 as part of an IEA-led international effort to stabilise global oil prices during the Libyan civil-war[35]. This last release led to global prices declining by approximately 5% but the effect was only short-lived, prices returning to previous levels within a week. This demonstrates that in the case where physical reserves need to be maintained (i.e. that releases must be replenished) that using the reserve can only have temporary effects and cannot be sustained.

[33] See http://www.eia.gov/finance/markets/supply-opec.cfm
[34] More information available at https://www.iea.org/publications/freepublications/publication/EPPD_Brochure_English_2012_02.pdf
[35] More information on this can be found in CFR (2012) Lessons Learned From the 2011 Strategic Petroleum Reserve Release

I.4 Case study: Food crops market

Maintaining food supplies is one of the basic requirements for modern civilisation. Food markets can be global but are typically fragmented. They are characterised by significant exposure to shocks due to weather and other disruptions, low price elasticity of supply and demand, particularly in the short term, and a lag between a shock and production adjustments being able to address it (growing time). Food markets have received more attention in recent years due to a price spike in 2007-2008[36], since which prices have remained relatively high.

Objective

Food reserves are maintained and used as buffer stocks in many developing countries to provide greater food security and to stabilise, and/or subsidise, prices. It is important to distinguish that buffer stocks are not intended for emergency relief, but as a continuous price stabilisation mechanism. There is often a strong combination of social and political reasons for government intervention in food markets in this way.

How does it work?

A variety of different buffer stock food reserve mechanisms and triggers have been used by different national governments[37], but since the 1990s there has been a reduction in global food reserves, as part of a general trend towards a more laissez-faire, non-interventionist approach to markets and also as a reaction to the costs of maintaining such reserves and examples of mismanagement. Some evidence[38] suggests that in cereals markets this overall lowering of reserves has contributed to greater price volatility.

Did it work?

Mismanagement is among the main criticisms of the actual implementation of buffer stocks, leading, for example, for releases from reserves being made too late to make any difference to prices or shortages, and that abrupt and unpredictable use of buffer stocks increased market risk and deterred private investment. Additionally, storing food was expensive and often food was stolen or wasted. Proponents of buffers[39] believe the main management problems can be avoided by use of rules-based mechanisms that work with the market, only stepping in to address market failures.

In terms of overall effectiveness of buffer stocks, a review by the G20 in 2011[40] following the food price spike of 2008 concluded that while buffer stocks and reserves had some success in moderating downwards price trends, they were less successful in tackling price increases. This was because stocks could quickly run out and the price ceilings of such mechanisms are open to speculative attack, although price spikes were significantly reduced in China, India and Malawi which all released food reserves.

---

[36] This price spike was caused by a variety of reasons including poor harvests, speculators using commodities as a safe haven from collapsing financial markets and concerns regarding food crops being displaced by crops used for biofuels.

[37] An international food reserve system was mooted in the 1970's but functional criteria for such a mechanism could not be agreed, and as a result countries pursued their own national reserve strategies.

[38] FAO (2011) Safeguarding food security in volatile global markets

[39] Oxfam (2011) Preparing for thin cows: why the G20 should keep buffer stocks on the agenda

[40] FAO, IFAD, IMF,OECD, UNCTAD, WFP, the World Bank, the WTO, IFPRI and the UN HLTF (2011) Price Volatility in Food and Agricultural Markets: Policy Responses

Further successful experience was reported in Indonesia in the 1970s-1990s and involved the use of floor and ceiling prices in rural and urban domestic markets with a government agency stepping in to maintain reserves. This was successful in social and economic terms, with one of the key factors in its success being regular review of the floor and ceiling prices to ensure their continued appropriateness.

Price discovery in the food sector has been relatively slow, or closed, in the past due to the fragmentation of markets and information and other uncertainties. The growing involvement of speculators and investors in recent years is speeding up the process but also making it more volatile, adding a new, and many believe, destabilising dimension. Buffer stocks, when mismanaged detract from price discovery due to the uncertainty they introduce, well-managed rules based systems could help reduce volatility, improve market function compared to discretionary buffer (reserve) stock management.

Case study in the food crops market – the cocoa market
The International Cocoa Organisation operated a buffer stock between 1972-1998, with the aim to manage global cocoa prices to increase the stability and sustainability of prices. When prices were below the agreed floor price, it would buy and store cocoa until prices increased above the floor, and when prices were above the ceiling, it would sell from its cocoa reserve to reduce prices. The floor and ceiling prices were agreed through negotiations between the major importing and exporting nations, with the agreement typically coming into force when a set percentage (usually 70-80%) of each group agreed. The agreements were periodically renegotiated, although this was not without difficulty, which was to be expected given the diverse and competing needs of different countries. The rules of the agreements could also change substantially each time. The impacts of this were mixed, it was able to support prices for a time, and led to greater price stability for producers[41], but in the 16 years agreements were active between 1973-1990, market prices only remained within the ranges for one year[42]. Among the biggest problems was the decision of some of the biggest importers, namely the USA, and exporters, to stay outside the agreement, undermining its effectiveness. The agreement also led to manufacturers reducing their private stocks. Similar agreements have been used in sugar, coffee and other agricultural commodity markets.

I.5 Case study: Currency markets

Currency markets vary globally, many (but not all) developed countries operate free floating currencies, in which central banks only directly intervene in markets on an occasional basis. Many developing economies, including China, operate a currency peg. Pegged exchange rates are relatively commonly employed, where they can be beneficial in trade and competitiveness when used to maintain a relatively low exchange rate. A downside is that they often result in higher costs for imports, fuelling inflation, although this also applies to profits being 'brought back' being inflated.

[41] R Swaray (2011) Commodity buffer stock redux: The role of International Cocoa Organization in prices and incomes
[42] M Raffaelli (1995) Rise and demise of commodity agreements:

Objective
Central banks in countries with a currency peg actively managing the exchange rate of their currency, so that it remains fixed within a tight range against another currency or commodity to which it is pegged, this is typically the US dollar, but in the past the price of gold was the global standard. This is in contrast to a 'floating' currency where central banks have alternative objectives, such as economic growth, inflation and employment, and therefore intervention in currency markets is less common.

How does it work?
Central banks and governments can influence the currency markets through affecting the supply of the currency, i.e. choosing how much money currency to create, setting rules on how it can be traded and through influencing demand for the currency, i.e. through interest rate policy. Direct intervention in markets to buy and sell currency is also common, often financed using the currency reserves that a nation maintains. These interventions can all affect the price (exchange rate) of the currency, with consequent economic impacts on trade, inflation and other variables.

Did it work?
Maintaining a currency peg requires managing the supply and demand of a currency in the market and therefore requires the central bank to hold significant currency reserves, both for actual trading and as a reassurance/deterrent to speculators. The costs to the central bank, and ultimately government, of this can be significant and problems have occurred regularly in the past, with a withdrawal or failure of government support, causing currency crises in Mexico (1995), Thailand, South East Asia and Russia (all 1997). In each case the currency became overvalued (peg too high relative to actual value), increasing the burden on government to balance markets, leading to worried investors selling the currency, joined by speculators, eventually spiralling to a point where the peg was abandoned and the currency value crashed with significant negative economic impacts.

Some countries, such as China have operated relatively successful currency pegs, backed by very significant currency reserves (estimated at $2.5 trillion) which in a rapidly growing economy they could afford. Affordability is one of the crucial features, but flexibility has also been a key component, with the peg varying over time, i.e. a stricter peg being used to help kick start economic growth (1997-2005) and during the financial crisis (2008-2010) to reduce domestic price risk and uncertainty, with more relaxed semi-pegs in the intervening and subsequent periods where the currency was allowed to slowly appreciate in value.

Case study in the currency market – the UK and the ERM
The UK has had a negative past experience with currency pegging and intervention in markets, as part of the pre-cursor to the euro, the Exchange Rate Mechanism (ERM). The ERM was created by the European Community in 1979 to improve monetary and exchange rate stability in Europe prior to the introduction of the Euro. It linked participating currencies to a weighted average currency unit, the ECU, with member currencies being required to remain within a small margin (+/- 2.25%) of their assigned exchange rate. The UK joined the ERM in 1990 and was given a larger margin for variation (+/- 6%) along with the Italian Lira.

The UK (and also Italy) left the ERM in September 1992, an event widely dubbed 'Black Wednesday', after speculators gambled that the UK would not intervene to the extent necessary to keep the pound within its agreed exchange rate margins. Events in the lead up to the exit highlight a number of triggers and interventions by the government, including the use of currency reserves, to maintain exchange rates within the ERM margins. At the time of exit interest rates had been increased in one day from 10% to 15%, and over £7 billion was spent buying pounds on currency markets. At the time overall losses to the treasury were estimated at £13-27 billion, but more recent estimates put the total at £3.3 billion.

The ERM mechanism was dominated by the largest economy, Germany, and therefore other countries effectively had to mirror German monetary policy to maintain their relative exchange rates. These exchange rates were reviewed each year by the ERM members and between 1979-1987 adjustments could be made, but between 1987-1992 adjustments were stopped. The system was meant to function with all members supporting each other to avoid countries slipping outside their agreed margins, at the time of the UK exit this function did not work, with the UK largely left to itself to defend the pound[43]. Politics and economics played a key role in these decisions in Europe. They were also crucial in the UK, with the high interest rates required to maintain the value of the pound contributing to a prolonged recession and making government reluctant to go further or spend more to remain within its margin[44]. Speculators rightly gambled that it could not, or would not, afford to do this.

After the UK left the ERM the value of the pound immediately fell a further 15%, which could be argued as reflecting the extent to which the mechanism impaired price discovery in currency markets. Italy was also forced to leave the ERM at the same time, but re-joined with wider margins (+/- 15%) shortly afterwards. Spain, Portugal and Ireland were also allowed to adjust (devalue) their currencies in the wake of the ERM exit. In the end, the value of the pound did return to a level consistent with the ERM valuation, this is where it currently remains. The economic impacts of the UK exit were mixed, it was widely viewed as a massive failure, but letting the currency float and the devaluation that occurred enabled UK industry to recover. In terms of market messages the ERM offered semi-fixed exchange rates, which gave greater certainty for investors, a floating currency means less certainty for investment, although hedging and other services are available to mitigate these risks.

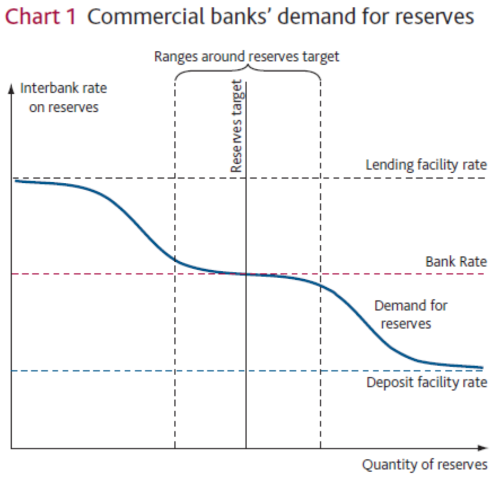
The ERM did, in the end, successfully support the introduction of the euro currency, which while not being without significant problems, caused in part by similar difficult adjustment of periphery economies to policies more suited to the economic core of the euro (Germany), and the biggest financial crisis in decades, has proved relatively robust. A successor mechanism ERM II is now being used to prepare countries for joining the euro currency and a commitment to join ERM II is a part of EU accession policy, with the wider margins (+/- 15%) now institutionalised and stricter enforcement of other monetary criteria.

[43] IEA (2004) Black Wednesday: A Re-examination of Britain's Experience in the Exchange Rate Mechanism

[44] Although rather speculative the reluctance may also have been ideological given the eventual fiscal and monetary implications of the euro, which were becoming clear at the time, and subsequent Conservative policy towards these issues and UK-EU sovereignty.

In reaction to this experience the UK, and as part of more general reforms, the UK moved to make the Bank of England independent, formalised an inflation target and liquidity function, as the Bank's main objectives, and has introduced more flexible currency control mechanisms. The Bank operates a flexible reserve mechanism to maintain interbank interest rates during the periods between decisions by the Banks Monetary Policy Committee (MPC) to change them. This mechanism (see figure) sets a target average reserve level, banks must hold average reserves at this level, or within the margin range that is set, or pay fines. The Bank is committed to ensure sufficient reserves are available to the market so that they can meet the reserves requirements. In this way the mechanism promotes market stability around the bank rate, as banks should be unwilling to trade outside these bound due to the costs that are imposed. The mechanism has not been without problems, the financial crisis of 2007-2008 placed significant strains on the system and the mechanism for the interbank (LIBOR) rate was open to manipulation by market players, and various banks have since been charged and fined for these offences. Reforms to the mechanism are now being enacted.

Figure 24 Bank of England reserve mechanism, Chart 1 from BoE Monetary



Annex II Stakeholder and expert interview case studies

An attempt has been made to reflect the wording and opinions of the interviewees is as closely as possible. Nevertheless, the texts below do not necessarily accurately reflect the wording of the interviewees.

Interviewed stakeholders and experts
Alistair Brown, Public Affairs, SSE **Tom Bent, Trading, SSE**
Summary notes
The "right" level of surplus • SSE would say that the market is currently in the speculative investment realm, i.e. the surplus significantly exceeds the amount required for hedging. More allowances are available to the market than participants need for hedging their exposure. It is therefore the speculators' view on the carbon price that we see reflected in the market, which should have embodied all the hopes and fears for the future of the EU ETS. These speculators are not only banks or other non-compliance companies, but also compliance companies such as utilities and industrials. • SSE believes hedging demand is probably not very sensitive to the price of EUAs. Participants will hedge or not; perhaps only fuel switching could introduce a small flexibility band in the hedging demand. The hedging flexibility band is small compared to the hedging requirement. • The hedging band for every country is different. SSE constructed a simple stylised hedging model for the UK power sector as there is a lot of information available. SSE looked at each type of customer, suppliers, and each generation type. There is some price sensitivity to generation profits (spark spreads). • Whether the majority of the allowances is held by the utilities is unknown. The energy-intensive industry may also still hold a large amount due to the free allocation in Phase II and now Phase III. There is no solid evidence that the utilities are holding a lot of allowances. In the end a large part of the price risk is held by speculators, which could be funds, utilities or industry (probably not banks at the moment), hoping for the price to increase. • To what extent companies actually respond to changes in the carbon price and to what extent they will participate in the market may be related to the level of free allowances they receive. The psychology is different if you have to buy allowances from the market compared to receiving them for free. Since the power sector doesn't receive free allowances, they are more involved in the market and are looking mostly at the differentials between power prices and input costs. Hedging decisions relate to those plants, and customer commitments; some utilities are also large enough to take a speculative position. • If companies receive free allowances, there is a smaller incentive to actively trade in the market. Companies can simply hold on to their current surplus if they expect to have a shortfall in future instead of going onto the market. In the last phase the steel industry also had a lot of active players, so they are sophisticated enough to actively participate in the market. • Companies do both instantaneous hedging and forward hedging. The power sector trades and commits electricity supply up to 3 or 4 years forward, and this will be reflected in the required

Interviewed stakeholders and experts
Alistair Brown, Public Affairs, SSE **Tom Bent, Trading, SSE**
Summary notes

hedging position. Each company has an underlying hedging strategy that comes into play with expectations about the future output of a plant. Hedging also depends on the profit at risk, so if there is no profit at risk, there is no point in hedging. For example if a plant is highly profitable against forward prices, it is very likely that the owner will consider it desirable to lock into that level of profitability by hedging; if it is loss-making, it would be a waste of time to hedge that plant.

- The "right" level of surplus for a more stable and reliable market would be a surplus very slightly above the hedging demand. This is taking into account that some participants holding allowances may not want to sell - but might hold on to allowances for future use instead.

Impact of a market stability reserve

- SSE is convinced that no one knows the impact of a market stability reserve for sure.
- No gaming of the reserve is foreseen though, as there is not enough collaboration on the market to make it happen.
- The level of the trigger thresholds, and other details of the reserve mechanisms exact implementation will be reflected in market prices. If thresholds are too weak or high, the reserve could be considered as surplus freely available to the market along with the rest of the allowances issued, and be priced accordingly. If they are sufficiently strong to create scarcity, there should be a positive impact on price.

Different designs of a market stability reserve – the Commission's proposal

- There are a couple of potential weaknesses in the current design. With back-loaded allowances returned to the market, and a 12% withholding rate it will take a long time before the existing surplus outside the reserve is removed. It is hard to tell how the market will respond to anticipated scarcity near 2030 – a lot of other developments could occur in that timeframe, and it is well outside the 3-4 year maximum hedging window.
- SSE is not absolutely sure whether the lower threshold trigger of 400m is too high or low. A price signal trigger – along the lines of Article 29a - would be a better, more targeted mechanism.
- One potential advantage of the low 12% withdrawal rate is that it would allow the market time to gradually adjust to reduced levels of surplus and explore price. The disadvantage is that would take some time for surplus to be reduced to the upper threshold level of 833m tes, if back-loaded allowances are returned to the market.
- Hedging requirements in the UK are quite high now but will be quite low once coal-fired power plants have been phased out. The 400 and 833 million threshold are therefore roughly in the right ballpark, but no one can be very confident what the right number is.
- It doesn't make a lot of sense to put the allowances back into the market just before a new mechanism; it would make more sense to coordinate the two more.
- Back-loading appears to have had an impact on the carbon price; some of this could be that some market participants expect the allowances not to come back into the system.
- Back-loading is something the market has been waiting for. The current carbon price is a function of the probability of predicted political reform, rather than representing any form of abatement costs. Backloading is close enough to be able to see that it will have an impact in the market as it is within the time reference of the traders and hedgers.

Interviewed stakeholders and experts
Alistair Brown, Public Affairs, SSE **Tom Bent, Trading, SSE**

Summary notes

- The 2030 announcement is factored in the price to some degree; but the successful implementation of the proposed market stability reserve is still very uncertain. The actual timing of implementation - whether it is 3 of 7 years from now – is less important than either achieving legislative certainty that it will happen, or the degree of intervention. If the market anticipates it confidently and knows it is a strong tool, it will have more of an impact.

Different designs of a market stability reserve – alternative designs

- SSE would be very interested in seeing a hybrid form of reserve design being implemented, with a volumetric surplus as the trigger for withholding and a relative price as a trigger for return.
- Absolute price triggers might not be particular helpful or feasible; there are potential legal issues around it being seen as a tax, and it was clear from the Commission's consultation that most stakeholders were against it.
- SSE hasn't looked at absolute price triggered options lately, because it was found politically unfeasible; but in the past some prices were investigated. The preliminary findings were that the maximum price should not be higher than the main abatement measure used to achieve the GHG target on the long run, perhaps carbon capture and storage. The floor price should also not be too high as it should allow space for low-cost abatement opportunities to set price should they arise – perhaps 4–5 €/tCO_2. In the UK carbon price floor is already implemented, and is already higher than e.g. the California auction reserve price.

Other design details

- It should not make much of a difference whether allowances are withheld in one go, or spread over the year. Spreading it would give a bit of a smoother price trajectory
- Under the proposal it is not certain what happens to a long-term accumulation of allowances in the reserve – and ultimately this could invite political discretionary intervention. There could be a cap the amount of allowances in the reserve; or they could be given a certain shelf life. Ideally certainty should be achieved early.
- The credibility of the reserve can be improved by ensuring in the design that it is mechanistic and does not allow discretionary political intervention
- The review after 5 years mentioned by the Commission is quite surprising, as given the 12% decrease in surplus per year there will probably be very little new development as the upper threshold will not be reached by then. It might only provide some information though if the upper threshold is supposed be much higher than 833 million.
- In principle it is sensible to review the reserve after a number of years, but there should preferably be as little adjustment as possible; the mechanism should be designed to be as durable as possible for all circumstance. The current Commission proposal suggests reviewing the mechanism after only 5 years, by which time the upper threshold will not have been reached. However, if information emerges showing 833m is too low, this might give the Commission an opportunity to adjust it before it is hit.

Other commodity markets

- It is difficult to compare the carbon market reserve to reserves in other commodity markets. e.g.

ECOFYS
sustainable energy for everyone

Interviewed stakeholders and experts
Alistair Brown, Public Affairs, SSE **Tom Bent, Trading, SSE**
Summary notes
strategic oil reserves are managed on a discretionary intervention basis. • One important difference is that in the oil market both demand and supply respond to price; while in the EU ETS the supply is totally inflexible, and at many price levels demand is not very elastic either.

