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INTRODUCING SHORT TERM FLEXIBILITY IN THE EU ETS TO ASSURE ITS LONG-TERM CREDIBILITY: A MULTI-CRITERIA ANALYSIS OF POLICY OPTIONS

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It is now well established that the European Union Emissions Trading Scheme (EU ETS) needs to be reformed. After more than 18 months of discussions, the EU Commission disclosed, in its communication published in January 2014 on "*A policy framework for climate and energy in the period from 2020 to 2030*", its legislative proposal of a market stability reserve (MSR) in the EU ETS. This measure, that should be implemented from the next compliance period (2021-2028) onwards, would reduce the surplus of allowances growing since 2008 and improve the ETS's resilience to external shocks by automatically adjusting the supply of allowances to be auctioned. The operation of this MSR would be determined by predefined rules that, once agreed on, leave no discretion to either the Commission or Member States.

The choice of the EU Commission to introduce a reserve in the EU ETS is very innovative even if other emissions trading schemes have already introduced a reserve in their design. Initial discussions began in March and April 2014 in the European Parliament and Council and the question of whether the MSR really improves the functioning of the EU ETS in the long term is still being debated. What other structural mechanism would be better suited in improving the long-term effectiveness of the EU ETS?

To help in the decision making process, this report presents a multicriteria analysis. Without prejudging their political support, five policy options have been evaluated that would introduce some flexibility in the EU ETS and potentially ensure its long-term credibility: an auction reserve price, permit supply rules that target a certain corridor of surplus (market stability reserve), permit supply rules that target economic activity, permit supply rules that target overlap with other energy policies and a rolling emissions cap. The assessment of these five policy options was based on a criteria tree and on the EU ETS experts' panel's votes that expressed their preferences collected through a survey conducted in February 2014. Each policy option was evaluated according to their performance on the CO_2 emissions reductions, on their political & economic performance and on their institutional feasibility. This report highlights the conclusions from this research, that could contribute to the ongoing debate:

1. In priority, the choice of the policy option should be based on its environmental and political and economic performances rather than on its institutional feasibility. There was consensus on this between public decision makers, industry decision makers and researchers.

2. The EC's proposed mechanism - MSR - is never the most preferred option to restore the long term credibility of the EU ETS, and instead other options such as an auction reserve price or a rolling emission cap are considered more useful for restoring the scheme's credibility. However, when the institutional feasibility is considered to be a priority, the surplus corridor (MSR) appears in the first position in the ranking.

3. The choice of the best policy option is not supported by all stakeholders and the difficulty of the regulator remains to build a consensus. Whereas setting an auction reserve price has the lowest level of consensus between stakeholders, the choice of a surplus corridor (MSR) or a rolling emissions cap represent a wider consensus.

4. Results demonstrate that, as part of the objective of the best policy option to reform the EU ETS, "certainty" seems to be preferred to "ambiguity"; and "automation" seems to be preferred to "discretion".

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INTRODUCTION

A large literature is now underlining the need for reforming the European Union Emissions Trading Scheme (EU ETS) (European Commission, 2012 and 2014; Berghmans et al., 2013; Grosjean et al., 2014; Taschini et al., 2014). At the beginning of phase 3 (2013 – 2020), it has become apparent that the EU ETS cap on emissions is no longer stringent. The increasing allowance surplus will be carried over to future years, thus lowering the EU CO_2 allowance price (Koch et al., 2014). Several drivers have led to the decrease of emissions during the phase 2 of the EU ETS: the increasing development of renewable energies, the EU economic recession, etc. (Gloaguen and Alberola, 2014) and have therefore negatively impacted the carbon price.

The main difficulty in a cap-and-trade scheme remains the fixing of the cap based on the projections of a business-as-usual (BAU) scenario. However, how can the EU ETS deliver enough incentives to operators to reduce emissions, when the supply is fixed for an entire compliance period, without the prospect of a constraint in the short-term, and with demand fluctuating on the basis of external shocks? How then, should short-term flexibility be introduced into the EU ETS supply to ensure the market's long-term credibility?