Interviewed stakeholders and experts
Dr. Ruben Lubowski, Chief Natural Resource Economist Environmental Defense Fund *The interviewee indicated that his comments are his own personal opinion and might or might not represent the views of any others at the Environmental Defense Fund.*
Summary notes

The "right" level of surplus

- The so-called surplus in the EU ETS is not the problem, but a symptom of the underlying problem. Discussing the right level of surplus would not address the fundamental problem in the EU ETS.
- The fundamental problem is that there is a lack of certainty on the long term targets. Once that certainty on the long-term target is given, it should be left to the market to figure out what the optimal abatement pathway is to that target.
- The discussion of the surplus is all relative to 2020, but if the EU ETS is serious about reaching the long-term target, the discussion should be more focused on this long-term target. The so-called surplus represents more allowances than needed through 2020 but is not an excess and should be thought of as a "bank" in the context of targets through 2030 and beyond. The current EU ETS prices are so low because there is great uncertainty about the future in the long term and this depresses demand to bank allowances for use in the future.
- This brings the question to how to solve the fundamental problem. The price is a symptom based on the supply and demand, and the price can be raised by decreasing the supply of allowances. This would raise the price, but this approach may not incentivise low-carbon investments. What we actually want is to raise the demand for more emissions reductions. This in turn would translate into a higher price, but the price itself is not the objective.
- Just raising the price by restricting supply might not even incentivise low-carbon investment, because firms might decide not to invest for the long term anyways if there is a risk that the price will drop in future again, and they will just comply with the higher prices for now. This will raise their costs and may even decrease longer term investments.
- What we actually want is to increase the demand for allowances, i.e.to bring the demand in the future further forward to the present. To achieve this, the problem of the large policy uncertainty has to be solved.
- The price and the so-called surplus are therefore symptoms and not the problem in the EU ETS. The surplus should be considered as a "bank" of allowances for after 2020. Firms should be considering banking even more for use through 2030 or beyond, but with the large policy uncertainty this is risky.

Interviewed stakeholders and experts
Dr. Ruben Lubowski, Chief Natural Resource Economist Environmental Defense Fund *The interviewee indicated that his comments are his own personal opinion and might or might not represent the views of any others at the Environmental Defense Fund.*

Summary notes

Impact of a market stability reserve

- A reserve in the system might help to buffer price spikes, but it doesn't solve the fundamental problem of unclear long term targets.
- A reserve in which the government tightens supply in response to more allowances in circulation restricts the banking ability of the firms in the EU ETS, while we actually want to encourage banking. It is expected that firms would need a large amount in the bank as reducing emissions is going to get harder and more expensive. Banking of firms should therefore be encouraged.
- Adjusting the "surplus" through the proposed reserve may not result in the desired effect stabilising the market as there are scenarios with extreme low prices and low surplus levels, e.g. if the EU ETS has lost its credibility as an instrument for the future or the expected demand for allowances will remain to be low in the future, and vice versa (high prices and high surplus levels). One can thus imagine situations where the reserve would lower already low prices or raise already high prices.
- The reserve might raise prices in the short term, but it might not stimulate low-carbon investments at all as firms might take on a wait-and-see attitude.

Different designs of a market stability reserve – the Commission's proposal

- It is not clear what the Commission's proposal of the reserve is trying to solve. It is unclear what the basis for the adjustment is and what goal the MSR is trying to achieve.
- Since it is possible for the market to have low prices when surplus is low and high prices when there is a large surplus, the reserve could lower prices when they are low and increase prices further when they are already high.
- If a goal of the reserve is to mitigate shocks to near term demand (e.g. as a result of a recession or an economic boom), then it is important to decompose demand into short and long term component and target the first component specifically. Just looking at the aggregate result is a blunt approach and might produce unintended results.
- The reserve may only increase the uncertainty. It seems that the regulator wants to transfer the option to bank from the private sector to the government.

Different designs of a market stability reserve – alternative designs

- A price-triggered reserve mechanism such as the one operating in California and the one proposed in the Waxman-Markey bill has cost containment as its primary purpose, which works well to contain the price
- In California the price floor fulfils its purpose as long as there is some demand from auctions as it is an auction reserve price. There is still a potential problem that there is a lack of long-term certainty on the cap, which could be why the price in California has been close to the floor price.
- If the purpose of a reserve is to stabilise prices in the most cost-effective way, a price-triggered reserve might not be the best option. With a price ceiling, the price could temporarily spike due to short term factors, leading to a rush to buy allowances from the reserve. The price could later just subside and firms would have bought a lot of allowances too expensive.
- Analternative option for a cost-containment reserve would be to give or sell firms options or rights to buy allowances at a certain price, which would be available at any time the firm needs it. This would

Interviewed stakeholders and experts
Dr. Ruben Lubowski, Chief Natural Resource Economist Environmental Defense Fund *The interviewee indicated that his comments are his own personal opinion and might or might not represent the views of any others at the Environmental Defense Fund.*

Summary notes

provide more certainty for the future.

Other design details

- An alternative option that would increase the credibility of the EU ETS as well as avoid the disadvantages of a reserve is the auctioning of allowances with the guarantee that the government would stand ready to buy them back in the future, say in 2030,at a certain price, similar to a bond. This would immediately raise the price that the government would receive for the allowances and could be revenue neutral or even revenue enhancing for the government. This would also directly target the long-term credibility and certainty problem and will also incentivise firms to make long-term investments.
- If a cost containment reserve runs out it cannot provide market stability if the price goes up. The reserve could also operate as revolving fund and be filled with high quality credits/offsets generated from real reductions from activities that have actually reduced emissions, such as credits from reduced deforestation at large scales. Such a reserve would be very different environmentally from a reserve based on allowances printed only on paper so that releasing the reserve only loosens the cap. The reserve could also be decentralised so that under certain conditions private actors could sell these real reductions through a tender process. This was the proposal under the Waxman Markey bill.

Other commodity markets

- The comparison with other commodity markets is interesting, e.g. with oil. The US buys oil for national security, and this can also be applied to address the climate problem. The reserve could be stockpiling credits from real emissions reductions for climate security.

Interviewed stakeholders and experts
Richard Folland, European Energy and Environment Policy Advisor JP Morgan, EU Climate Finance Chair CMIA

Summary notes

The "right" level of surplus

- The current EU ETS market is in the area of speculative investments. Not only pure speculators, but a lot of compliance entities are sitting on their allowances as well, waiting to cash in on their allowances, and this is one of the major problems in the EU ETS.
- Some surplus is indeed needed for the market to function well, but the status of the oversupply has gone much beyond what is needed for the normal functioning of the market
- Some intermediaries might have left the market and we know that many banks have pulled their carbon desk due to the low prices, which puts a squeeze on the margin
- Financial intermediaries contribute to a better functioning of the market as they are able to bear risks and liquidity, and without the intermediaries it would have been a more dysfunctional market with greater price volatility

Interviewed stakeholders and experts
Richard Folland, European Energy and Environment Policy Advisor JP Morgan, EU Climate Finance Chair CMIA
Summary notes

- It is hard to say what the right level of surplus is, but from experience the current level is way too much as demonstrated by the low price. The oversupply needs to be reduced, but the question is whether the MSR will be sufficient
- The hedging level needed in the market could be an indicator of the right level of surplus

Impact of a market stability reserve

- The establishment of the reserve is partly psychological and partly symbolic as it is very driven by policy. Just establishing a reserve ought to impact behaviour of market participants as it shows policy makers recognise the shortcomings of the EU ETS that it cannot respond to shocks. They show that they are doing something about these shortcomings, which is important for the market.
- This symbolic value is demonstrated by backloading, as the longer the backloading discussion went on, the more important it because due to its symbolism. Backloading was needed to stabilise the market and is a good thing, it was just necessarily the best of to implement it and it is not a viable policy solution in the long term.
- There is still quite some uncertainty, and possibly the hope, that the backloaded allowanced might not return to the market. It has bought the policy makers a few years of time to put longer term solutions in place.
- The market is probably less bothered by when a long-term solutions such as a market reserve is introduced, but look more at when the decision to implement it is made. This will provide more certainty to the market.
- If the reserve is transparent, then it would provide more confidence to the market.

Different designs of a market stability reserve – the Commission's proposal

- Looking at the way the MSR is implemented, it will probably take a long time, most likely the whole of Phase IV, before the overhang is reduced. The 12% might be too low to effectively reduce the surplus.
- There are still arguments for retiring all the allowances from backloading as it addresses some of the overhang, but we would rather see that it is removed permanently. This way the reserve would behave in a more responsive way.
- It is unclear where the numbers provided by the Commission comes from and we would like to see more evidence and assessment of the numbers. The Commission only said that it is within the levels provided by a range of stakeholders
- The quantity-based reserve instead of a price-based one is what we have always supported as it is political more feasible. Traders could also see the political sensitivities with the reserve proposal, so they are satisfied with it as well.
- The Commission's proposal is expected to change the behaviour, because it shows that the EU ETS is also learning from its experience. It will have an impact on the supply and demand balance, which determines the price. Tightening the market will bring the supply and demand fundamentals closer into focus and introduces greater possibilities for financial intermediaries
- The new MSR is expected to provide greater stability on the market and would help set the expectation in the market, reducing risks.
- It also sends a message to investors that the EU ETS remains central in reducing GHG emissions, and

Interviewed stakeholders and experts
Richard Folland, European Energy and Environment Policy Advisor JP Morgan, EU Climate Finance Chair CMIA
Summary notes

combined with the increase in the linear reduction factor the message is stronger.

Different designs of a market stability reserve – alternative designs

- Alternative designs based on price would be not be politically feasible, so these have not been considered in any detail.

Other design details

- Traders would prefer the injection of allowances from the reserve to be spread out as it would smooth prices and provide more purchase opportunities
- If the reserve becomes too large, it could be seen as not credible to maintain anymore. The current size of the surplus could be used as an indicator, which is 2 billion. This might be too large. If the size of the reserve becomes larger than 1 billion, it would be quite sizable.
- More credibility could be provided through a sunset clause. CMIA has thought about such a sunset clause and proposed a period of 3 years to retire the allowances in the reserve. Some thought could be given to a reciprocal design if this was politically acceptable.
- Reviewing the MSR is necessary, but should not be done too often. 5 years is a good balance. In this review, the fundamental design and principles of the MSR should be preserved and the review should more focus on the numbers that would need to be established through experience.

Other commodity markets

- The idea for a reserve most likely comes from commodity markets, so interesting lessons could be learnt from that.

Interviewed stakeholders and experts
Ravi Baga, Head of Upstream Policy & Regulation, EDF Energy **Anurag Mall, Senior Policy Advisor, EDF Energy**
Summary notes

The "right" level of surplus

- Most markets have some form of supply response such as perishment or supply destruction, or in the case of increased demand, a supply adjustment.
- The EU ETS does not have any of these features and ideally it should have a supply adjustment mechanism without any price references. It should be aimed towards cancelling surplus allowances.
- The "right" level of surplus should not be too large, and in the range of 10 to 15% of the annual allocation of allowances (i.e. the cap).
- While the market currently uses the surplus to hedge, the question is whether a surplus is actually needed to hedge.
- Before the start of Phase III, there were significant concerns about whether auctioning platforms would be ready in time to supply allowances for liquidity and hedging, and this was found to be a risk. This prevented the development of forward trading as it required participants that were willing to

Interviewed stakeholders and experts
Ravi Baga, Head of Upstream Policy & Regulation, EDF Energy **Anurag Mall, Senior Policy Advisor, EDF Energy**
Summary notes

trade forward.

- Now that the forward market has developed, the question is whether you need to hold onto the full amount of allowances through the surplus to hedge, or only a share of allowances. This is because the rest can be hedged through forward trading, and allowances are only required to be surrendered three months after the end of the relevant year.
- As long as there is a forward price profile that the market has confidence in, then there is no need for a surplus. This is because forward allowances of current and future vintages can be bought from other parties or auctions. It does not matter whether the allowances are from Phase II or from forward trading because with forward trading participants will definitely receive them and the allowances can be traded with confidence.
- Market participants may use the surplus to hedge but this does not mean that a surplus is required to be able to hedge as forwards can also be used.
- The surplus should therefore mainly be used to provide a buffer for any fluctuations in emissions. If the demand for allowances were to change/fluctuate approximately 3% per year, then this would suggest that a 12% surplus would provide a sufficient buffer to deal with demand changes up to three to four years ahead. A significantly larger surplus would create an unnecessary and damaging supply overhang as most participants are not trading beyond four years ahead.
- The history of the ETS suggests that prices fell considerably when the surplus hit 500 million allowances. Since participants want a reliable price signal in the EU ETS, the surplus should be maintained at a level that will prevent price crashes.

Impact of a market stability reserve

- Which party holds the surplus in allowances should not make a difference because the market knows that the allowances are in the reserve, and this fact would therefore already be factored into the market price.
- One of the main reasons that backloading had any impact on the allowance price at all was because it was believed that there was a possibility that the backloaded allowances would be cancelled. If the market has 100% confidence that the backloaded allowances will be restored, then there will be no impact on the price.
- The reserve is likely to cause a delay in investment and increases the risk of price spikes. This is because an investor will wait until the reserve is exhausted before investing as it knows the allowance price will not rise to true marginal abatement cost levels for abatement investment until this happens. Real options will start to develop but only if the investment provides a higher level of certainty e.g. when the reserve is empty, firms will exercise these options.

Different designs of a market stability reserve – the Commission's proposal

- The Commission's proposal will not help the market because allowances will just return to the market when the surplus decreases. The main difference with the current situation is that in the proposal part of the allowances will be held centrally rather than by the participants, and some will take comfort in the fact that a central authority will be holding them.
- If a large share of allowances is held by a few parties, then some participants may believe that it is easier for such parties to manipulate the allowance price. This is the reason why they may take

Interviewed stakeholders and experts
Ravi Baga, Head of Upstream Policy & Regulation, EDF Energy **Anurag Mall, Senior Policy Advisor, EDF Energy**

Summary notes

comfort in the surplus being held centrally.

- The volume trigger to stop absorbing allowances into the reserve is about 50% of the annual cap, which is too large and is unlikely to have a significant price impact.
- The problem is that the MSR is designed with two mindsets. One is how to make the instrument effective, and the other is seeking to minimise any price rises in the near term. These two very different perspectives mean that we are unlikely to see any robust consensus on the design of a stability reserve.

Different designs of a market stability reserve – alternative designs

- If the reserve was designed with a price trigger (such as a minimum price at which allowances are released from the reserve), then this would be more likely to alter behaviour in the market than the Commission's current proposal.
- The price must be credible and could be based on the UK carbon price projections that are consistent with some of the earlier EU price projections for the ETS.
- A minimum price for allowance release will not be effective unless this price is closely aligned with marginal abatement costs for new investment. This is because no one will pay above that price as they will know that allowances are available at that price. Firms would also delay investment in this scenario as access to the allowances from the reserve could produce a price which is significantly below the marginal price required for investment.
- If the reserve was designed with a price trend trigger, this would make things unnecessarily complex and add more uncertainty.

Other design details

- The credibility of a reserve could be improved by setting a sell-by date for the allowances in the reserve. This can be either based on a first-in-first-out principle or the vintage date of the allowances. A potential sell-by date could be 5 years.
- If a sell-by date is combined with a price-triggered reserve, the minimum price at which allowances are released from the reserve could be set over a period of 5 years.

Other commodity markets

- Other commodity markets provide good examples of how to tackle a large surplus. Supply destruction can quickly affect prices and cause prices to increase to the desired level.

Interviewed stakeholders and experts
International energy company with significant trading activities on various carbon and commodity markets (Confidential)
Summary notes

The "right" level of surplus

- The market is very much influenced by political decisions, and the uncertainty about the future market influences today's price. There are no contracts beyond 2020 on the market for trading and the political framework for beyond 2020 is still uncertain.
- Some market participants are taking a speculative position as the surplus is larger than they would need for hedging, so they plan to sell allowances at some point in time. These are mostly compliance entities.
- Banks used to play a large role in speculation and the market was more speculative, but under current market conditions little money can be made, so many banks have exited the market.
- Hedging demand would change over the future as it would depend on changing expectations on many factors at that time include the future emissions, the economic situation and status of the MSR proposal. If the market is indicated to be tight, market participants will hedge more aggressively.
- The surplus is not strictly needed to hedge. The current situation is that because there is a surplus, prices are lower and utilities will hedge more.
- When hedging for power forward contracts, it makes more sense to use forward contracts. Even if the market is tight in the future, there is no need to worry about the access to forward contracts; the price might only be higher. If there is a demand for forwards for hedging, there will always be trading companies and banks on the selling side as long as money can be made. This way the financial sector provides more liquidity in the market.
- A healthy market would be a balanced market

Impact of a market stability reserve

- The market has been long all the time and the price did not collapse, it is only in the recent years that there was a collapse. The reason was that it became clear that no corrective measures could be taken for the surplus.
- With backloading it is a sign that this lack of possibilities to take corrective measures was recognised and there was the hope that the market would be balanced again. If the backloaded allowances just come back again, this would depress the prices.
- The MSR proposal will allow the price impact due to backloading to remain intact as it will be able to balance the market more by both spreading injection of the backloaded allowances up to 2022 and putting allowances in the reserve.
- The impact of the MSR is not assessed in that much detail now by utilities yet, which will more likely be in 2 or 3 years when the start date of the MSR moves into the hedging time window for the utilities.
- The impact will depend on how the rules are set, which periods are used and what year the MSR comes into force. It will also depend on the exact volumes to withhold or inject, how the volume intervention is managed and who manages it. The current MSR design is only a proposal, so it can still change on many fronts and it is too early to take a position on what the impact of the MSR will be.
- Utilities will not change too much in their hedging strategy with the new MSR and they will still hedge according to their power contracts and emissions. Traders know the MSR is going to happen at some point in the future, but they don't position it into their trades yet.

Interviewed stakeholders and experts
International energy company with significant trading activities on various carbon and commodity markets (Confidential)

Summary notes

- Most market participants have not thought about the MSR is that much detail yet as it is seen as too far away in the future and a too political discussion. The current intention of many market participants is to observe the developments of the MSR and form an opinion.
- As a utility we do not have a large compliance position, while other larger utilities have a much more different provide.
- Some industrial parties need a lot of EUAs per year, but there are very passive about the whole system and see it as a tax. Reasons may be that the prices are too low for the EUA market to be interesting or that they still have many EUAs from the past.
- For some operational companies looking ahead for more than 1 year is already difficult, and anything beyond 1 year is considered as long-term strategy

Different designs of a market stability reserve – the Commission's proposal

- The Commission's proposal is only a proposal now, and it is expected to take a long time for it to be in a final form to be adopted, which can contain many changes. Just to take an example, backloading was presented as a simple measure, but it took a long time to take effect.
- We don't know where the levels proposed by the Commission come from and have not formed an opinion yet whether the levels are too high or too low. At this stage it is too early for us to have an opinion on the numbers proposed, but we see it as a positive development to have some control over the market.

Different designs of a market stability reserve – alternative designs

- If a choice would have to be made between a volume trigger or a price trigger, volume trigger would be preferred, because all the current problems of the market imbalance originates from the volume.
- A possible price ceiling could be the cost of CCS, but price ceiling could limit the amount of investments, so this might not be desired.
- We can imagine that some investors would prefer price triggers as it would provide more certainty and it would justify the investment abatement they would have to make. Current prices are too low, so compliance entities do not abate yet and rather take the carbon costs than investing in abatement measures as that is deemed too risky under current carbon price levels. From experience companies will start looking at the carbon price around 20 euros or higher.

Other design details

- A central bank to manage the reserve would be much more reliable than politicians.
- The MSR should not have a large impact on the market, so intervention should not be done in large chunks as it would prices more uncertain, causing more volatility. There should also be as little intervention as possible.

Interviewed stakeholders and experts

Daniel Jefferson, Senior Analyst E.on Global Commodities SE

Summary notes

The "right" level of surplus

- As regards the graph presented in the background paper for this interview the proportions held by industry and speculative investors (incl. strategic reserves) does not appear to be right, expects that a larger part is be held by industry
- The question on the "right or healthy" level of depends on what one wants to achieve with the EU ETS. If the overall objective is to reduce emission then the lower the surplus the better. In case "healthy or right" level of surplus is related to a specific price level one wants to achieve than this looks differently.
- If the objective is to achieve a "desired" price level, it is hard to determine the "right" surplus limits since the effect on the carbon price will never be linear and therefore are hard to predict.
- If the true objective is an investment signal than the lower the surplus the better
- If the surplus is below the surplus that is currently required for hedging, then for the market to balance, either the power sector needs to change its hedging behaviour or emissions need to be reduced, in line with the objective of the EU ETS. If reductions in emissions are required to balance the market, carbon prices are likely to be significantly higher than they are today, and this must be backed by political commitment if the carbon price is to provide an effective investment signal.
- The size of the surplus would most likely not affect the hedging behaviour. It is more likely that any shortfall in the market would have to be dealt with by actually reducing emissions (i.e. the objective of the EU ETS), rather than being compensated for by an adjustment in hedging activity.
- There are reasons why hedging activity might increase over time, e.g. increased liberalisation of the Eastern European power markets and a growing shortfall in allowances in the industrial sectors (as you mentioned). It could also decrease if e.g. the costs associated with hedging (such as margining) become too much of a burden for companies.