The introduction of reform measures was suggested by several Member States during the discussions on the 2020 EU energy and climate package. This debate on introducing some short-term flexibility in the EU ETS' supply began in 2011 during the discussions on the proposal for a new directive to improve energy efficiency. At that time, the option of backloading allowances was discussed to limit the impact of greater energy efficiency on CO_2 emissions reductions within the EU ETS. After having launched a stakeholders' consultation in July 2012 on backloading, the European Commission released its first report on "The state of the EU ETS" in November 2012, which indicated the need for structural reform of the market to combat the imbalance between supply and demand. Six policy options were proposed, falling into three general categories: *(i)* removing allowances from the market (either temporarily or permanently*), (ii)* increasing the scope of the EU ETS, and *(iii)* discrete management (Grosjean et al., 2014). Several studies provide an insight into each of these six options, among which Verdonk et al. (2013) and Clo et al. (2013).

In 2013, the debate narrowed down the options to two: a permanent set-aside of allowances and a "flexible supply mechanism." On 22nd January 2014, in the context of the publication of the 2030 Energy and Climate framework, the European Commission disclosed its first legislative proposal to reform the EU ETS: the establishment of a market stability reserve (MSR) in order to improve the market's functioning. According to the proposal, the mechanism would reduce the surplus of allowances, which has been growing since 2008, and improve the system's resilience to external shocks by automatically adjusting the supply of auctioned allowances. The operation of this MSR is established according to predefined rules that leave no discretion to either the Commission or the Member States.

With the aim of restoring the long-term credibility of the EU ETS, to what extent can this measure be well understood, which aims to mechanically absorb the surplus of allowances, predicted to be over 2 billion in 2020? The MSR will reduce the amount of allowances in circulation in the market each year by an estimated 200 Mt until 2028, thus diminishing the surplus to a minimum volume of 500 Mt according to the impact assessment published by the Commission. However, this proposal remains imprecise on the role that the MSR will play in dealing with changes in demand for allowances resulting from the interaction with other climate and energy policies. According to Desai et al, (2014), this proposal could be a marginal long-term structural reform for two reasons: firstly, if the objective of the MSR is to absorb the current surplus, its role is only temporary since the annual amount of allowances "in circulation" should be within the 400-800 Mt range by 2030; secondly, if the consistency of policies sufficiently limit their potential overlap with the EU ETS' CO2 objective upstream and, in the absence of unanticipated external shocks, the role of the reserve will remain marginal. In fact, the impact of this measure on the carbon price will likely be limited in the long-term.

According to a literature review, various quantitative versus price instruments can be integrated in a cap-and-trade scheme in order to support carbon prices. How to choose between these policy options? What is the best option to restore the long term credibility of the EU ETS in the short term? This is a multidimensional question, as some mechanisms are more effective in certain areas than others, but there is no clear way to handle this trade-off.

In this report, we provide an approach to answer this challenge, using an empirically grounded strategy that uses a multi-criteria methodology. We have evaluated five options that could introduce some flexibility and ensure long-term credibility in the EU ETS. We used the multi-criteria methodology first proposed by Konidari and Mavrakis (2007), and identified three main criteria to evaluate the effectiveness of each of the five policy options to improve the functioning of the EU ETS. Each main criterion has a series of sub–criteria and each option was analysed with respect to 16 criteria overall. The main branch criteria are the following:

- their environmental performance in terms of incentives to reduce CO_2 emissions;
- their economic and political performance linked with their ability to give support to the price level, to limit compliance costs and potential negative competitiveness impacts;
- their institutional performance (feasibility) regarding the timing and costs of their implementation.

To contribute to the debate on the market stability reserve's legislative proposal of the European Commission, the objective of this *Climate Report* is to analyse the performance of this option, explore alternative options, and to evaluate their effectiveness. The first section is dedicated to elaborating the context of the problem at hand and introduce ideas for structural reform in the EU ETS. The second section explains the multi-critera methodology and outlines our analytical strategy by describing policy instruments and the criteria according to which they will be assessed. The third section presents the results and sensitivity analysis. This report does not provide a specific analysis on the market stability reserve, and focuses instead on the state of the current debate by developing a methodology in order to rank several policy options.

I. THE STRUCTURAL PROBLEMS OF THE EU ETS AND ITS LACK OF LONG-TERM CREDIBILITY

Why do we need to reform the EU ETS? To justify the need to intervene and change the design of the EU ETS, it is necessary to first explain the current features of the EU ETS and examine how these features lead to a structural problem. It is also helpful to outline the possible avenues of reform and the last proposals made by the European Commission to stabilise the EU ETS.