Impact of a market stability reserve

- The question of whether market participants "price in" allowances in the reserve boils down to the question: Will the market with an MSR act differently to a situation where allowances are cancelled? The basic difference here is that with a reserve (as opposed to cancellation) withheld allowances will come to the market at some point in time. The price impact of this will depend on how far in the future this point in time is, and how rapidly allowances from the reserve will return to the market once this point in time is reached.
- With 12% of the surplus being moved annually to the reserve, it would take a number of years to move into the defined surplus band, and given the limited time horizon of market participants, this could limit the price impact of the reserve in the early stages of implementation of the proposal. After this, it could again take a number of years to drop below the lower threshold. When this happens (dropping below the lower threshold), the market would already be tight, but pressure on prices could be reduced, depending on the rate at which allowances are returned from the reserve to the market.
- While there will be uncertainty over when and how they will come back, there is certainty that these come available at some point and thus allowances in the reserve will be priced in at some point, although the various uncertainties, together with the limited time horizon of market participants, can delay the point in time at which this occurs (e.g. anticipated return of allowances from the reserve may not have a clear price impact at the start of phase 4).

Interviewed stakeholders and experts
Daniel Jefferson, Senior Analyst E.on Global Commodities SE
Summary notes

- However, with a market stability reserve, price dynamics of phase 4 are expected to be quite different from how they are now anyway, and the precise price impact of the return of allowances from the reserve is hard to predict.
- The MSR idea is clearly supposed to compensate for events such as recessions/booms. However, since there is a two year delay in the response of the adjustment mechanism, it is still possible that higher/lower than expected economic growth could trigger volatility in the EUA price in the medium term. An MSR could in principle compensate for the longer-term impact of a recession (such as we are experiencing now, with the effect of the 2008/2009 financial crisis still weighing on EUA prices). A recession could therefore trigger a drop in prices, since the MSR would not react to any consequent additional oversupply for two years. However, anticipation by market participants of the adjustment two years down the line could help limit the drop in prices.

Different designs of a market stability reserve – the Commission's proposal

- When designing the MSR the Commission should be careful about the possibly impacts. Have not seen the rationale behind setting the band at max. 833M and min. 400M EUA. Therefore it is difficult to anticipate how market participants will react to them. Particularly if they are not set in a transparent manner.
- Assuming that the graph of the current surplus is correct, than the Commission Proposal could make the market tight at some point in the 2020s, but this might not happen for over a decade. It therefore may take a considerable amount of time for the proposal to restore the EU ETS as an effective investment signal. In addition, if the EU ETS is to be allowed to become an effective investment signal, market participants must have confidence that policymakers will not intervene further in the EU ETS to limit carbon price rises triggered by the market stability reserve.
- When crossing the lower band at 400M, the market is likely to be quite tight, meaning that price dynamics are different from those we see today. The subsequent injection of 100M back into the market would dampen the effect of market tightness but the precise price impact is hard to predict.
- If back-loaded EUA volumes to come back in 2019 and 2020, the market will be flooded and prices could collapse.
- Back-loading some of the back-loaded volumes, as suggested in the Commission Proposal, would ease this effect only to a limited extend: proposal only allows adjustments of this type to take place "in the last year of each period", meaning that this back-loading can happen only in 2020, which means that 2019 will be oversupplied in any case. Also, only a share of the back-loaded volume scheduled to be come back in 2020 can be postponed to Phase 4, meaning that even with this adjustment, it is likely that 2020 would also be oversupplied.

Different designs of a market stability reserve – alternative designs

Hybrid approach:

- See difficulties with this approach:
  - Not easy to understand the relationship between the two triggers
  - potentially both triggers could be pulled at the same time, i.e. the while a surplus still exists in the market the price could have risen above the threshold
  - seems to involve more risks as its design is more complex. This could lead to participants being able to game it as more opportunities arise to create impacts on the market

Interviewed stakeholders and experts
Daniel Jefferson, Senior Analyst E.on Global Commodities SE

Summary notes

- EU ETS in its self-becoming more complex, the mechanism should be kept as simple as possible
- Hybrid the most complex of all the options presented in the interview.

Price corridor:

- More simple than hybrid but unclear how to set the upper threshold of the price. If the objective of the system is to reduce emissions, then setting the maximum price below the price that induces investments in mitigation technology would undermine the system.
- Opens opportunities for gaming which potentially leads to volatility within the price corridor. Volatility of price would lead to a less effective as investment signal.
- Price trend instead: again the question is what the EU ETS should achieve. Setting a limit to price growth can undermine the objective of providing an effective carbon price signal and of reducing emissions.

Other design details

- The rules of any flexible supply mechanism should be as simple as possible. Additional rules based on factors other than those mentioned would create additional complexity which would reduce the ability of the system to provide a clear investment signal.
- Clearly the tranches and timing through which allowances are injected back to market can make a difference. The EU ETS' cap is reduced every year anyway, making the market tighter at a certain rate, hence putting '100M' back into the market dampens the tightness more than putting 50M in two years. But if in two consecutive years reserve allowances are injected one might end up again with 100M injected in one year. The bigger picture plays a role here and more thorough analysis would have to be made to judge this.
- An important function of the EU ETS is to provide a strong signal for low-carbon investments. From this perspective it does not matter how many allowances are in the reserve as long as the investment signal is maintained. What is important here is the rate at which allowances might potentially come back to the market from the reserve. If they could flood back rapidly, this creates the risk of a price collapse. If they can only come back very gradually, the existence of the reserve should cause less price uncertainty.
- Letting allowances in the reserve expire after a certain time in the reserve would of course make the system more robust in terms of providing longer term certainty over the market becoming tight. Boils down to having a lower cap, which will drive more reductions. Cancelling allowances in the reserve would provide a much stronger signal than keeping them in the reserve.

Interviewed stakeholders and experts
International industrial firm with large EU allowance trading activities (Confidential)
Summary notes

The "right" level of surplus

- The interviewee does not have an opinion on the "right level of surplus" or which part of the current surplus is held by whom.

Impact of a market stability reserve

- Free allocations based on benchmarks and actual outputs will make supply more flexible in addition to their initial aim to align the competitiveness and climate policies of the EU. While it would not tackle the current surplus, it would help prevent manage surplus after 2020.
- A flexible free allocation system based on real output rather than on historical emissions is desirable. The principle of an output-based allocation system should apply post-2020.
- In the context of assessing the impacts of an MSR on the market and the surplus, the contribution of free output-based allocation to stabilising the surplus availalble in the market should be taken into account as well.
- MSR will have a price impact. The discussion on an MSR cannot be split from the discussion on the competitiveness /carbon leakage considerations post 2020.

Different designs of a market stability reserve – the Commission's proposal

- Level of the corridor, specifically the floor of 400 million EUA seems low. Currently, markets needs around 1 billion EUA for hedging purposes, which take place up to 3 years in advance.
- No understanding of where the ceiling level of the 833 million EUA comes from, either. Surplus ceiling should be higher to allow also for banking by industry.

Different designs of a market stability reserve – alternative designs

- Both approaches, the hybrid approach and the price corridor approach, are not desirable since the EU ETS is a quantity driven system.
- In favour of volume driven system in order to not undermine the principle of the EU ETS volume driving the market.

Other design details

- Key to the design of the MSR are also its governance and the review approach.
    - Need to know who is governing the MSR, preferably an independent body that is regularly reviewing the effectiveness of the reserve and adjusts its functioning as required. Reviewing it in 2026, as scheduled, is not early enough.
    - Extend of the review is unclear.
- Competitiveness impact of the reserve and its impact on prices need to be overseen and reacted to. The MSR design should therefore not be discussed separate from carbon leakage discussion for 2020.
- An independent governance body for the EU ETS, to review and adjust the system in case of shocks and issues, would be preferable over an MSR and would provide the required predictability. The entire system is overly rigid and an MSR would only introduce flexibility to one aspect.

Interviewed stakeholders and experts
International industrial firm with large EU allowance trading activities (Confidential)
Summary notes
Other commodity markets • Californian price containment: auction price floor and Allowance Price Containment Reserve introduced mainly because of wide overlap with other policies, which creates a risk of high volatility in the ETS. ETS is not the prime policy tool to reduce emission but to achieve a certain (limited) amount of reductions. To protect from this volatility the price containment reserve has been introduced. Californian cap-and-trade scheme has a different architecture than the one of the EU ETS. The MSR may be introducing volatility rather than removing it.

Annex III Kollenberg and Taschini (2014) model

III.1 Model description – how the model works

Kollenberg and Taschini (2014) model an emissions trading system where compliance entities are small (price takers on the allowance market) and have to comply with the regulation by entirely offsetting their emissions by the end of the compliance period. In particular, firms can abate emissions and trade allowances. Depending on the relative cost difference between abatement and trading, companies adapt their abatement and their trading strategies. The model identifies the equilibrium abatement and trading strategies and determines the equilibrium allowance price dynamics. In particular, the equilibrium allowance price can be decomposed into two terms:

P(t) = Pi(t) – 2rho/(T-t) * X(t),

where X(t) = N(0) + phi(t) – epsilon(t) + A(t).

with Pi(t) representing the marginal abatement cost and rho indicating the slope of the marginal abatement cost curve (more on these two parameters in Table 18 below); N(0) representing surplus level, phi(t) representing cumulated future supply of allowances, epsilon(t) representing cumulated future demand of allowances and A(t) representing the cumulated abatement effort up to (and including) time t. Hence, X(t) captures market expectations about the future cumulated abatement efforts within the foresight, e.g. the difference between expected total cap and expected total emissions.

Put differently, the term X(t) represents the market-wide expectation about the level of market imbalance. The objective of any reform of the EU ETS is to guarantee an orderly functioning of the allowance market. Kollenberg and Taschini (2014) model allows to test different mechanisms (different types of reforms), checking their "correcting" power and assessing how these mechanisms address the excessive market imbalance - the term X(t). As such, the model will not be used to predict allowance prices: the level of modeled prices under each possible reserve mechanism does not represent likely levels of prices in the EU ETS; it is the relative difference in modeled prices and their behaviour in time across scenarios that is insightful.

As described below, the modeling results allow us to evaluate which design would perform better in terms of overall emissions, frequency and use of the reserve, and overall compliance entities welfare.

III.2 Model Assumptions and Properties

The assumptions of the model and its properties are summarised in table

- We consider an atomistic player structure; in particular all players are assumed to be *small* enough to consider themselves price-takers. Each player now minimizes her expected costs (emissions abatement and purchase of allowances constitute costs) while maximizing profits (sales of allowances constitutes profits) under the constraint of offsetting all emissions with an equal number of allowances at their time-horizon.
- At each point in time, all players simultaneously choose a respective number of tonnes of CO_2e to abate and a number of permits to sell or buy, each of those depending on the price of allowances.
- The equilibrium allowance price is determined via market clearing, e.g. all allowances sold at any point in time must be simultaneously bought by other players, and vice-versa.
- This results in a market equilibrium consistent of trading-, abatement strategies and the allowances price, each of these being stochastic processes.

Table 18 Overview of model assumptions and properties.

Property	Attribute
Player structure	Atomistic
Perceived price impact	Price taker
Pricing	Via market clearing
Risk aversion	Risk neutrality
Equilibrium type	Cournot type Nash equilibrium in pure strategies
Equilibrium components	Trading-, abatement strategies and allowances price as stochastic processes.
Secondary market	The model abstracts from the primary market (auctioning) of allowances, i.e. the cumulated future supply of allowances is grandfathered. As such, any potential impact related to auctioning is not included.
Perfect compliance	Compliance entities are required to offset all their emissions; i.e. the penalty for noncompliance is high enough to enforce compliance.
No policy uncertainty	Compliance entities' beliefs about future cumulated emissions levels epsilon(t) and the future cap phi(t) are assumed to be constant. In other words, policy uncertainty is not modelled. The results of the model are valid between times of policy changes.
Hedging	There are no specific assumptions about hedging in the model. While the model does not explicitly call it "hedging", it effectively includes it by construction since all market participants compare their abatement effort to past and future emissions. Therefore, hedging has implicitly been 'reflected' in firms' compliance strategies.
Banking/Borrowing	The model allows for full temporal flexibility, i.e. unlimited banking and borrowing within the postulated foresight.

III.3 Model Inputs

In order to assess the impact of several mechanism designs in different scenarios and with- or without myopia, a variety of input datasets are fed into the model.

The compliance period is set equal for all cases to 2050; the starting date is 2012 in accordance with BAU data provided. We switch between perfect foresight (companies' time horizon is 37 years) and the myopia associated with a rolling time-horizon of 5 years. Firms can bank and borrow within the postulated myopia.

Allocation and emissions data, as well as MAC data for different time-horizons were provided by DECC and sourced from the POLES model. The MAC parameter is estimated based on the latter and the trading parameter is estimated using bid-ask spreads on the carbon market.

Table 19 Overview of model inputs

Input	Description	Unit	Value
Compliance period T	Year at which we assume all companies have to offset their cumulated emissions with allowances	Years	2050
Time horizon	Length of the companies' time horizon in years	Years	5 or 37
Allocations phi(t)	Yearly allocations of allowances in the absence of a mechanism	Tonne of CO_2e	Data provided
Emissions epsilon(t)	Yearly emissions of CO_2e in the BAU scenario in the absence of a carbon price.	Tonne of CO_2e	Data provided
MAC Pi(t)	Marginal abatement costs. These correspond to the fundamental-based allowance price estimates in the DCPM.	£/tonne	Data provided
MAC parameter rho	Yields the amount paid more for each abated tonne depending on the tonnes abated per time unit; i.e. it quantifies the cost of a quicker abatement. We estimated the parameter based on the MACC data provided.	(£/tonne)/(tonne/time unit)	$2857 \cdot 10^{-3}$
Trading parameter nu	Trading cost parameter. For each order, execution costs proportional to the order size are paid. The proportionality is represented by this parameter and is assumed to be equal half of the usual bid-ask spread.	(£/tonne)/(tonne/time unit)	0.1

III.4 Model Outputs

We first identify the time horizon, T, and initialise the MAC parameter, rho, the trading parameter, nu, and the surplus level, N(0). Then, the time resolution is identified (1 month).

We select the DCPM carbon price output and the corresponding BAU and total CAP including international credits. The DCPM carbon price output identifies the marginal abatement cost, Pi(t); CAP and BAU are used to quantify the cumulated future supply of allowances, phi(t) and the cumulated future demand of allowances, epsilon(t), respectively. Later we will perturb epsilon(t), i.e. consider different possible states of the world, and test the sensitivity of the reserve mechanisms under investigation.

Compliance entities are small (price takers) and have to comply with the regulation by offsetting their emissions by the end of the portion of the regulated period that falls within their foresight window. Firms can abate emissions and trade allowances. Depending on the relative cost difference between abatement and trading, compliance entities choose their abatement strategies and their trading strategies. By letting abatement strategies take negative values, we consider a profitable increase in dirty production. We interpret a positive (negative) trading strategy as selling (buying) allowances.

At each evaluation point t, where t goes from t =1 to end of the foresight, we evaluate:

- the cumulative surplus at month t given by

  X(t)=N(0) + phi(t) – epsilon(t) + A(t)

  where A(t) corresponds to the cumulated abatement effort up to (and including) time t and X(t) captures market expectations about the future cumulated abatement efforts, e.g. the difference between expected total cap and expected total emissions. All these quantities represent aggregate terms and not quantities of particular installations.

- the abatement and trading strategies;

- and the allowance price:

  P(t) = Pi(t) – 2rho/(T-t) * X(t).

The equilibrium price obtained by feeding the input data into the model adds to the understanding of the mechanics behind the impact of the different mechanism under investigation and changes in the economic circumstances. Note that due to its nature as an equilibrium price, it is obtained by reconciling all companies' objectives. In particular it takes into account the opportunity to abate emissions rather than keeping emissions at the BAU levels provided.

Table 20 Overview of model outputs. In addition to the equilibrium strategies of abatement, trading, and the equilibrium price process, companies' costs due to the presence of a trading systems are compared through different scenarios, mechanism designs, and with- or without myopia.

Output	Description	Unit
Abatement	For each point in time, the model provides the number of tonnes of CO_2e abated. The abatement behaviour through time has an impact on the total costs faced by all companies and thus on the welfare.	tonne / time unit
Trading	For each point in time, the model provides the total volume of allowances traded. Thereby, the total costs of market activity and its impact on the welfare can be estimated.	tonne / time unit
Allowance Price	The model provides a description of the allowance price behaviour through time.	£/tonne
Costs	The total costs inflicted on companies by the presence of a allowances trading system. These costs lower the effective welfare; their variation along different MSR designs is quantified.	£

III.5 Differences between the DECC carbon price model and Kollenberg and Taschini model

The DECC Carbon Price Model (DCPM) is a fundamentals-based model of the carbon market under the EU ETS. The model is used to estimate carbon prices over a chosen number of years given annual caps on emissions levels and projections for business as usual emissions in all sectors and countries covered by the EU ETS. DCPM matches demand for abatement (abatement effort that needs to be undertaken to meet the cap) to supply of abatement (given by the marginal costs of technologies that need to be deployed to undertake abatement) and provides the EUA price by equalizing supply and demand.

DCPM estimates the annual effort as the difference between Business As Usual (BAU) emissions trajectory and the EU ETS cap less international credits that will be admitted to the system. Cumulative effort will include the surplus of allowances that have built up in the system since 2008. Marginal Abatement Cost Curves (MACCs) that are used for estimation of supply of abatement, describe the cost to abate a certain amount of GHGs by different means, split by sector and country. The cost of carry is then applied to MACCs to reflect the cost of carrying allowances / cost of investment and MACCs are then aggregated over the same time span as the cumulative effort. The EUA price is found as the price level required for delivering the amount of abatement (stipulated by the aggregated MACCs) that matches the total effort.

DCPM relies on the economic argument stating that, in equilibrium, the price for carbon should equal the (long-term) marginal cost of abatement (MAC). The reasoning behind this can be illustrated by considering a company choosing to abate one tonne of CO_2e or purchasing an allowance to emit the same amount of greenhouse gases. If the cost of abating this ton of CO_2e is lower than the current allowance price, then the company should abate rather than purchase an allowance. Conversely, if the marginal abatement cost is higher than the allowance price, then the company should buy an allowance rather than abating. Reconciling companies' specific abatement costs by considering an integrated MAC, one can thus argue that the allowance price should be equal to the integrated MAC provided: A higher allowance demand would lead to a price increase, while a lower allowance demand would entail the opposite. By means of this argument, projections of an integrated MAC for different time-horizons yield a corresponding allowance price projection.

The additional model structure in the Kollenberg and Taschini (KT) complements the DCPM model by extending its results. First note that the above economic argument relies on a frictionless setup where the *pace* of abatement and trading activity does not impact the cost of abatement. In KT model, however, these additional costs are part of the companies' decision problem, represented by the additional parameters ν (for trading) and ρ (for abatement). Assume, for example, that a company decides to abate 100 tonnes of CO_2e. The costs of abating such a quantity then depend on how quickly the company chooses to abate it; i.e. it is more expensive to abate quicker rather than slower. Analogously, trading large quantities of allowances in a short period of time yields much higher trading costs due to a short-term price impact, than splitting a large trade up into several smaller portions, spread across longer a time-window. Furthermore, the notion of an *equilibrium* in KT model is obtained as part of the problem solution:[45] Each company decides not only on its abatement effort for a given time horizon, but rather chooses on *when* to abate what volume of GHGs, as well as *when* to purchase or sell how many allowances. The resulting allowance price reconciles the companies' trading behaviour in every point in time. In particular, market friction and additional costs due to high-paced abatement are part of the equilibrium solution, adding the time dimension.

In a nutshell, KT model provides a powerful extension to DCPM. By deviating from a strict equality between carbon prices and marginal costs, KT obtains results that are possibly different to DCPM results and exhibit an insightful extension of the latter. Overall, the additional structure of KT approach allows for a great deal of flexibility when comparing different mechanisms.

[45] In economic terms, we obtain a Nash equilibrium in pure strategies, consisting of three stochastic processes: trading and abatement processes for every company and an equilibrium price process.

Annex IV Detailed modelling scenario results

This Appendix first describes how we select the model inputs of Kollenberg and Taschini (2014) model. Second, it discusses the target dimensions of the MSR under investigation.
As a sensitivity analysis we choose different shock scenarios and trigger levels under each design option to test the impact of the choices made for the trigger levels and shock levels.[46] The third section of this Appendix describes how we select the shock scenarios. The last section summarise all model runs using a table/graph style report for a given set of selected model inputs, states of the world and trigger levels.