The EU ETS is a purely quantitative policy: based on emissions forecasts, the EU Commission then establishes the overall emissions cap and allocates the allowances to operators, either freely or through auctionning according to the rules established in the Directive 2009/29/EC. Then, the Commission lets the market trade – transactions take place between industrial, power and financial operators – which reveals the CO_2 price based on this quantity constraint. This inherently implies that the carbon price is volatile since it has to incorporate changes in its short term drivers (such as economic cycles, weather, energy prices etc.) and future expectations of the emission reduction target in the scope of the ETS. Analyses of price developments indicate that Phases 1 and 2 of the EU ETS demonstrated that carbon prices in times of low political uncertainty adjust to market fundamentals to ensure that the emissions target is reached at minimal economic cost. This has been demonstrated by the clear correlations between carbon prices and relative fuel prices, weather conditions and economic output which are good proxies of CO_2 emissions levels (Alberola et al (2007)).

The complex step for the regulator, in order to guarantee the environmental and economic effectiveness of the ETS, is to define the cap for the compliance period by forecasting all its parameters a few years earlier based on Business-As-Usual (BAU) emissions. During the first phase (2005-2007) of the EU ETS between 2005 and 2008, the cap was a voluntary one assumed by the EU Commission to prepare for the subsequent trading period when a legally binding obligation did exist. As a result, the criteria for cap-setting in the trial period were closely tied to expected business-as-usual (BAU) emissions (Ellerman et al., 2010). This was evident in the first phase of the EU ETS: at the end of the period, the modest cap had been reached and there was no more demand for further allowances as they could not be banked over to phase 2. As a result, prices fell to 0. This is demonstrated in the following figure:

Figure 1 – EUA prices (€/tCO_2) from 2005 to 2014

Source: CDC Climat Research from EEX data

The second phase saw a more stringent cap and prices were higher in the beginning, several factors led to the decrease of the CO_2 emissions and thereafter to a massive drop in prices. Since 2009 the emissions from EU ETS sectors are significantly lower than the number of allowances distributed each year either through free allocation or through auctioning and the international credits used by EU ETS operators have amounted to 1 052 million (Stephan et al, 2014), the surplus of allowances has continued to rise to 1 800 million and is predicted to be over 2 billion in 2020 (European Commission, 2014). As a result of all these factors, the CO_2 price dropped to 3 € and has fluctuated between 4-7 € for more than eighteen months. This has been experienced in other emissions trading schemes: the Regional Greenhouse Gas Initiative (RGGI) experienced extremely low prices at \$2/tCO_2 (the auction reserve price) when the emission levels fell 33% below the cap (Point Carbon, 2012) and the American SO_2 emissions trading market saw prices fell to \$1/tSO_2 from highs of \$150/tSO_2.

The current situation where the surplus can be banked to the next year (since the end of phase 3 is in 2020) provided that the EU ETS price have not fallen to 0 notwithstanding an unprecedented level of surplus build-up. The fact remains that the current price levels of the EUA, around €4-6/tonne of CO2 (ICE, 2013), are far below the "switching price" (the fictional price necessary to make the switch from coal plant electricity generation to gas plant generation profitable), which was calculated to be around €30/tCO_2 (Tendances Carbone, 2013) and remains insufficient to stimulate investments in low carbon technology and thus to have a long term impact on emissions pattern.

In this section, the context of the challenges that the EU ETS is currently facing will be presented. The need for structural reforms to restore long term credibility in the EU ETS will be discussed, as well as how these reforms can be implemented, and what sort of problems they can be expected to address. Finally the paper will discuss the policy proposals proposed so far by the European Commission. A brief description of reserves in other ETS systems around the world will also be provided.

A. The structural rigidity of the EU ETS under a conjunctural uncertainty at the end of its phase 2

The answer to the question to reform the EU ETS lies in the main objective we want the EU ETS to pursue. As suggested by Grosjean et al (2014), if the goal of the EU ETS is to reduce emissions at the lowest economic cost possible the current low carbon prices are not a problem and do not require intervention. However, if the EU ETS is to represent a credible policy instrument to align long-term expectations of the market towards a low-carbon pathway and induce technological development, intervention is necessary. To be more specific, a very low carbon price, while providing countercyclical effects[4], presents many challenges to the EU and its future climate and energy goals. The disadvantages of a persistently low carbon price are mainly:

- Lack of investment in low-carbon technologies or inefficient use of capital (because of stalled investments) (Helm 2008, European Commission 2010, European Commission 2011).
- Sign of low confidence in the EU ETS as a market mechanism to reduce emissions.
- Regulatory uncertainty, at the EU and national levels, promotes carbon lock-in that raises costs in meeting long-term targets.