IV.1 Selected model inputs

We first identify the foresight, i.e. the time horizon we want to consider when considering the expected abatement effort (myopia time horizon). Then we initialise the model parameters – for a detailed description of the initialisation of the model inputs we refer to the Annex I. In particular, using the data provided by DECC, we select the surplus level, the future supply of allowances, and the future demand of allowances. The cost abatement parameter and the trading parameter used for the calculation of the abatement and trading strategies are estimated using the MACC-2050[47] and market data, respectively. The model horizon of 2050 was chosen to allow sufficient years to illustrate the response of the MSR in different scenarios. The selected model inputs are the following. The table below summarises the model inputs.

Model input	Description	Value
Compliance period	General model horizon	2050
Time horizon	Length of the limited foresight	5 years
Surplus	Surplus of allowances in 2013	1,791 Mt.
Allocation	Yearly allocations of allowances in the absence of a mechanism It is the CAP allocation program from 2013 to 2050 and includes international credits from 2013 to 2020	Data provided by DECC
Emissions	Yearly emissions of CO_2e in the BAU scenario in the absence of a carbon price. It is the BAU expected emissions from 2013 to 2050	Data provided by DECC

[46] At this stage, we would like to stress that the selection of the trigger levels is part of the sensitivity analysis, e.g. selecting trigger levels is an iterative process. Exact levels do not matter that much; it is the market response relative to different design choices that we are exploring in this study.
[47] In the DCPM the cumulative supply corresponds to aggregated annual MACCs. After the length of foresight has been chosen, the cumulative supply is computed for the years within the foresight only. If foresight window is five years, the total supply is found by aggregating MACCs for those five years only. The cost abatement parameter is assumed to be time-invariant. Hence, we could calibrate it to the 5-year MACCs with a rolling window of 5 years and take the average. We prefer to calibrate the cost abatement parameter to the MACC-2050.

Model input	Description	Value
MAC	Marginal abatement cost within the foresight	Data provided by DECC
Abatement parameter	Yields the amount paid more for each abated tonne depending on the tonnes abated per time unit; i.e. it quantifies the cost of a quicker abatement. We estimated the parameter based on the MACC data provided.	0.0029
Trading parameter	Trading cost parameter. For each order, execution costs proportional to the order size are paid. The proportionality is represented by this parameter and is assumed to be equal half of the usual bid-ask spread.	0.10

IV.2 Target dimensions and corresponding trigger levels

There are a number of options for the design of a supply control mechanism. The report describes three types of MSRs: volume-based mechanisms, price-based mechanisms, and a combination of the two dimensions, henceforth hybrid mechanisms. Under the volume-based mechanisms, the target dimension is the so-called "total number of allowances in circulation" as described below. Using this MSR, the adjustment mechanism would make available or withhold allowances from the auction using as activation trigger a pre-determined level of 'surplus' in the market – quantified using surrendered allowances and emissions data. Instead, the target dimension for price-based mechanisms is the allowance price. Under this MSR, the adjustment of the auction volume is based on a price measure. In particular, the adjustment mechanism would make available or withhold allowances from the auction when a pre-determined price-based criteria is met – a certain price level or a difference in price trends. The report considers also an hybrid mechanism, where withholding of allowances from the auction uses as activation trigger a pre-determined level of 'surplus' in the market and the injection of allowances uses as activation trigger a pre-determined price based criteria.

IV.2.a Volume-based target dimension: Total Number of Allowances in Circulation

- Following the European Commission definition, the total number of allowances in circulation (TNA) at the end of year t is equal to the total number of allowances issued from 2008 to year t plus total number of international credits used form 2008 to year t minus total verified emissions from 2008 to end of year t minus number of allowances in the market stability reserve.
- Our modelling exercise starts in 2013, as such the TNA at the end of year t (where t goes from 2013 until 2050) is equal to
    - Initial surplus of allowances;
    - + past and present number of allocated allowances (e.g. CAP minus adjustment from 2013 to end of year t; hence past and present allocated allowances plus the reserve equals the total number of allowances issued from 2013 to year t);
    - - past and present post-shock BAU;
    - + past and present emission abatement.

Firms can bank and borrow within the postulated foresight. This allows for negative TNA. A negative TNA represents a temporarily non-compliance position. However, the model command perfect offset by the end of the compliance period.

IV.2.b Price-based target dimension: Allowance Price

- The allowance price is the resulting equilibrium price (model output) and will be used as target dimension.

IV.3 Selected state of the world

With the objective to consider different possible states of the world and test the sensitivity of the reserve mechanisms under investigation, we consider both positive and negative shocks, which may represent changes in economic circumstances, technology advancement and implementation of overlapping policies. As such, shocks affect future emissions and thus the future demand for allowances.

Based on the conversations we had with DECC on BAU emissions projections, over the period 2013-2020 there has been an annual reduction of about 10-13% in each year. Therefore, in the modeling exercise we consider two extreme economic or technology scenarios, i.e. two possible scenarios:

- 10% reduction every year for six consecutive years;
- 10% increase every year for six consecutive years.

Scenario	Description
No shock	No variations in the BAU
Negative shock	Economic or technology shock that corresponds to 10% reduction in BAU emissions every year for six consecutive years from 2023 to 2029
Positive shock	Economic or technology shock that corresponds to 10% increase in BAU emissions every year for six consecutive years from 2023 to 2029 or from 2029 to 2035

IV.4 Sensitivity analysis – selecting different trigger levels and shocks

The table below describes the withholding and injection conditions (trigger levels and withholding and injection quantities) of the three types of MSR under investigation: European Commission MSR proposal (EC); hybrid MSR (hybrid mean price, HM, and hybrid price trend, HT) and price-based mechanisms (absolute price, AP, and mean price, MP). The table below offers a summary of the MSR sub-cases listing their trigger levels (upper volume threshold UVT, and lower volume threshold LVT, respectively; and upper price threshold UPT, and lower price threshold LPT, respectively), and withholding and injection quantities (withholding quantity WQ, and injection quantity IQ, respectively).

MSR sub-case	Start year	Shock*	Withholding threshold	Injection threshold	Withdrawal quantity	Injection quantity
EC 1.1 (surplus)	2021	-	833 Mt	400 Mt	12% of surplus	100 Mt
EC 1.2 (surplus)	2021	-10% in 2023–2029	833 Mt	400 Mt	12% of surplus	100 Mt
EC 1.3 (surplus)	2017	-10% in 2023–2029	833 Mt	400 Mt	12% of surplus	100 Mt
EC 1.4 (surplus)	2021	-10% in 2023–2029	1000 Mt	200 Mt	12% of surplus	100 Mt
EC 1.5 (surplus)	2021	-10% in 2023–2029	833 Mt	200 Mt	12% of surplus	100 Mt
EC 1.6 (surplus)	2021	-10% in 2023–2029	Step-wise threshold	Step-wise threshold	12% of surplus	100 Mt
EC 1.7 (surplus)	2021	+10% in 2023–2029	833 Mt	200 Mt	12% of surplus	100 Mt
EC 1.8 (surplus)	2021	+10% in 2023–2029	Step-wise threshold	Step-wise threshold	12% of surplus	100 Mt
Hybrid HM 2.1 (absolute price)	2021	-	833 Mt	60 €/tCO_2 (4.8%/a increase)	12% of surplus	100 Mt
Hybrid HM 2.2 (absolute price)	2021	-10% in 2023–2029	833 Mt	60 €/tCO_2 (4.8%/a increase)	12% of surplus	100 Mt
Hybrid HM 2.3 (absolute price)	2017	-10% in 2023–2029	833 Mt	60 €/tCO_2 (4.8%/a increase)	12% of surplus	100 Mt
Hybrid HM 2.4 (absolute price)	2021	-10% in 2023–2029	833 Mt	15 €/tCO_2 (4.8%/a increase)	12% of surplus	100 Mt
Hybrid HM 2.5 (absolute price)	2021	-	833 Mt	20 €/tCO_2 (no increase)	12% of surplus	100 Mt
Hybrid HM 2.6 (absolute price)	2021	+10% in 2029–2035	833 Mt	20 €/tCO_2 (no increase)	12% of surplus	100 Mt
Hybrid HM 2.7 (absolute price)	2021	+10% in 2029–2035	833 Mt	Step-wise threshold	12% of surplus	100 Mt
AP 3.1 (absolute price)	2021	-	8 €/tCO_2 (4.8%/a increase)	60 €/tCO_2 (4.8%/a increase)	200 Mt	100 Mt
AP 3.2 (absolute price)	2021	-10% in 2023–2029	8 €/tCO_2 (4.8%/a increase)	60 €/tCO_2 (4.8%/a increase)	200 Mt	100 Mt
AP 3.3 (absolute price)	2017	-10% in 2023–2029	8 €/tCO_2 (4.8%/a increase)	60 €/tCO_2 (4.8%/a increase)	200 Mt	100 Mt
AP 3.4 (absolute price)	2021	-10% in 2023–2029	8 €/tCO_2 (4.8%/a increase)	60 €/tCO_2 (4.8%/a increase)	100 Mt	100 Mt
AP 3.5 (absolute price)	2021	-10% in 2023–2029	Step-wise threshold	Step-wise threshold	200 Mt	100 Mt
AP 3.6 (absolute price)	2021	+10% in 2029–2035	8 €/tCO_2 (4.8%/a increase)	60 €/tCO_2 (4.8%/a increase)	200 Mt	100 Mt
MP 4.1 (mean price)	2021	-	8 €/tCO_2 (4.8%/a increase)	60 €/tCO_2 (4.8%/a increase)	200 Mt	100 Mt
MP 4.2 (mean price)	2021	-10% in 2023–2029	8 €/tCO_2 (4.8%/a increase)	60 €/tCO_2 (4.8%/a increase)	200 Mt	100 Mt

* This is a shock to the level of BAU emissions; -10% represents an economic recession and +10% represents an economic boom

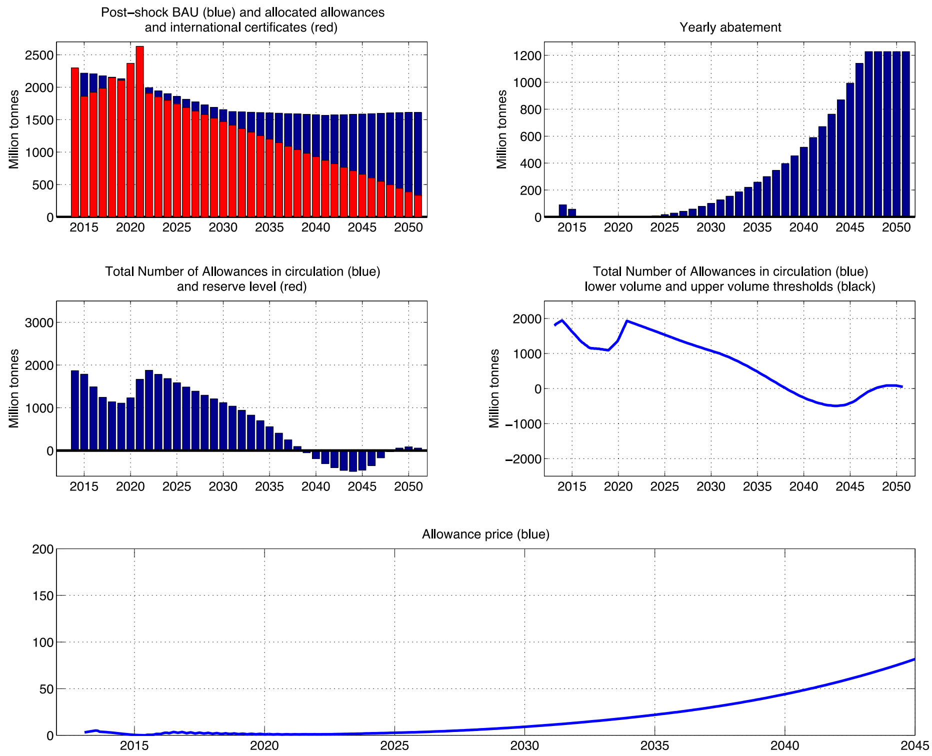
The different parameters have been selected to show the most interesting results using the European Commission's MSR proposal as a starting point. Particularly, the rationale for selecting the trigger thresholds is provided in the table below.

Trigger type	Threshold level	Rationale
Surplus, withholding	833 Mt	EC's MSR proposal
Surplus, withholding	1000 Mt	Increase in threshold level based on the EC's MSR proposal Impact Assessment
Surplus, withholding	833 Mt 2021-2031 633 Mt 2032-2041 500 Mt 2042-2050	Step-wise decrease representing the gradual drop in surplus needed by installations for their abatement strategy, e.g. banking or hedging. Using the EC's MSR proposal threshold as a starting point, decrease by 200 Mt in the first step and levelling at 500 Mt in the second step in ten year intervals.
Surplus, injection	400 Mt	EC's MSR proposal
Surplus, injection	200 Mt	Decrease in threshold level by halving the threshold proposed in the EC's MSR proposal Impact Assessment
Surplus, injection	400 Mt 2021-2031 200 Mt 2032-2041 100 Mt 2042-2050	Step-wise decrease representing the gradual drop in surplus needed by installations for their abatement strategy, e.g. banking or hedging. Using the EC's MSR proposal threshold as a starting point, halving the threshold in each step in ten year intervals.
Price, withholding and injection	4.8%/a increase in price thresholds	Rate of annual increase of selected price thresholds corresponding the annual carbon price increase assumed in the model based risk-adjusted interest derived from EUA futures contract prices
Price, withholding	8 €/tCO_2	Price selected based on the EUA price after the economic crisis in 2008 as a proxy to price at which the MSR should respond to an unexpected shock. This price also roughly corresponds to the carbon price used in the California Cap-and-Trade Program as the auction reserve price.
Price, withholding	8 €/tCO_2 2021-2032 15 €/tCO_2 2033-2050	Step-wise increase instead of an gradual increase of the price threshold. 15 €/tCO_2 has been chosen to trigger additional withholding of allowances in the model.
Price, injection	60 €/tCO_2	Price selected based on an estimate for the marginal abatement costs of CCS, which was suggested by several interviewees as a potential upper threshold.
Price, injection	20 €/tCO_2	Price selected to allow full depletion of the reserve under a price trigger during the modelling horizon. Price threshold remains constant.
Price, injection	15 €/tCO_2	Price selected to allow the injection threshold to be triggered under a price threshold increasing with the annual rate of 4.8%
Price, injection	10 €/tCO_2 2021-2032 20 €/tCO_2 2033-2050	Step-wise increase to prevent the reserve from injecting allowances before the shock, and full depletion of the reserve after the shock. Price threshold remains constant in each respective period.

Below we summarise all model runs using a table/graph style report and a final figure that indicates the total abatement costs for each sub-case. The total abatement costs correspond to the aggregate sum of abatement costs plus purchasing costs, minus selling profits. We refer to this as aggregated compliance costs.

IV.5 Status quo (SQ) – no MSR

IV.5.a No MSR



Aggregated compliance costs = 642,870

IV.6 Design option 1: European Commission design

IV.6.a Mechanism

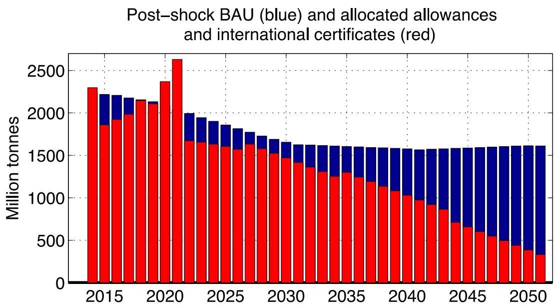
The Commission proposed a volume-based mechanism starting from Phase IV in 2021:

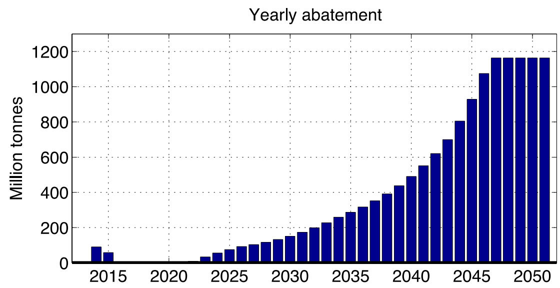
- **Withdrawal** When the total number of allowances in circulation at the end of a given year is above the upper volume threshold (UVT), a percentage of the total number of allowances in circulation will be placed in the reserve (WQ) the following year.
- **Injection** - When the total number of allowances in circulation at the end of a given year is below the lower volume threshold (LVT), a pre-defined volume of allowances is automatically released from the reserve (IQ) the following year.
- **Injection** – When the EU ETS Directive Article 29a applies, a pre-defined volume of allowances of 100 million allowances is automatically released from the reserve (IQ).

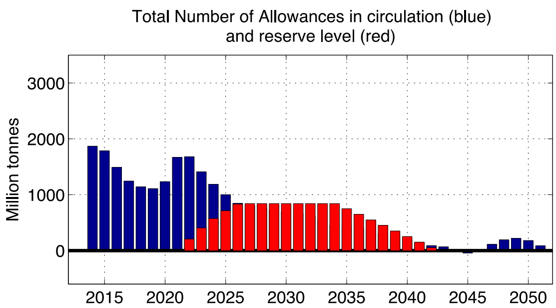
Below we discuss the model results for selected state of the world, selected trigger levels and withholding and injection quantities.

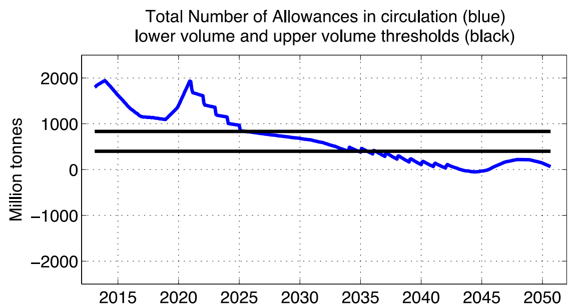
IV.6.b EC sub-case 1.1 – No shock and original thresholds

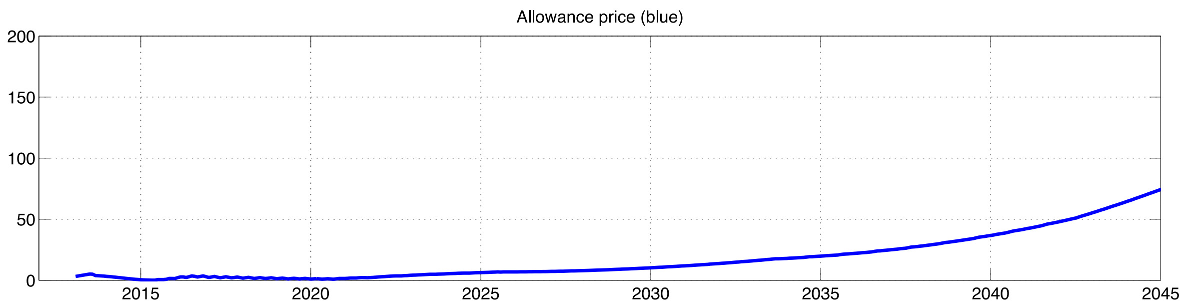
Input	Description	Value
UVT	Upper volume threshold	833 Mt
LVT	Lower volume threshold	400 Mt
WQ	Withholding quantity	12%
IQ	Injection quantity	100 Mt
Initial reserve	Initial level of the reserve	0 Mt
Start	Starting date of the mechanism	2021
Scenario	State of the world – economic or technology shock	None