Thus, the need for reform can be explained and defended by the presence of these negative externalities which result from a low carbon price. However, are low prices the main weakness of the EU ETS? We believe that low prices are nothing but symptoms of a broader and more structural defect in the system.

According to Berghmans et al. (2013), the EU ETS suffers from three structural weaknesses, which have been exposed by the drop in the carbon price during Phase 2 (2008 – 2012): a lack of sufficiently credible commitments on the post-2020 cap; an insufficient level of abatement ambition in the EU ETS after allowing for abatement driven by other policies and international credits; an absence of flexibility in response to extraordinary events impacting the demand for allowances (Berghmans et al., 2013).

The system is vulnerable to external demand shocks

A quantity based instrument, such as the EU ETS, is characterised by structural supply rigidity as the cap is fixed at a known level. The market is left to discover the equilibrium price that "clears" the market.[5] This implies that the carbon price keeps on adjusting with respect to the demand for allowances that can be subject to important variations. The carbon price cannot optimally take into account these exogenous shocks *ex ante* because of the uncertain nature of these shocks. It can only react once the shock has happened, and does so in a very volatile way.

The economic crisis is evidently one such exogenous shock. Europe has been in recession for many years after 2008. This obviously affects industrial production, one of the leading drivers of EU ETS sector emissions. The PRIMES baseline for 2007 was calculated at a much higher level than the PRIMES baseline for 2009, which implies that the baseline economic growth used to calculate the 2020 cap was no longer applicable. The hysteresis that the European economy has suffered since then has contributed to the build-up of a surplus in phase 3 (European Commission, 2014; IETA, 2013). Based on a "business-as-usual" scenario, Gloaguen and Alberola (2013) estimate that around 1.2 GtCO_2 were avoided between 2005 and 2011but only between 0 and 10% are linked to the EUA price variations (see Figure 2) : around 30% of the reduction was the result of a fall in manufacturing output, while around 60% of the reduction was caused by the development of renewable energy and the reduction of the energy intensity. However, since the end of phase 2, while the demand for allowances has plummeted because of the economic recession, the supply of allowances has remained unchanged.

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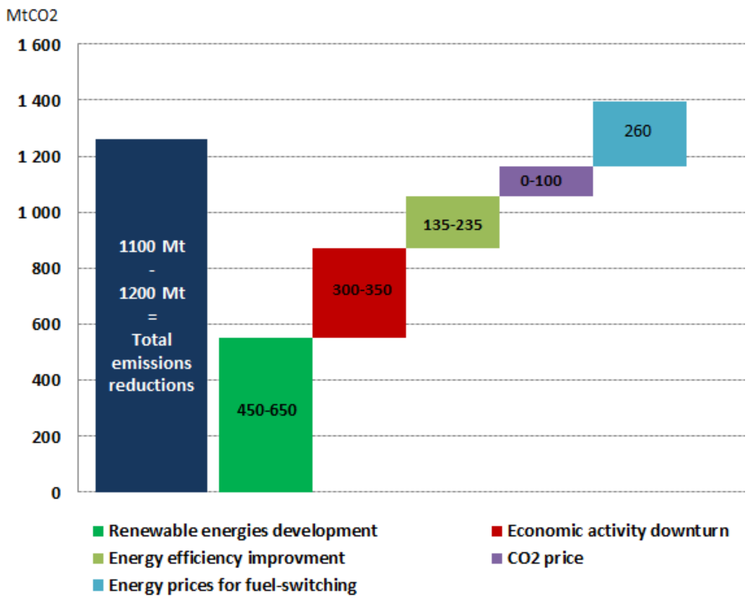
[4] The current system implies a low carbon price during years of recession (and the years following a recession), thus helping competitiveness.

[5] In practice, however, an emissions trading market functions better with a certain level of surplus because it provides the necessary hedging quantity to market participants to deal with factors that lead to imbalances between supply and demand.

Figure 2 -The relative contribution of CO_2 price in EU ETS emissions reductions (2005-2011)



Source: Gloaguen and Alberola, CDC Climat Research, 2013.