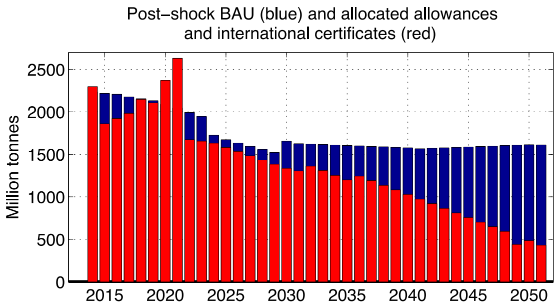


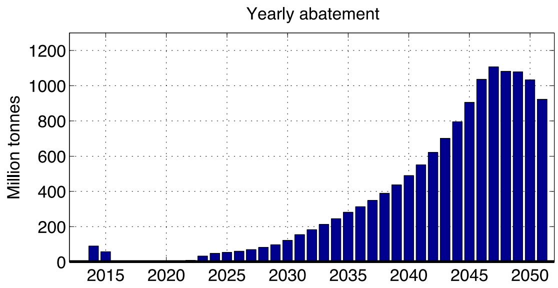


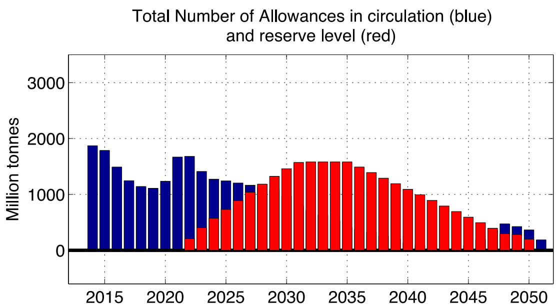
Aggregated compliance costs = 625,080

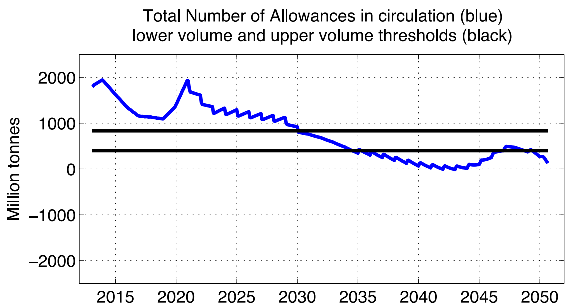
IV.6.c <u>EC sub-case 1.2</u> – Shock in 2023-2029 and original thresholds

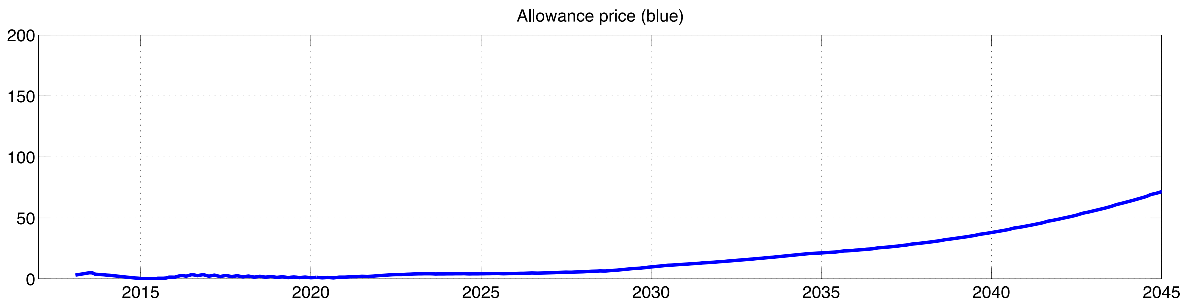
Input	Description	Value
UVT	Upper volume threshold	833 Mt
LVT	Lower volume threshold	400 Mt
WQ	Withholding quantity	12%
IQ	Injection quantity	100 Mt
Initial reserve	Initial level of the reserve	0 Mt
Start	Starting date of the mechanism	2021
Scenario	State of the world – economic or technology shock From 2023 to 2029	-10%







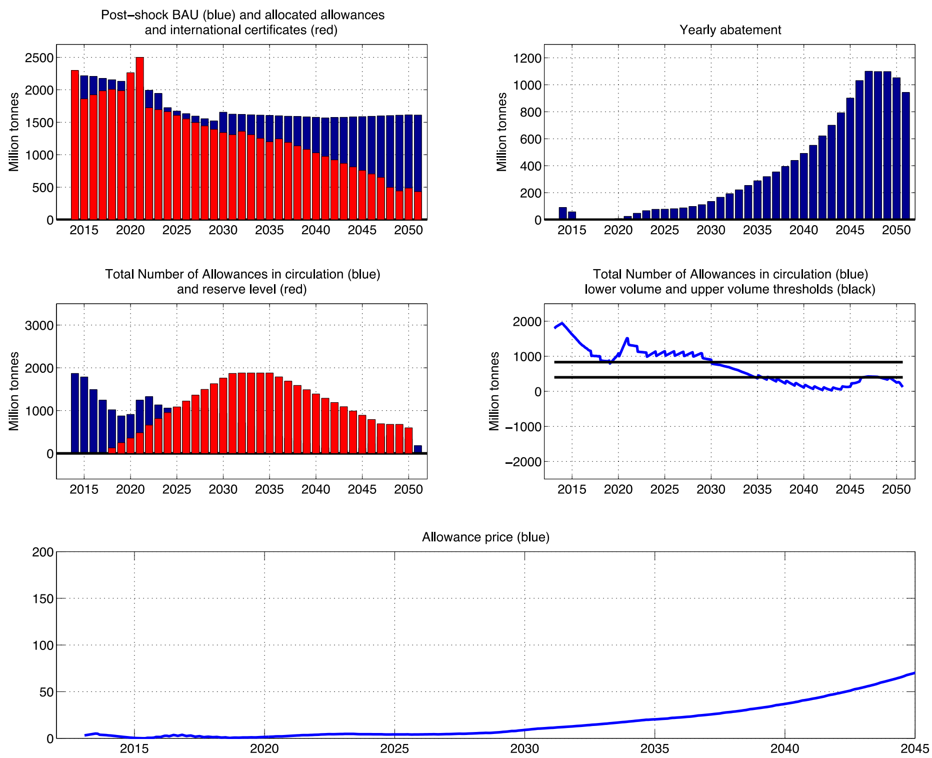




Aggregated compliance costs = 618,480

IV.6.d EC sub-case 1.3 – Shock in 2023-2029 and original thresholds and starting date 2017

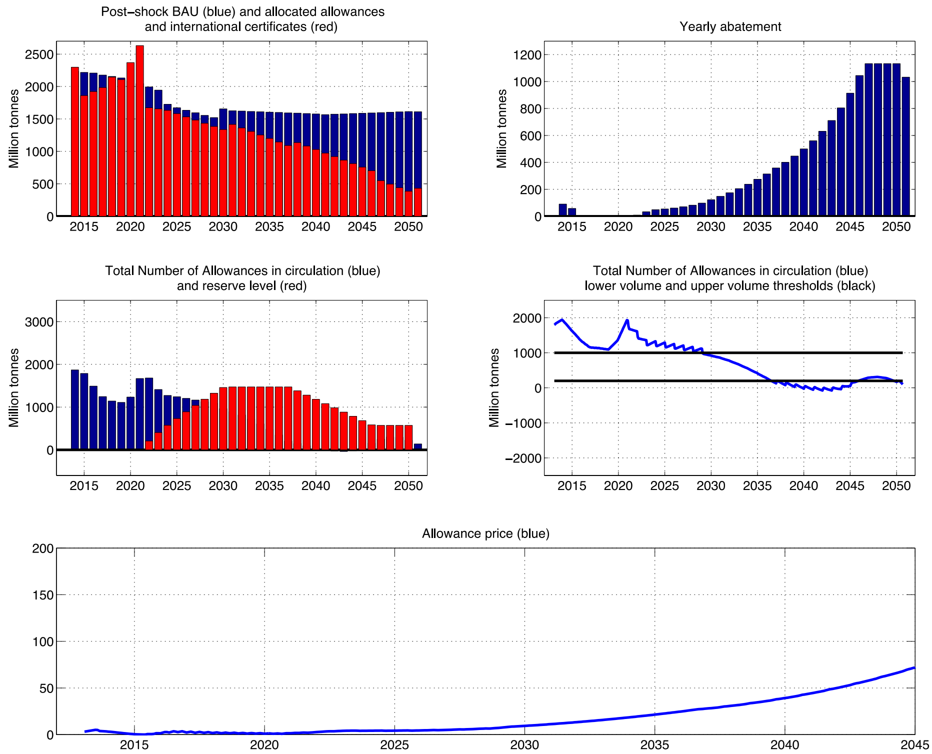
Input	Description	Value
UVT	Upper volume threshold	833 Mt
LVT	Lower volume threshold	400 Mt
WQ	Withholding quantity	12%
IQ	Injection quantity	100 Mt
Initial reserve	Initial level of the reserve	0 Mt
Start	Starting date of the mechanism	2017
Scenario	State of the world – economic or technology shock From 2023 to 2029	-10%



Aggregated compliance costs = 607,650

IV.6.e EC sub-case 1.4 – Shock in 2023-2029 and different UVT and LVT

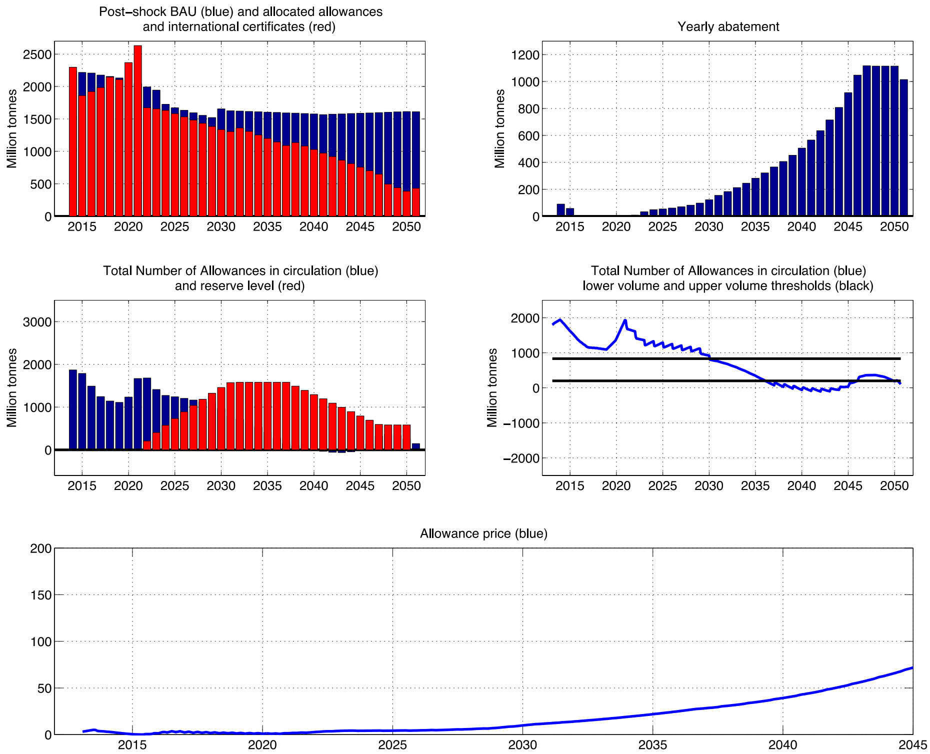
Input	Description	Value
UVT	Upper volume threshold	1,000 Mt
LVT	Lower volume threshold	200 Mt
WQ	Withholding quantity	12%
IQ	Injection quantity	100 Mt
Initial reserve	Initial level of the reserve	0 Mt
Start	Starting date of the mechanism	2021
Scenario	State of the world – economic or technology shock From 2023 to 2029	-10%



Aggregated compliance costs = 623,050

IV.6.f EC sub-case 1.5 – Shock in 2023-2029 and different LVT

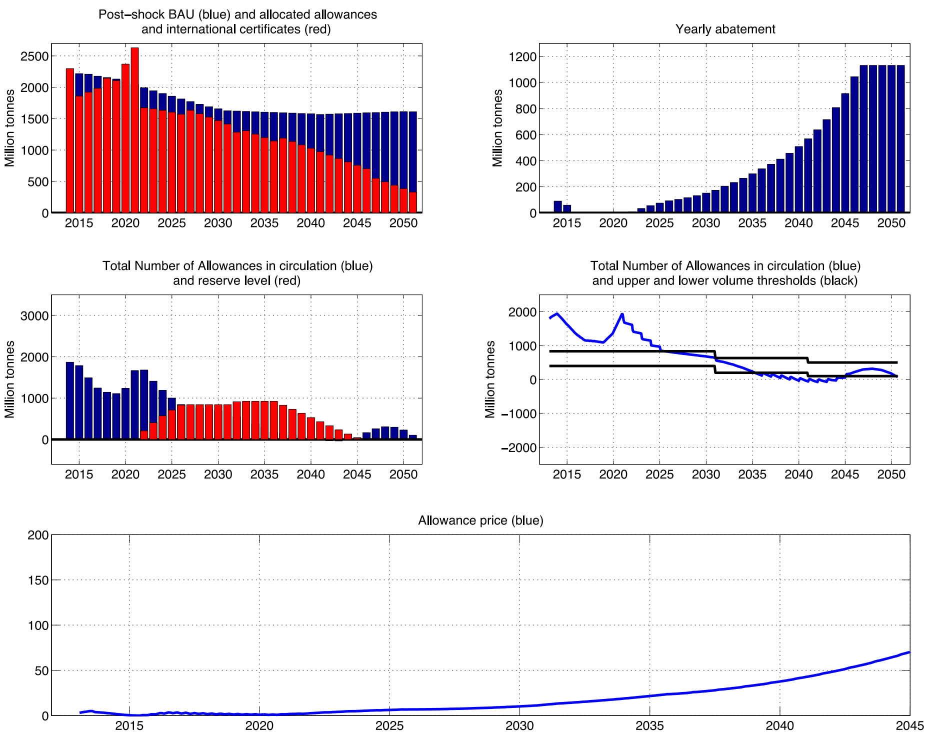
Input	Description	Value
UVT	Upper volume threshold	833 Mt
LVT	Lower volume threshold	200 Mt
WQ	Withholding quantity	12%
IQ	Injection quantity	100 Mt
Initial reserve	Initial level of the reserve	0 Mt
Start	Starting date of the mechanism	2021
Scenario	State of the world – economic or technology shock From 2023 to 2029	-10%



Aggregated compliance costs = 623,500

IV.6.g EC sub-case 1.6 – Shock in 2023-2029 and changing UVT and LVT

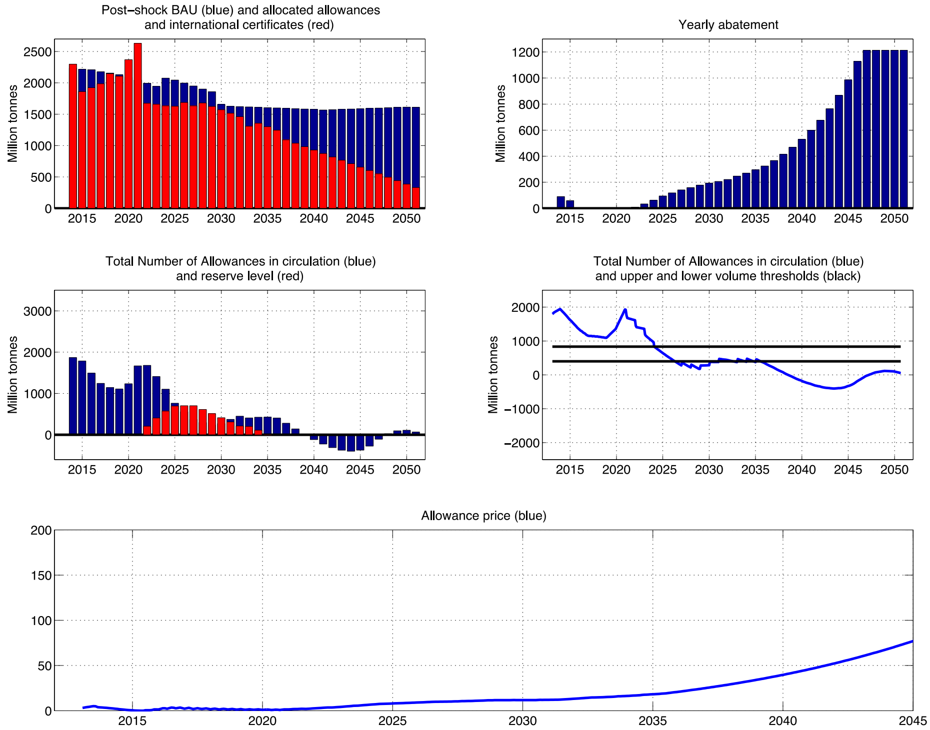
Input	Description	Value
UVT	Upper volume threshold	833 Mt 2021-2031 633 Mt 2032-2041 500 Mt 2042-2050
LVT	Lower volume threshold	400 Mt 2021-2031 200 Mt 2032-2041 100 Mt 2042-2050
WQ	Withholding quantity	12%
IQ	Injection quantity	100 Mt
Initial reserve	Initial level of the reserve	0 Mt
Start	Starting date of the mechanism	2021
Scenario	State of the world – economic or technology shock from 2023 to 2029	-10%



Aggregated compliance costs = 624,750

IV.6.h EC sub-case 1.7 – Shock in 2023-2029 and original thresholds

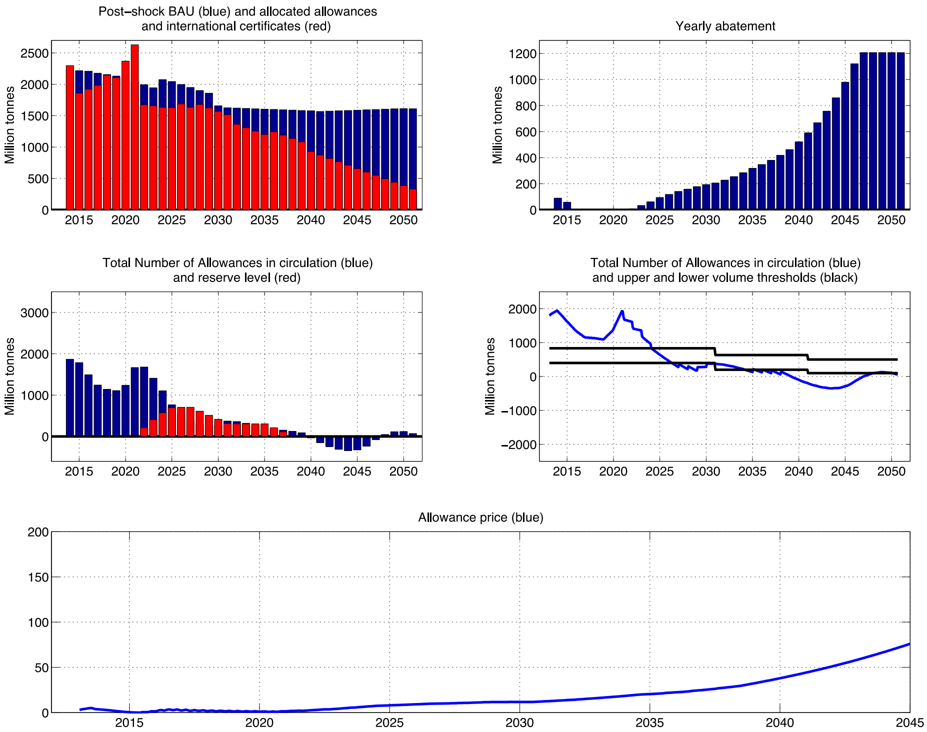
Input	Description	Value
UVT	Upper volume threshold	833 Mt
LVT	Lower volume threshold	400 Mt
WQ	Withholding quantity	12%
IQ	Injection quantity	100 Mt
Initial reserve	Initial level of the reserve	0 Mt
Start	Starting date of the mechanism	2021
Scenario	State of the world – economic or technology shock From 2023 to 2029	+10%



Aggregated compliance costs = 639,660

IV.6.i EC sub-case 1.8 – Shock in 2023-2029 and changing UVT and LVT

Input	Description	Value
UVT	Upper volume threshold	833 Mt 2021-2031 633 Mt 2032-2041 500 Mt 2042-2050
LVT	Lower volume threshold	400 Mt 2021-2031 200 Mt 2032-2041 100 Mt 2042-2050
WQ	Withholding quantity	12%
IQ	Injection quantity	100 Mt
Initial reserve	Initial level of the reserve	0 Mt
Start	Starting date of the mechanism	2021
Scenario	State of the world – economic or technology shock from 2023 to 2029	+10%



Aggregated compliance costs = 638,870

IV.7 Design option 2: Hybrid surplus and absolute price reserve

IV.7.a Mechanism

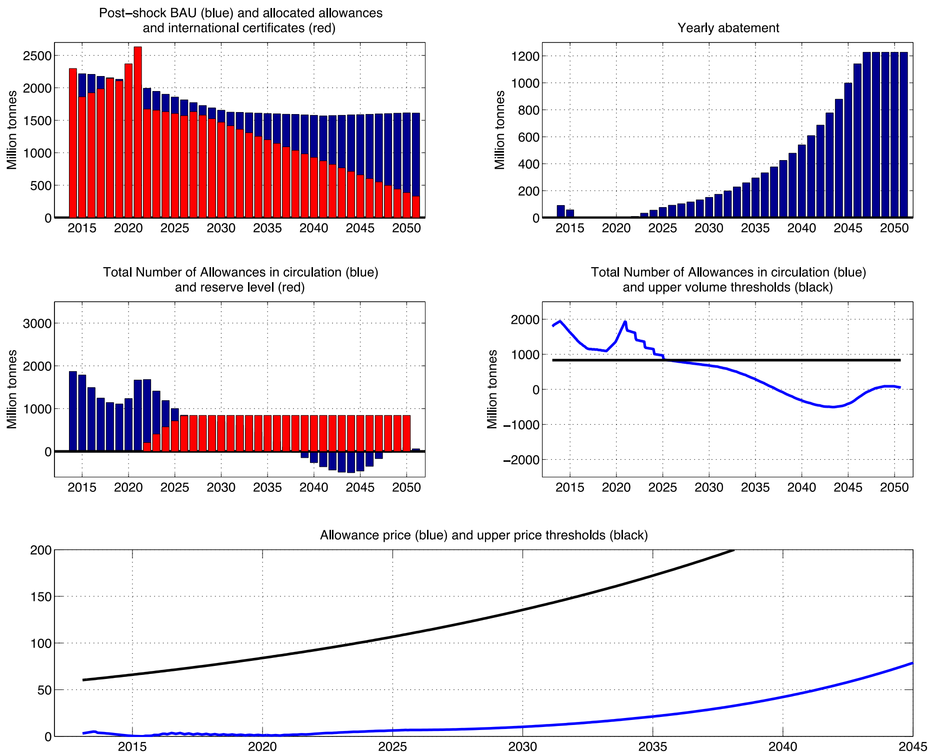
Below we investigate a hybrid volume-based and absolute price mechanism.