No coordination between the interaction of energy and climate policies

Another important factor that policy makers did not completely take into account was the complex interaction between different energy and climate policies at the European level. In order to meet their 20-20-20 targets, many Member States adopted different policies such as carbon taxes (Frankhauser et al., 2010), and "renewable energy support schemes" (European Commission, 2012a). The latter schemes can also be of different types.[6]

Fischer and Peronas (2010) consider the theoretical effects of overlapping policies with an emissions cap. They find that when emissions are capped, overlapping policies decrease allowance prices. This result is also shown by Bohringer and Rosendahl (2010). These theoretical results are supported by various empirical studies as well. Bohringer and Keller (2011) show in their Computable General Equilibrium (CGE) analysis of the 2008 Energy and Climate package that a restrictive renewable energy target drives the carbon price in the ETS sector by 50% and by an even greater share in the case of a simultaneous imposition of 20-20-20 targets. Berghmans (2012) establishes that the Energy Efficiency (EE) Directive could reduce emissions within the scope of the EU ETS by 450 $MtCO_2$ between 2014 and 2020 if primary energy consumption fell by 17% and by 650 $MtCO_2$ if it fell by 20%. He shows that over the period between 2008 and 2020, Member States' renewable energy development programmes are expected to reduce emissions by 2 $GtCO_2$; over 80% of that amount is in the electricity sector. Koch et al. (2014) demontraste a strong evidence that the growth of wind/solar electricity production help explain EUA price movements in phase 2.

These results have again been replicated by the European Commission's (2014a) Impact Assessment of the 2030 Energy and Climate Package. The EU policy package is asymmetric: it combines a price driver (EU ETS) with bottom-up policies to meet separate targets for Renewables (RES) and Energy Efficiency (EE). As the level of achievement of the RES and EE targets will influence the ETS carbon prices, concerns arise about the compatibility of the three targets and the possible adverse effects on ETS prices (Capros, 2014). As presented in the Figure below, the carbon price is much lower in scenarios with additional ambitious energy efficiency policies and a renewable energy target than in a scenario with just a single GHG target.

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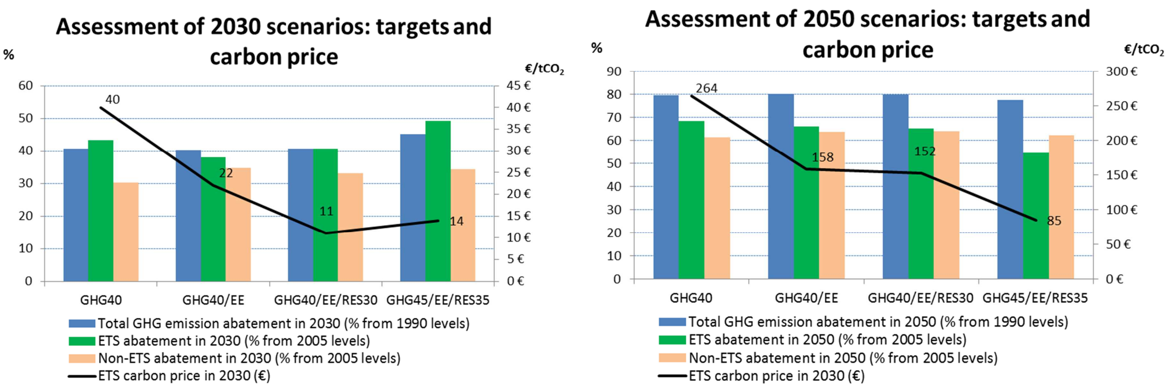
[6] Ranging from state-aid and subsidies to feed-in tariffs and feed-in premiums to tradable green certificates.

Figure 3 - Effects on the carbon price from additional RES targets and EE measures



Note: GHG40 refers to the scenario with only a 40% GHG target, GHG40/EE refers to the one with additional ambitious energy efficiency (EE) policies, GHG40/EE/RES30 refers to the one with an additional 30% EU level renewable energy target and GHG45/EE/RES35 refers to the one with a 45% GHG target and a 35% EU level renewable energy target

Source: CDC Climat Research according to European Commission (2014a)

According to Capros (2014), RES deployment and EE improvements in the scenario proposed by the EU Commission of a GHG target of – 40% by 2030, would drive down carbon prices. Combining EE and RES policies to this GHG – 40 % target thus implies very low carbon prices until 2030. The impact of EE on carbon prices is higher than that of RES according to his analysis.