Withdrawal When the total number of allowances in circulation at the end of a given year is above 833 million (UVT), a percentage of the total number of allowances in circulation will be placed in the reserve (WQ) the following year.

Injection – When for more than six consecutive months, the average price of allowances is higher than a given price reference (UPT), a pre-defined volume of allowances is automatically released from the reserve (IQ) the following year.

IV.7.b Hybrid (HM) sub-case 2.1 – No shock and starting selected thresholds

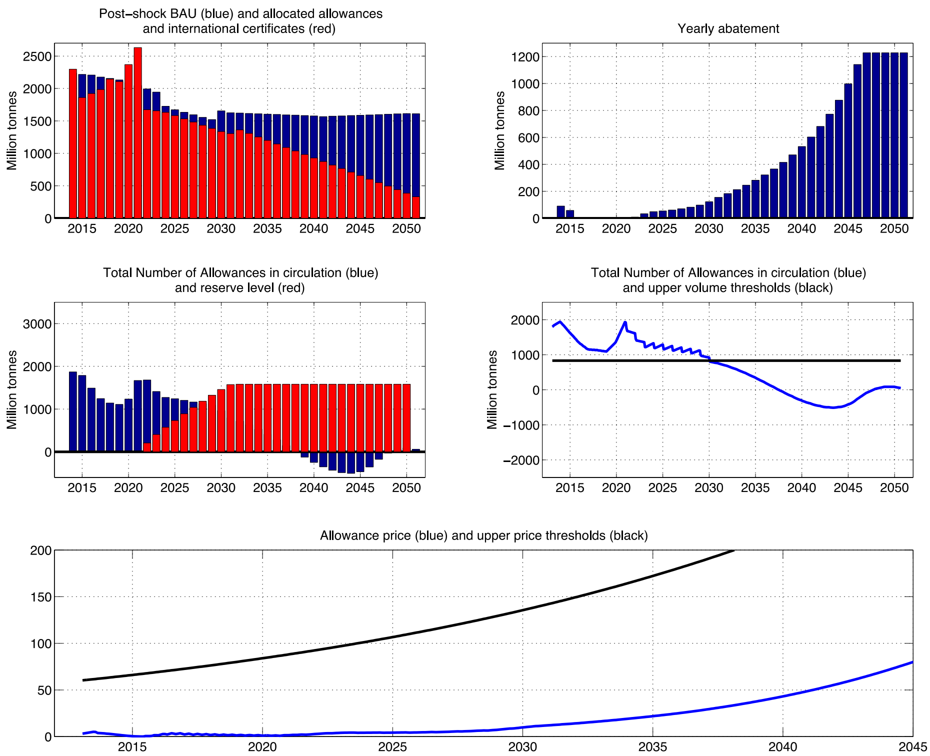
Input	Description	Value
UVT	Upper volume threshold	833 Mt
UPT	Starting upper price threshold - interest rate 4.8%	60 euro
WQ	Withholding quantity	12%
IQ	Injection quantity	100 Mt
Initial reserve	Initial level of the reserve	0 Mt
Start	Starting date of the mechanism	2021
Scenario	State of the world – economic or technology shock From 2023 to 2029	None



Aggregated compliance costs = 641,350

IV.7.c Hybrid (HM) sub-case 2.2 – Shock in 2023-2029 and original thresholds

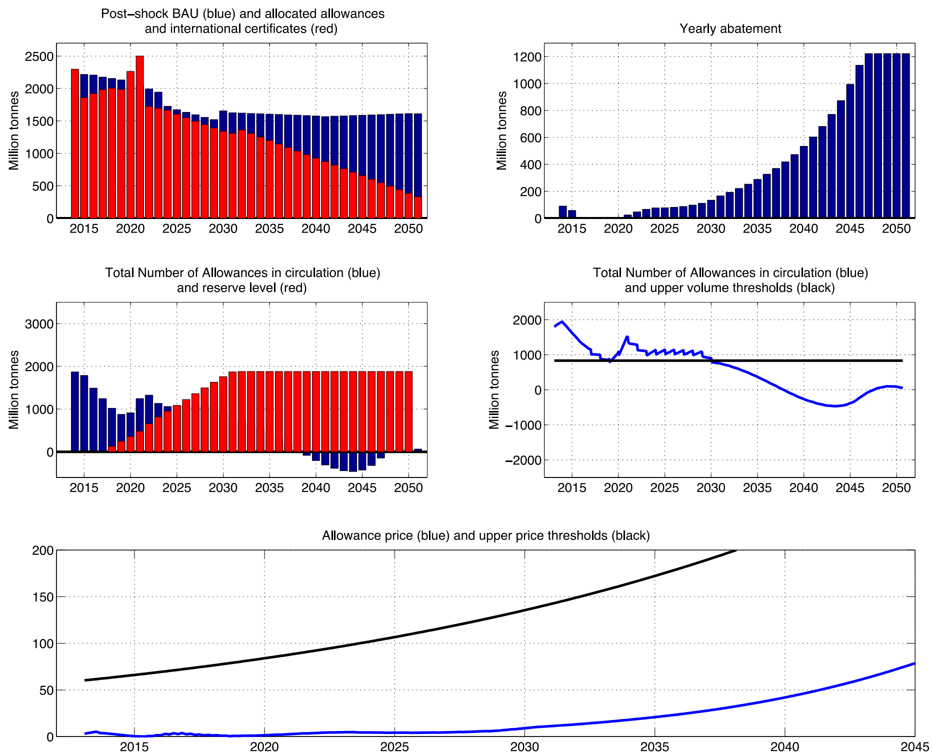
Input	Description	Value
UVT	Upper volume threshold	833 Mt
UPT	Starting upper price threshold - interest rate 4.8%	60 euro
WQ	Withholding quantity	12%
IQ	Injection quantity	100 Mt
Initial reserve	Initial level of the reserve	0 Mt
Start	Starting date of the mechanism	2021
Scenario	State of the world – economic or technology shock From 2023 to 2029	-10%



Aggregated compliance costs = 641,030

IV.7.d <u>Hybrid (HM) sub-case 2.3</u> – Shock in 2023-2029 and original thresholds and starting date 2017

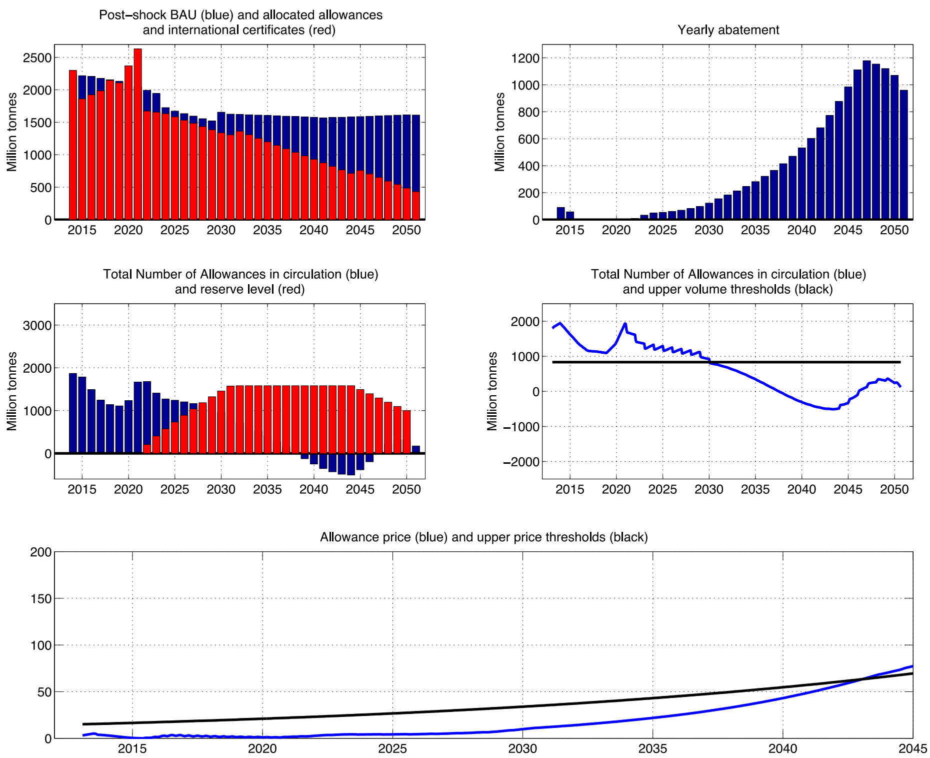
Input	Description	Value
UVT	Upper volume threshold	833 Mt
UPT	Starting upper price threshold - interest rate 4.8%	60 euro
WQ	Withholding quantity	12%
IQ	Injection quantity	100 Mt
Initial reserve	Initial level of the reserve	0 Mt
Start	Starting date of the mechanism	2017
Scenario	State of the world – economic or technology shock From 2023 to 2029	-10%



Aggregated compliance costs = 628,860

IV.7.e <u>Hybrid (HM) sub-case 2.4</u> – Shock in 2023-2029 and different UPT*

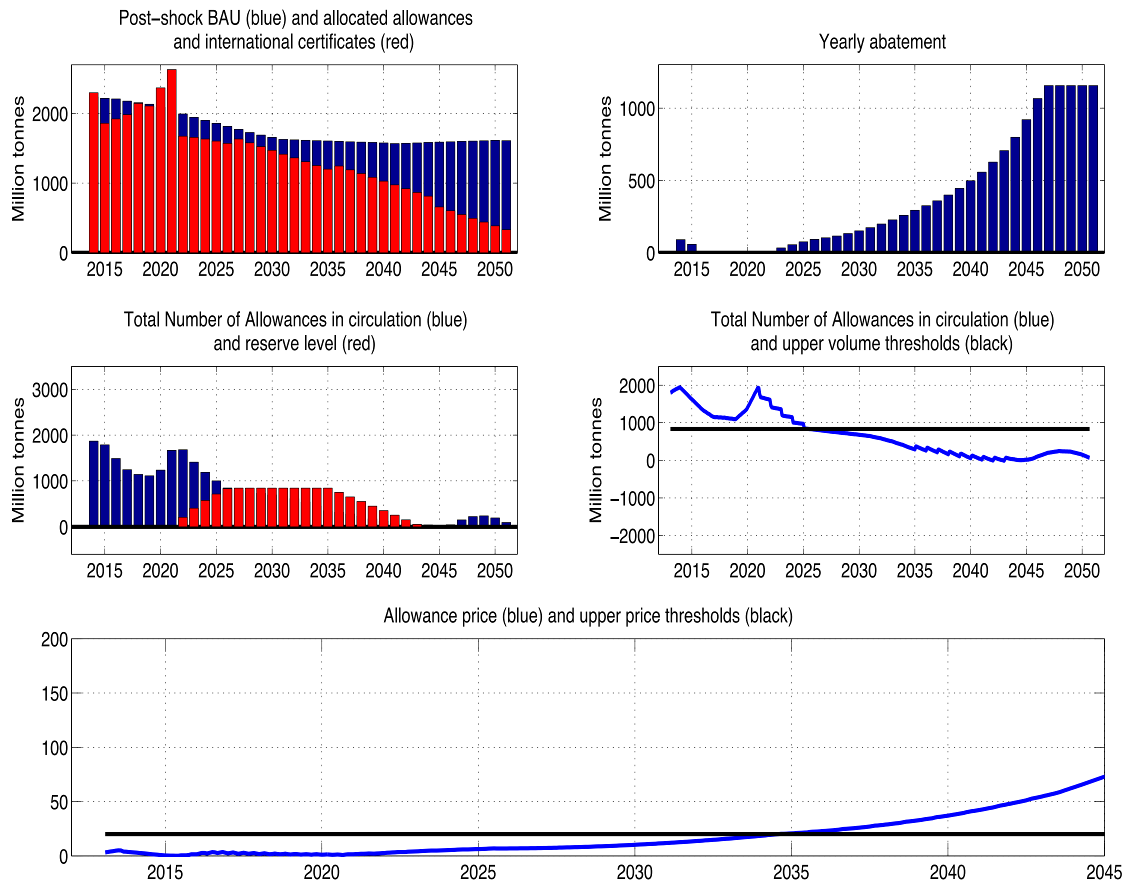
Input	Description	Value
UVT	Upper volume threshold	833 Mt
UPT	Starting upper price threshold - interest rate 4.8%	15 euro
WQ	Withholding quantity	12%
IQ	Injection quantity	100 Mt
Initial reserve	Initial level of the reserve	0 Mt
Start	Starting date of the mechanism	2021
Scenario	State of the world – economic or technology shock From 2023 to 2029	-10%



Aggregated compliance costs = 633,940

IV.7.f Hybrid (HM) sub-case 2.5 – No shock and different UPT

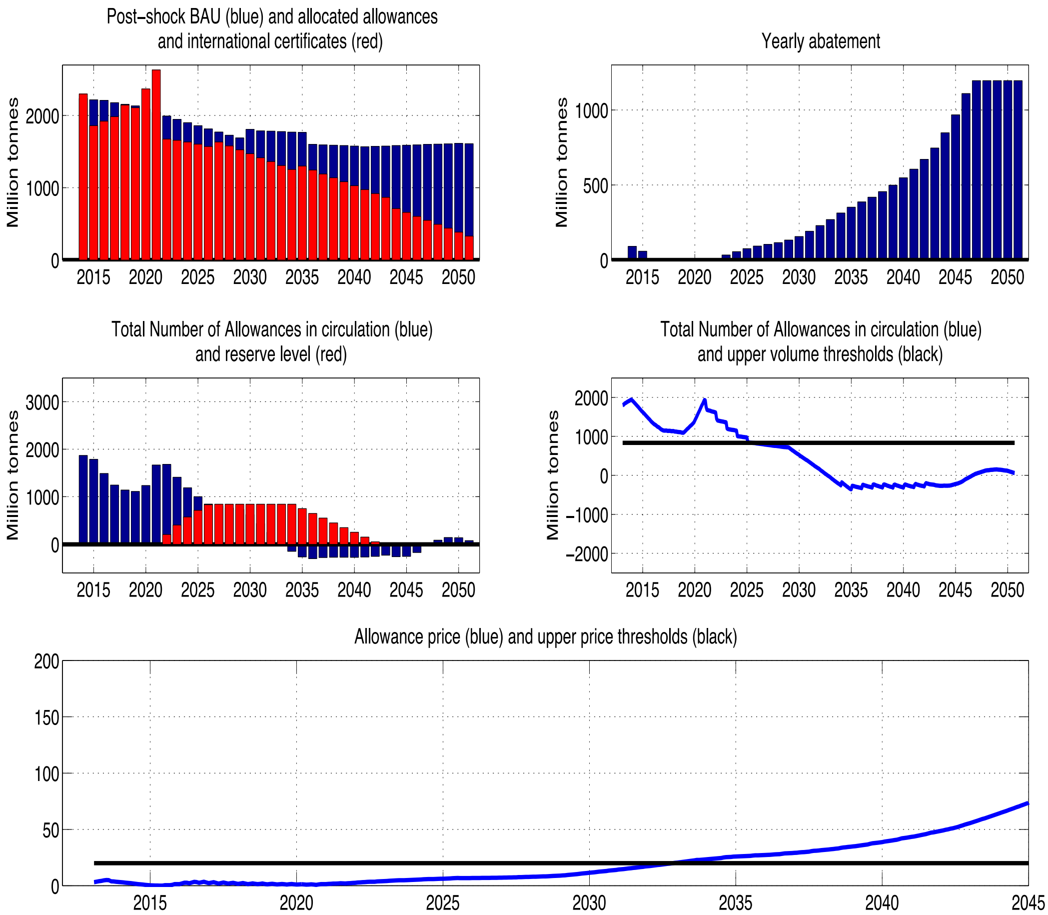
Input	Description	Value
UVT	Upper volume threshold	833 Mt
UPT	Upper price threshold	20 euro
WQ	Withholding quantity	12%
IQ	Injection quantity	100 Mt
Initial reserve	Initial level of the reserve	0 Mt
Start	Starting date of the mechanism	2021
Scenario	State of the world – economic or technology shock	None



Aggregated compliance costs = 625,070

IV.7.g Hybrid (HM) sub-case 2.6 – Shock in 2029-2035 and different UPT

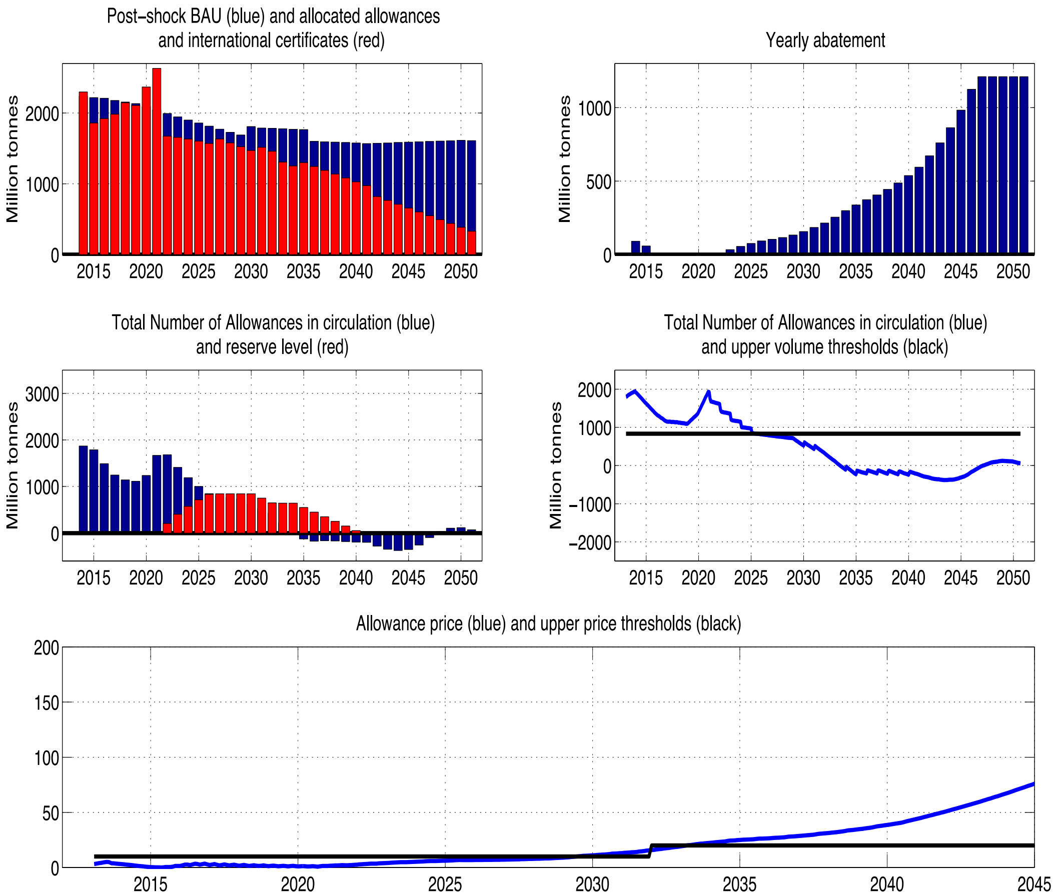
Input	Description	Value
UVT	Upper volume threshold	833 Mt
UPT	Upper price threshold	20 euro
WQ	Withholding quantity	12%
IQ	Injection quantity	100 Mt
Initial reserve	Initial level of the reserve	0 Mt
Start	Starting date of the mechanism	2021
Scenario	State of the world – economic or technology shock	+10%



Aggregated compliance costs = 639,610

IV.7.h <u>Hybrid (HM) sub-case 2.7</u> – Shock in 2029-2035 and different UPT

Input	Description	Value
UVT	Upper volume threshold	833 Mt
UPT	Upper price threshold	10 euro from 2021 to 2032 20 euro from 2033 to 2050
WQ	Withholding quantity	12%
IQ	Injection quantity	100 Mt
Initial reserve	Initial level of the reserve	0 Mt
Start	Starting date of the mechanism	2021
Scenario	State of the world – economic or technology shock	+10%



Aggregated compliance costs = 639,760

IV.8 Design option 3: Price-based reserve

IV.8.a Mechanism

Below we investigate two price-based mechanisms: one where the mechanism is triggered using an absolute price target and one where the mechanism is triggered using a mean price target.