Link between scarcity of allowances and the long-term credibility of the scheme

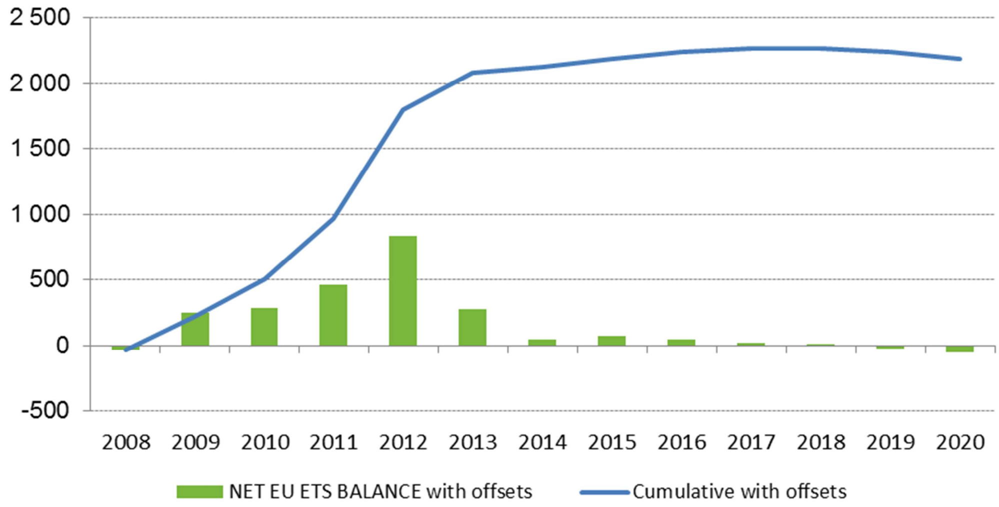
We have so far established the existence of a large surplus in the EU ETS carbon market as a result of an exogenous shock and the effects of overlapping policies. A large surplus is not in itself a problem: operators can anticipate the future constraint and thus bank surplus allowances. Since the launch of the EU ETS, the main source of demand comes from hedging needs of utilities. For example, they hold allowances beyond their current compliance needs to cover for future electricity production (Schopp and Neuhoff, 2013). Speculators can also hold allowances with the expectations that prices will rise in the future (Bailey, 2005) and firms can bank allowances for future use as well. Between 2008 and 2012, the amount of banked allowances by compliance operators increased from 17% to 94% of annual emissions (Trotignon, 2013). In other cap-and-trade schemes, banking provisions can lead to a similar situation. According to the EPA, in the US SO_2 trading scheme, the amount of banked allowances fluctuated between 60% to 140% of annual emissions without leading to a decrease of the price.

Therefore, a surplus of allowances after a compliance deadline is not a problem in itself but it is rather the symptom of a double deficiency: a lack of short-term scarcity of allowances and a lack of long-term credibility in the scheme. According to Zachmann (2013), it is possible that market participants feel that this surplus will continue in the near future, thus reducing their future price expectations. The current low price simply reflects this future low expectation.

In the Figure 4, the yearly supply-demand equilibrium in the EU ETS demonstrates the historical and future expected evolution of the cumulative surplus. As we can see, the EU ETS is expected to be oversupplied throughout the whole of phase 3, which raises the concern of a persistently low carbon price. However, low allowance prices could also be a sign of a lack of long term credibility in the EU ETS in the eyes of the market participants (Zachmann, 2013). A similar reasoning has been adopted elsewhere as well to demonstrate the low credibility of the EU ETS. According to Neuhoff et al. (2012), the size of the surplus indicates to the market that the oversupply would service future needs as it is higher than the overall hedging demand. This means that in order for it to be profitable to bank allowances for speculators, current allowance prices should be heavily discounted relative to expected future prices.

Thus, prices dropped till they reflected such a high discount factor (Neuhoff et al., 2012). That is, the current low prices given an expected price of €40 in 2030 would imply a yearly increase of 13% making the EU ETS less credible than sovereign bonds of Pakistan (Zachmann, 2013).

Figure 4 - Supply-demand equilibrium in the EU ETS over phase 3



Source: CDC Climat Research, 2014

B. The EU Commission proposals: from "one-shot" intervention before 2020 to "robotic" adjustments by 2030

Even if the current legislation of the EU ETS does not provide a specific governance framework to supervise the development of this scheme, since 2013 its revised directive has introduced a new element: the EC has to publish a report analysing the functioning of the carbon market and consider whether regulatory action is needed as foreseen under Article 29 of the EU ETS Directive.