Absolute-price mechanism

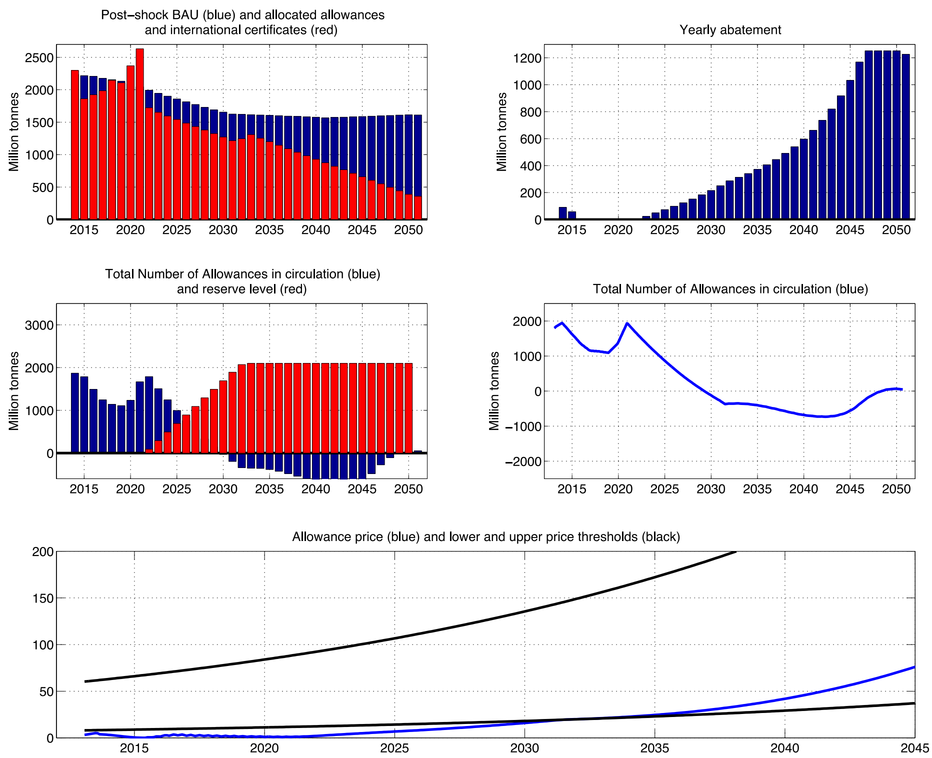
Withdrawal – When for more than six consecutive months, the price of allowances is lower than a given price reference (LPT), a pre-defined volume of allowances is automatically withheld and placed in the reserve (WQ) the following year.

Injection – When for more than six consecutive months, the price of allowances is higher than a given price reference (UPT), a pre-defined volume of allowances is automatically released from the reserve (IQ) the following year.

Below we discuss the model results for selected state of the world, selected trigger levels and withholding and injection quantities.

IV.8.b Price-based (AP) sub-case 3.1 – No shock and starting selected thresholds

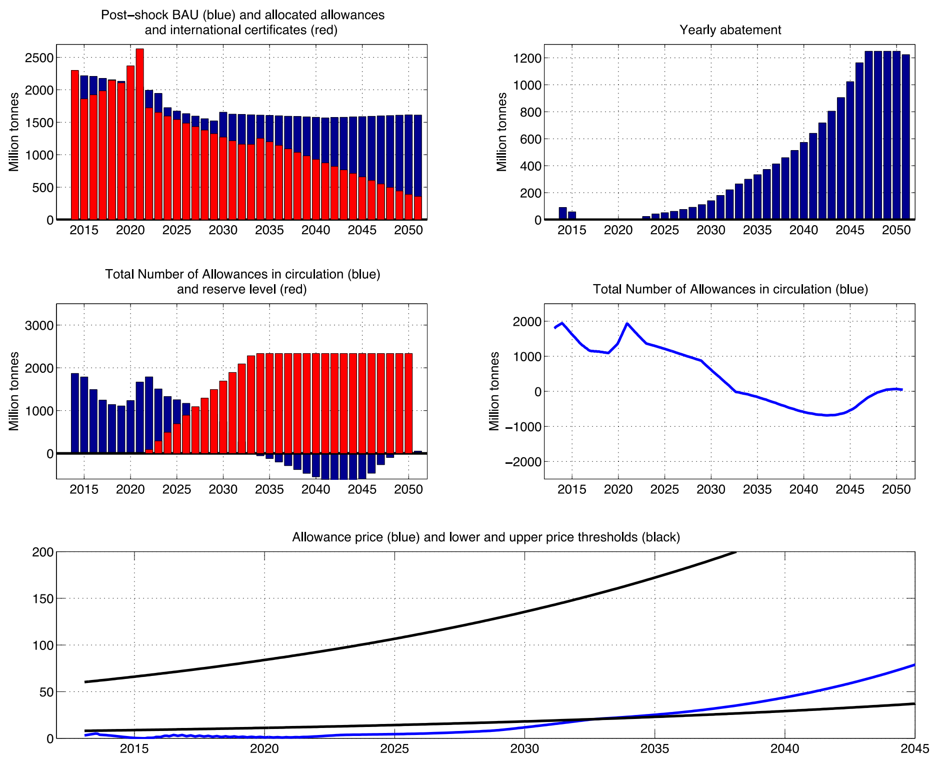
Input	Description	Value
LPT	Starting lower price threshold – 4.8% annual increase	8 euro
UPT	Starting upper price threshold – 4.8% annual increase	60 euro
WQ	Withholding quantity	200 Mt
IQ	Injection quantity	100 Mt
Initial reserve	Initial level of the reserve	0 Mt
Start	Starting date of the mechanism	2021
Scenario	State of the world – economic or technology shock From 2023 to 2029	None



Aggregated compliance costs = 661,380

IV.8.c Price-based (AP) sub-case 3.2 – Shock in 2023-2029 and original thresholds

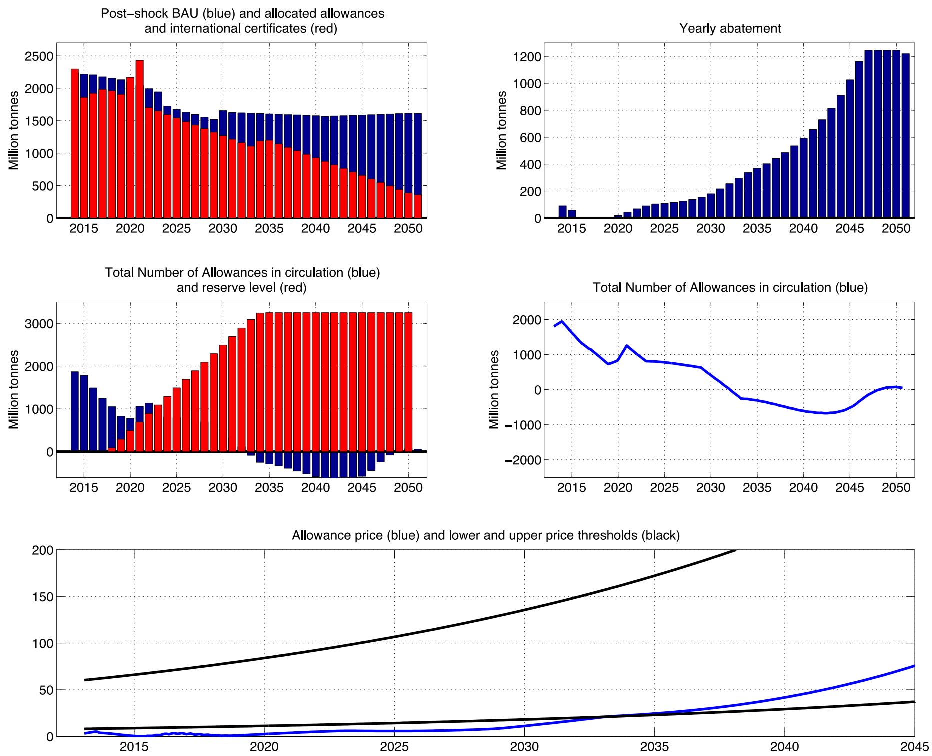
Input	Description	Value
LPT	Starting lower price threshold –4.8% annual increase	8 euro
UPT	Starting upper price threshold –4.8% annual increase	60 euro
WQ	Withholding quantity	200 Mt
IQ	Injection quantity	100 Mt
Initial reserve	Initial level of the reserve	0 Mt
Start	Starting date of the mechanism	2021
Scenario	State of the world – economic or technology shock From 2023 to 2029	-10%



Aggregated compliance costs = 653,790

IV.8.d Price-based (AP) sub-case 3.3 – Shock in 2023-2029 and original thresholds and starting date 2017

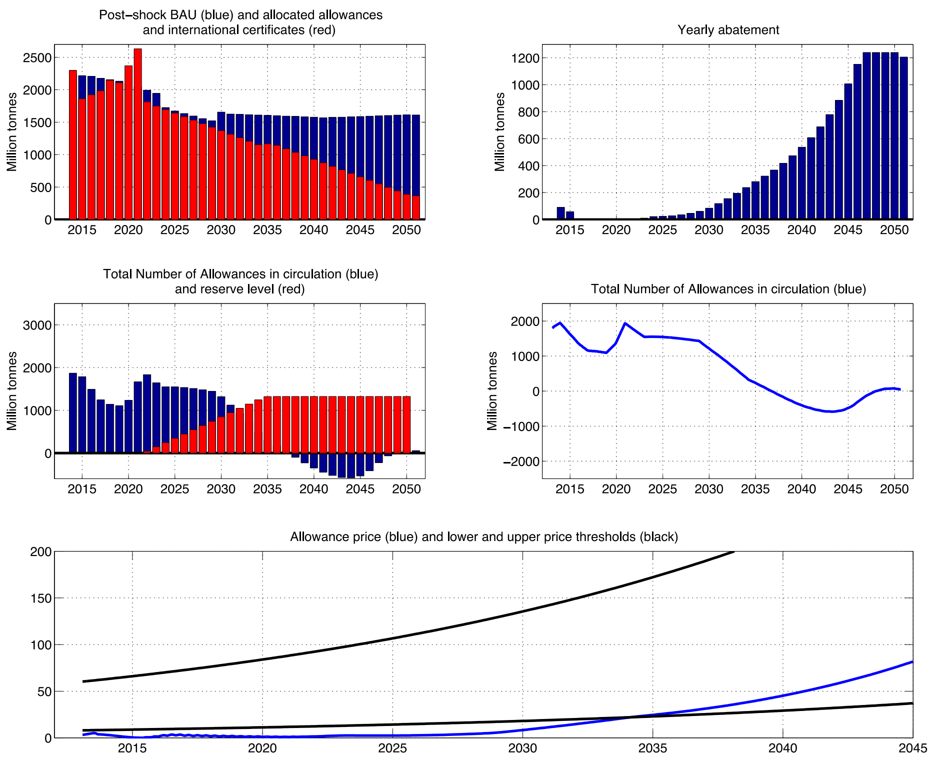
Input	Description	Value
LPT	Starting lower price threshold –4.8% annual increase	8 euro
UPT	Starting upper price threshold –4.8% annual increase	60 euro
WQ	Withholding quantity	200 Mt
IQ	Injection quantity	100 Mt
Initial reserve	Initial level of the reserve	0 Mt
Start	Starting date of the mechanism	2017
Scenario	State of the world – economic or technology shock From 2023 to 2029	-10%



Aggregated compliance costs = 640,920

IV.8.e <u>Price-based (AP) sub-case 3.4</u> – Shock in 2023-2029 and different WQ and IQ

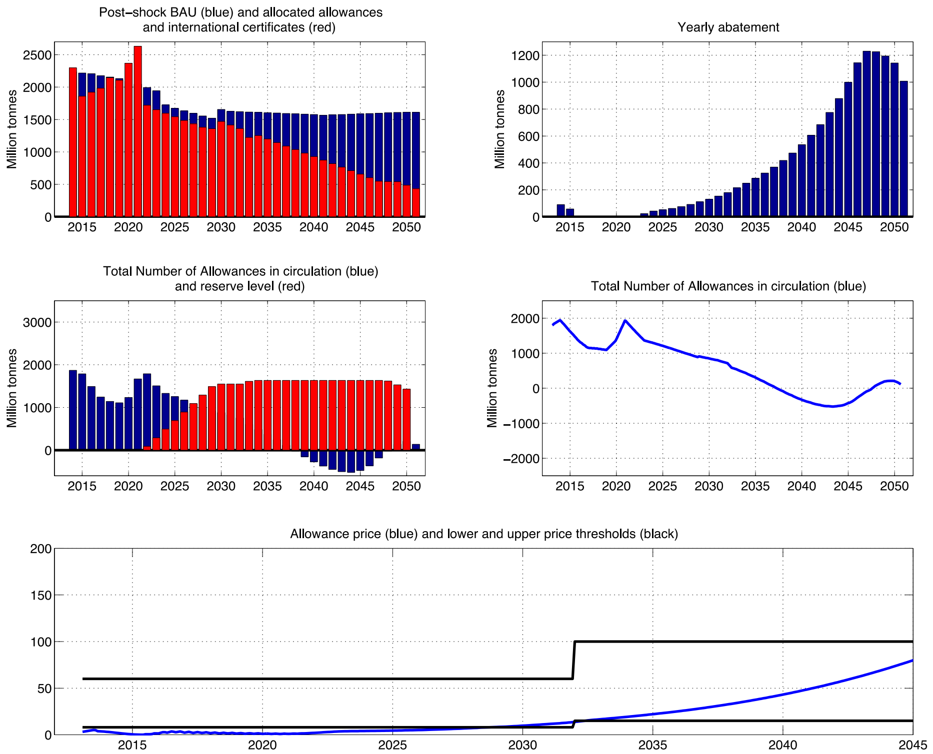
Input	Description	Value
LPT	Starting lower price threshold –4.8% annual increase	8 euro
UPT	Starting upper price threshold –4.8% annual increase	60 euro
WQ	Withholding quantity	100 Mt
IQ	Injection quantity	100 Mt
Initial reserve	Initial level of the reserve	0 Mt
Start	Starting date of the mechanism	2021
Scenario	State of the world – economic or technology shock From 2023 to 2029	-10%



Aggregated compliance costs = 647,780

IV.8.fPrice-based (AP) sub-case 3.5 – Shock in 2023-2029 and different LPT and UPT*

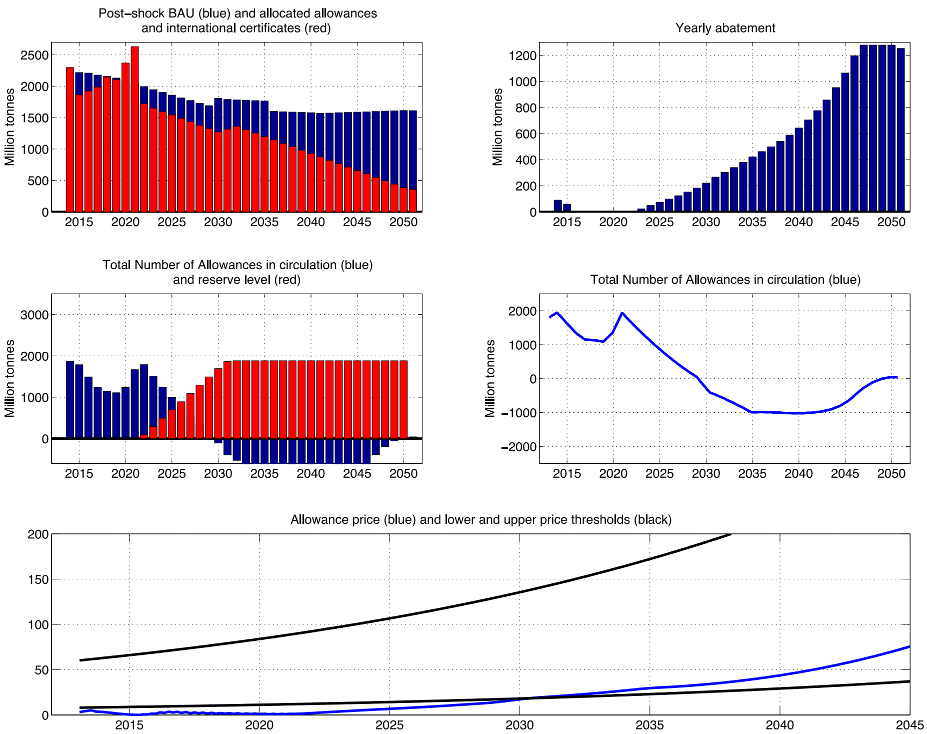
Input	Description	Value
LPT	Starting lower price threshold	8 euro 2021-2032 15 euro 2033-2050
UPT	Starting upper price threshold	60 euro 2021-2032 100 euro 2033-2050
WQ	Withholding quantity	200 Mt
IQ	Injection quantity	100 Mt
Initial reserve	Initial level of the reserve	0 Mt
Start	Starting date of the mechanism	2021
Scenario	State of the world – economic or technology shock from 2023 to 2029	-10%



Aggregated compliance costs = 640,010

IV.8.g <u>Price-based (AP) sub-case 3.6</u> – Shock in 2029-2035 and original thresholds

Input	Description	Value
LPT	Starting lower price threshold –4.8% annual increase	8 euro
UPT	Starting upper price threshold –4.8% annual increase	60 euro
WQ	Withholding quantity	200 Mt
IQ	Injection quantity	100 Mt
Initial reserve	Initial level of the reserve	0 Mt
Start	Starting date of the mechanism	2021
Scenario	State of the world – economic or technology shock From 2023 to 2029	+10%



Aggregated compliance costs = 674,990

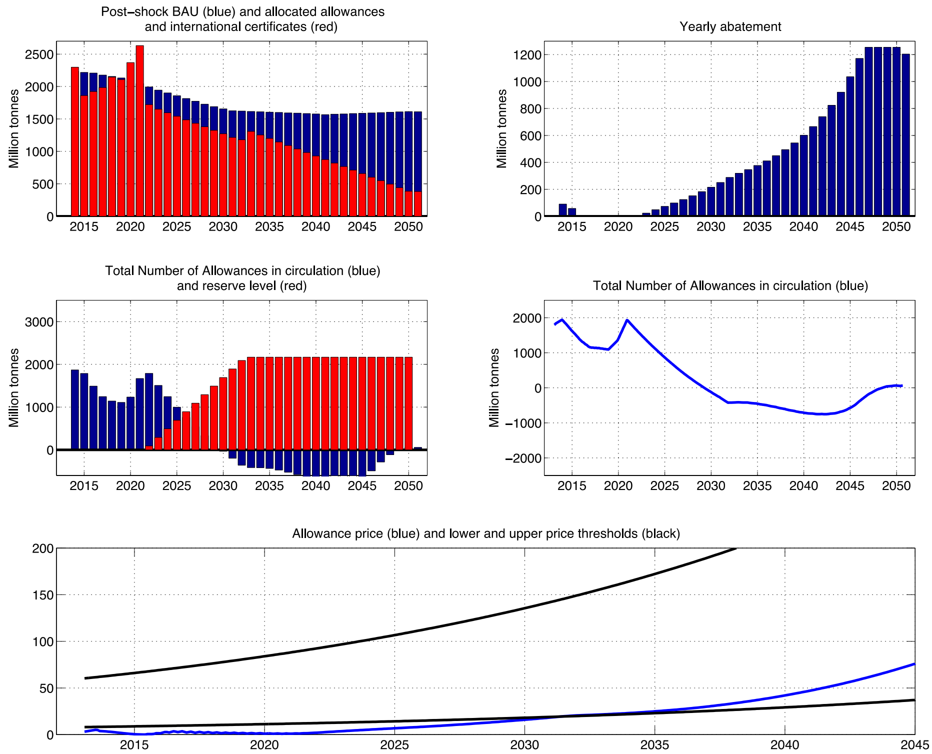
Mean-price mechanism

Withdrawal – When for more than six consecutive months, the average price of allowances is lower than a given price reference (LPT), a pre-defined volume of allowances is automatically withhold and placed in the reserve (WQ) the following year.

Injection – When for more than six consecutive months, the average price of allowances is higher than a given price reference (UPT), a pre-defined volume of allowances is automatically released from the reserve (IQ) the following year.

IV.8.h <u>Mean price (MP) sub-case 4.1</u> – No shock and starting selected thresholds

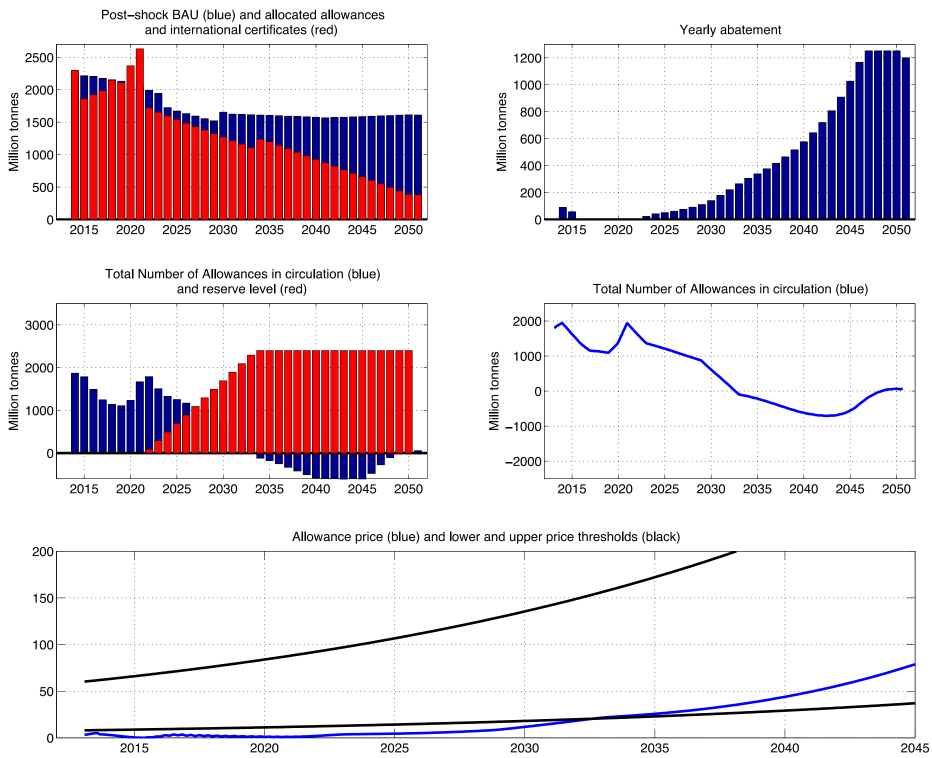
Input	Description	Value
LPT	Starting lower price threshold –4.8% annual increase	8 euro
UPT	Starting upper price threshold –4.8% annual increase	60 euro
WQ	Withholding quantity	200 Mt
IQ	Injection quantity	100 Mt
Initial reserve	Initial level of the reserve	0 Mt
Start	Starting date of the mechanism	2021
Scenario	State of the world – economic or technology shock From 2023 to 2029	None



Aggregated compliance costs = 662,570

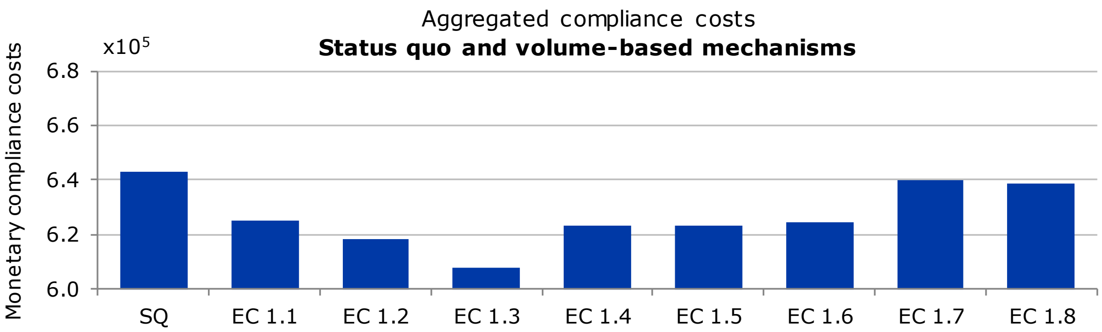
IV.8.i <u>Mean price (MP) sub-case 4.2</u> – Shock in 2023-2029 and original thresholds

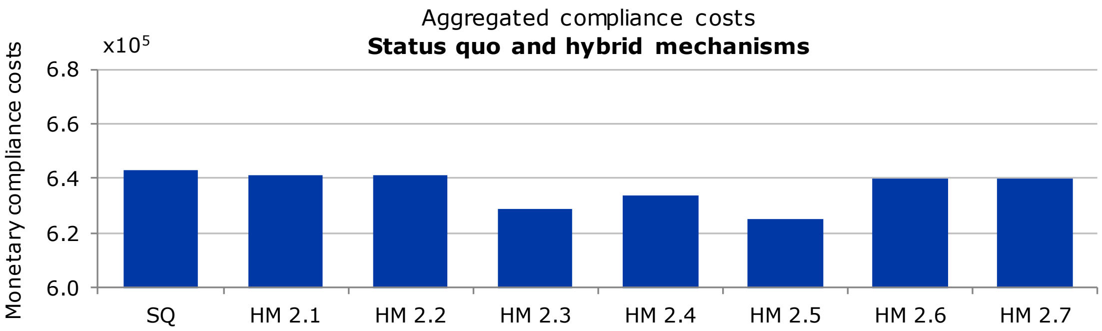
Input	Description	Value
LPT	Starting lower price threshold –4.8% annual increase	8 euro
UPT	Starting upper price threshold –4.8% annual increase	60 euro
WQ	Withholding quantity	200 Mt
IQ	Injection quantity	100 Mt
Initial reserve	Initial level of the reserve	0 Mt
Start	Starting date of the mechanism	2021
Scenario	State of the world – economic or technology shock From 2023 to 2029	-10%

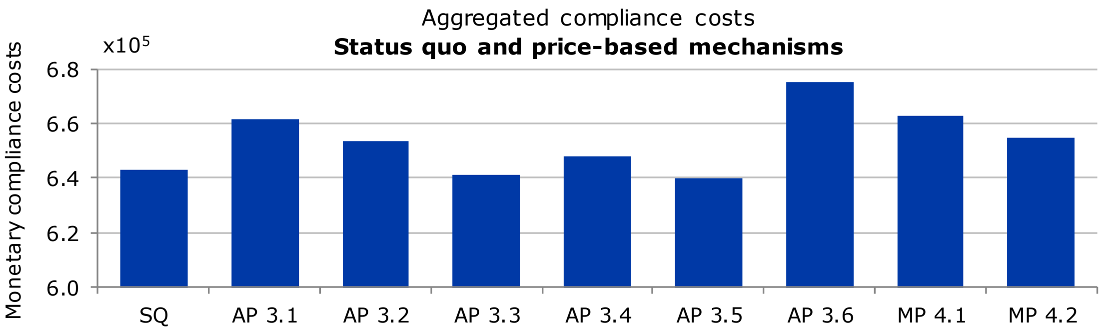


Aggregated compliance costs = 655,000

IV.9 Ranking the mechanisms using the aggregate compliance costs



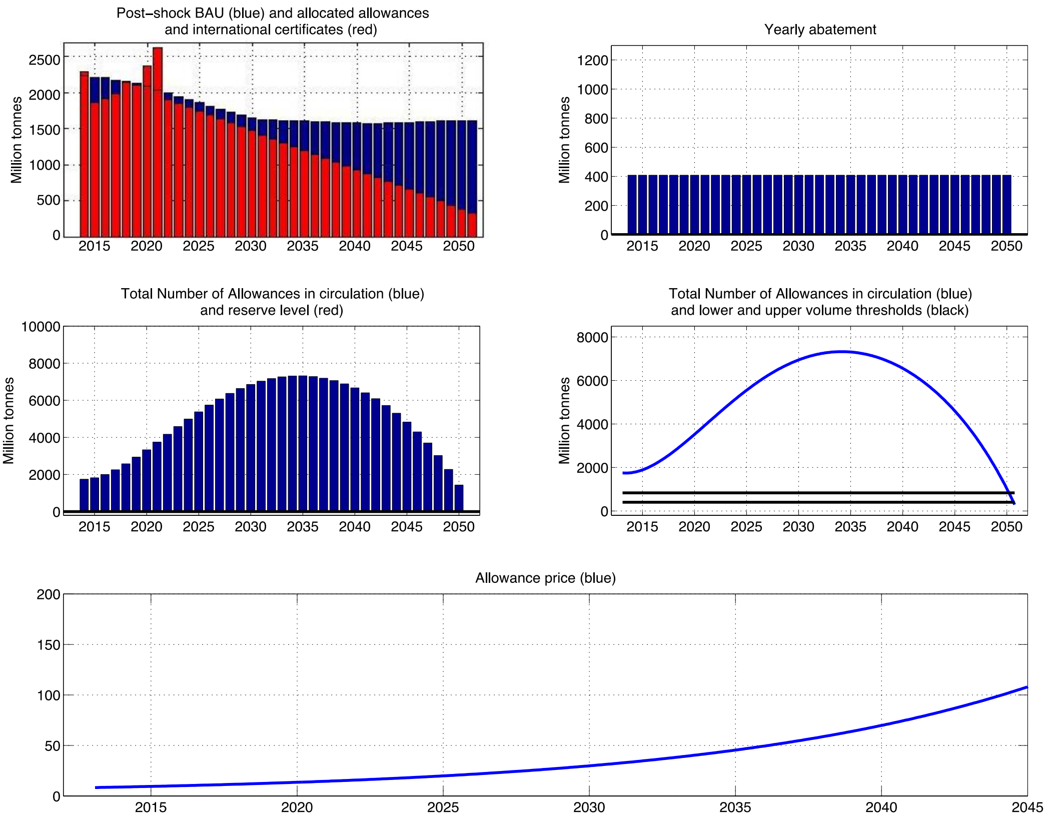




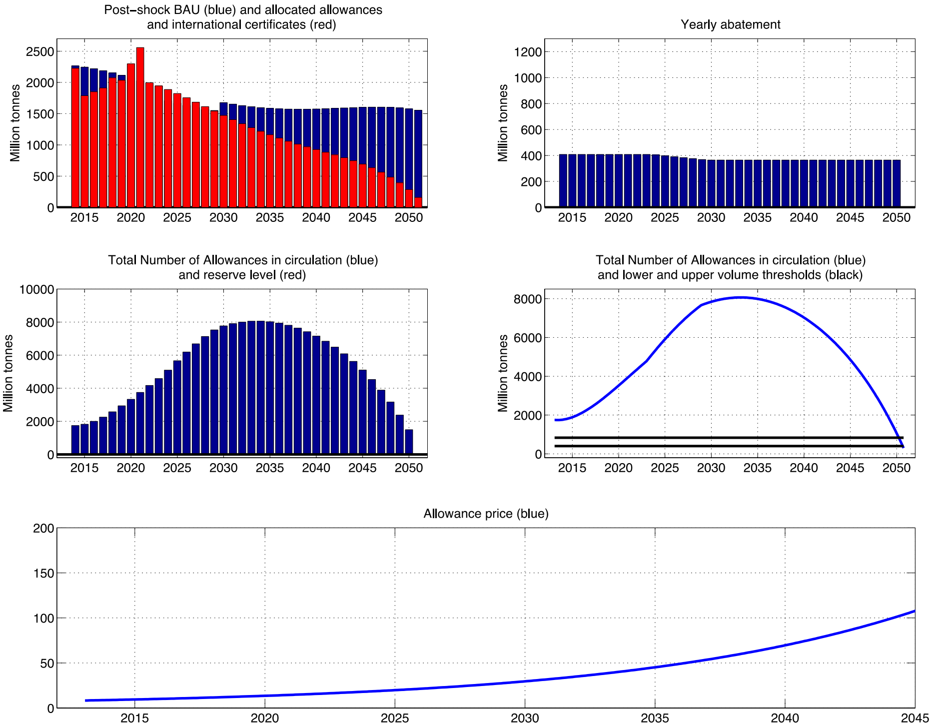
IV.10 Perfect foresight case

Below we assume perfect foresight and consider the case without MSR and with MSR as proposed by the European Commission

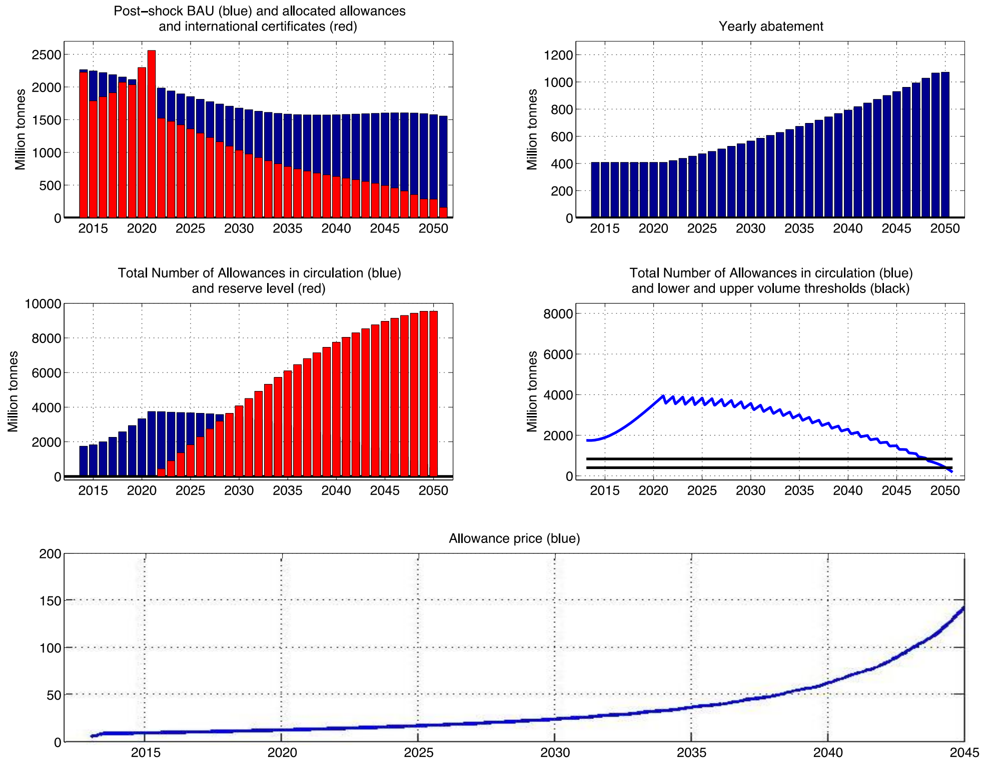
IV.10.a No MSR without shock



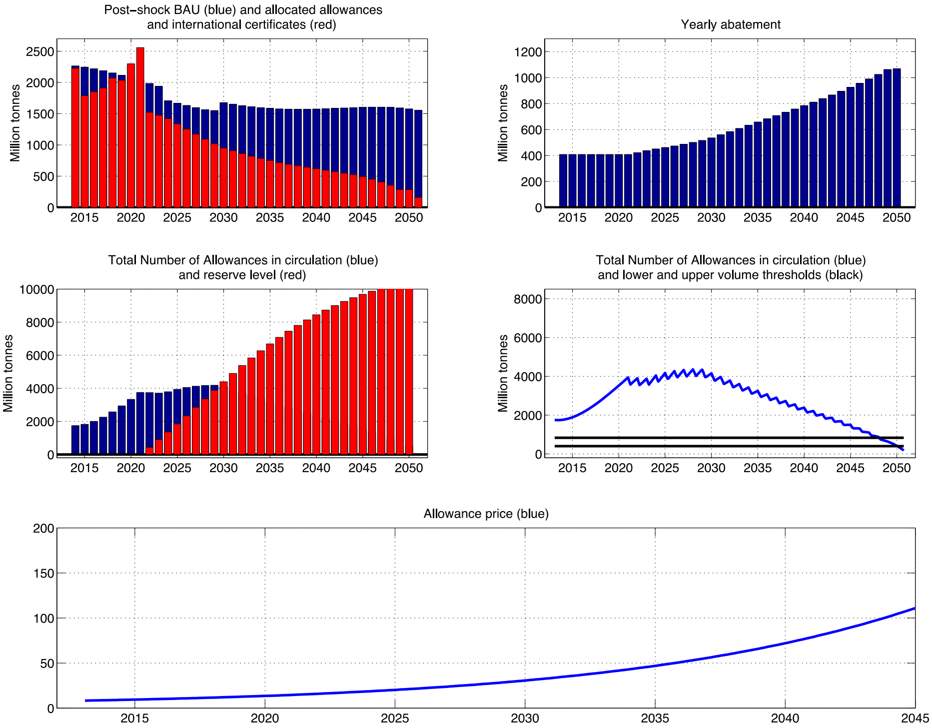
IV.10.b No MSR with shock



IV.10.c EC MSR without shock



IV.10.d EC MSR with negative shock – 10% decrease in BAU from 2023 to 2029



Annex V Quality assurance

A quality assurance process was put in place to ensure the results in this study were robust and evidence-based. The quality assurance process consists of an overall quality assurance applied to each part of the report and quality assurance processes specifically for the literature review, stakeholder interviews and economic modelling. The overall quality assurance covers:

- DECC steering group meetings with the project team at the start of the project, after the interim report and at submission of the final draft to ensure the right direction of the project
- Regular internal brainstorm session were held within the project team in person and in a telephone conference
- Weekly project management calls were held by the project manager with the project manager at DECC on the progress of the project
- The study and related documents is subject to a four-eyes principle: all documents sent have been checked by at least two project team members
- The final report has been subject to an internal proofreading process to ensure consistency and quality throughout the report
- Several iterations with the DECC steering group was held on interim and final report to ensure the correctness and appropriateness of the contents before publication

Quality assurance – Literature review

The following measures have been taken to ensure the literature review meets a high quality standard and identify the relevant literature:

- Ecofys, Luca Taschini and Sascha Kollenberg have investigated supply flexibility in emissions trading systems in their previous work and are well aware of the of available literature
- The literature list has been provided to DECC and DECC has supplied additional suggestions for literature relevant to this study
- A brainstorm session was held together with the DECC steering group after the initial literature review to show the gaps found in literature on the topics relevant to this project, which are addressed through the stakeholder and expert interviews
- The results of the literature review have been independently checked by Ecofys and Luca Taschini
- Throughout the project additional literature sources relevant to this study was added

Quality assurance – Stakeholder and expert interviews

The following measures have been taken to ensure the stakeholder and expert interviews meet a high quality standard and were as effective as possible:

- Prior to the interviews, a brainstorm session with DECC to align the topics to ask was held. Specific questions covering the gaps found in the literature identified
- Prior to the interviews, a list of questions was sent to the interviewees to allow them to think about the questions in advance and to steer the discussion
- After the interviews a summary was sent to the interviewees to check if no important issues were missing in the summary and that they were comfortable with publication of the summary given the sensitivity of some questions

Quality assurance – Economic modelling

The following measures have been taken to ensure the economic modelling meet a high quality standard and produces meaningful results for this study:

- The model has been peer-reviewed internally within the modelling team and relevant experts of the London School of Economics and externally
- Prior to the start of the modelling, the approach has been discussed in two modelling sessions with carbon price modelling experts in DECC. The meetings also included a project member of Ecofys to ensure the modelling assumptions are aligned with the rest of the report
- Prior to the start of the modelling, the project team has discussed the assumptions for the model and notes on model circulated within the DECC steering group, followed by several iterations with DECC and the project team
- Every result that is produced by the model is independently checked by Luca Taschini and Sascha Kollenberg
- The modelling results have been sense checked by Ecofys in discussion with Luca Taschini during the incorporation of the results in the report

ECOFYS

sustainable energy for everyone

ECOFYS UK Ltd. | 1 Alie Street | London E1 8DE | **T** +44 (0)20 74230-970 | **F** +44 (0)20 74230-971 | **E** info@ecofys.com | **I** www.ecofys.com

ECOFYS

sustainable energy for everyone

ECOFYS UK Ltd.

1 Alie Street
London E1 8DE

T: +44 (0) 20 74230-970
F: +44 (0) 20 74230-971

E: info@ecofys.com
I: www.ecofys.com