In this first report on the "State of the European carbon market", identifing the increasing surplus of allowances as the problem the EU ETS, the Commission published two kind of proposals: one legislative proposal called "backloading" and a list of "structural" reforms for the EU ETS. Thus, firstly as a short-term measure, the Commission proposed to postpone the auctioning of 900 million allowances until 2019-2020 to allow demand to pick up. In 2014, the auction volume is reduced by 400 million allowances, in 2015 by 300 million and in 2016 by 200 million. These amounts will be reintroduced through auctioning in 2019 and 2020.

Secondly, the Commission drew up a list of 6 options to reform the market in order to tackle this increasing surplus:

1. Increase the EU's 2020 GHG reductions target to 30% from 1990 levels.
2. Retire a number of allowances in phase 3 either temporarily (backloading) or permanently (set-aside).
3. Early revision of the linear reduction factor from 1.74% before 2020
4. Increase the scope of the EU ETS by including more sectors within the scheme.
5. Restrict the use of international credits.
6. Establish a discretionary price management mechanism.

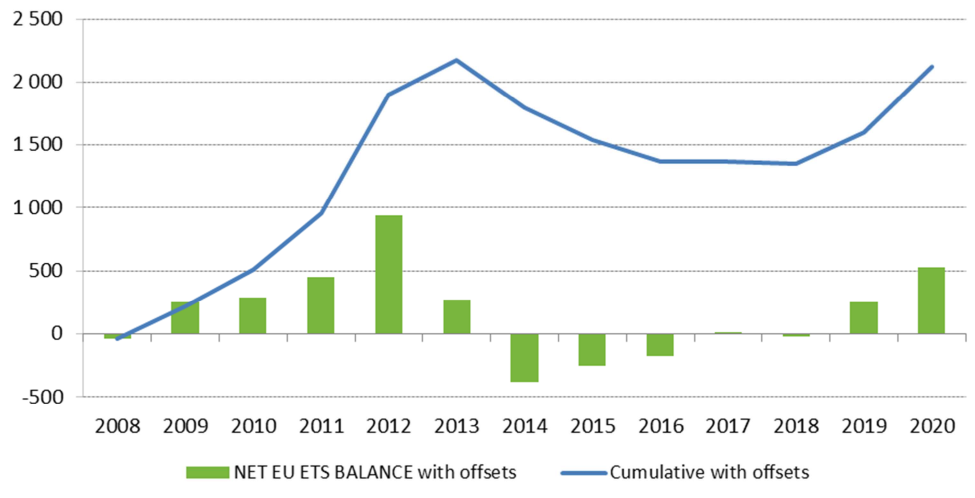
Grosjean et al. (2014) categorise the above 6 options as: measures to reduce allowance surplus (options 1, 2 and 3), measures to adjust the scope of the EU ETS (options 4 and 5) and measures to reduce price uncertainty (option 6). After a lengthy debate in 2013, the European Commission judged the proposals for a "flexible supply mechanism" to be interesting enough to warrant a separate expert's panel consultation in October 2013. Finally, the EU Commission finalised and proposed a structural measure to reform the EU ETS to improve its effectiveness in January 2014 by absorbing the surplus of allowances during the next compliance period (2021-2028).

Backloading: a first and temporary measure to tackle the surplus

The first proposal involves tackling the current surplus. The European Commission (2012b) made the proposal of reducing the supply of allowances between 2013 and 2015 in July 2012. This proposal, termed "backloading", involved setting-aside 900 million allowances early in phase 3 and reintroducing these allowances back into the market at the end of phase 3 (thus keeping the cap at the same level). The European Parliament finally approved the measure in December 2013. In February, the EC amended its Auctioning regulation (EU) No 1031/2010 to determine the auction volume from 2013-2020. In 2014 the auction volume will be reduced by 400 million allowances, in 2015 by 300 million, and in 2016 by 200 million.

In theory, assuming rational actors that optimise dynamically without any information constraints, backloading should not have little, if any, effect on the carbon price (European Commission, 2014b).This is so because the market participants would realise that the scarcity situation is an artificial and temporary one. They can thus sell their allowances safe in the knowledge that the extra allowances will be reintroduced and they can buy them back at the same price. However, according to the European Commission (2014b) such an outcome is unlikely in a market with a limited time horizon. Thus, it expects the price to rise in the short-term because the surplus holders will require a price premium to sell allowances. It also expects the price to fall at the end of phase 3 when allowances are reintroduced to absorb the extra supply.

Figure 5 - Supply-demand equilibrium in the EU ETS over phase 3 with backloading



Source: CDC Climat Research (2014)

The above figure demonstrates how backloading could work in practice. As the EU Commission backloaded allowances in 2014 and the allowances will be reintroduced at the end of the phase, the market will be even longer and the cumulative surplus will increase again. The EU Commission (2014b) admits that modelling the price impacts of backloading is difficult and does not provide its own analysis. Based on their simulation of backloading in the EU ETS, de Perthuis and Trotignon (2013) find that prices would rise to €16 per EUA in 2015 and fall to €3 per EUA in 2019, indicating that backloading remains a temporary measure that could "confuse" the market participants' expectations.

The Market Stability Reserve (MSR) proposal for an automatic adjustment of the auctioning supply

The European, Commission as part of its communication on 2030 climate and energy policies, also explored the possibility of a flexible supply mechanism which would be designed to adjust the amount of allowances to auction after 2020. This reserve would operate on the basis of pre-defined rules that would periodically adjust the supply of EUA's in the market. This proposal reflects the concern about the inflexibility of supply in the market and over low carbon prices through the build-up of a surplus. This mechanism would combat these concerns by providing market participants with a rule that they can use to align their long-term expectations with current conditions.

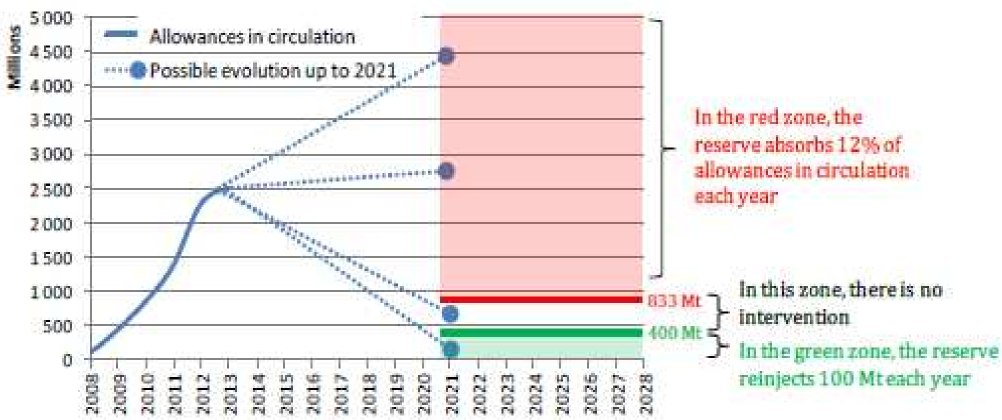
The indexed variable, i.e. the variable through which the MSR's intervention is made, is the cumulative surplus. That is the total number of allowances that are held by the market participants not used to cover emissions. According to the EU Commission (2014c), it is calculated from 2008 onwards, and includes all allowances (auctioned or freely allocated), Kyoto credits minus the total covered verified emissions (and allowances already put in the reserve). There is a lagged effect to this mechanism since changes to the auction volumes would take place two years after the emissions occurred. Thus, the cumulative surplus calculated in year *n* is in fact that of year *n-2*.

Two quantity thresholds and a price threshold are defined. The lower quantity thresholds is set so that when allowances in circulation go below the limit, the Commission commits to reintroducing allowances. The upper threshold is set so that allowances in circulation above the limit would lead to allowances being removed from circulation. The price threshold is an "emergency" trigger that works on the basis of an extremely volatile rise in prices. More specifically the EC:

- Commits to remove 12% of the total allowances in circulation and place it in the MSR if the amount of the **cumulative surplus is greater than 833Mt**.
- Commits to add 100Mt worth of allowances by removing them from the MSR and adding them to the auctioning volume if the total amount of the **cumulative surplus is less than 400Mt**.
- Finally, it commits to adding 100Mt worth of allowances if the **allowance price is higher than three times its average value over the previous two years**. This threshold is only valid when the price is rising: there is no provision to remove allowances on the basis of a volatile drop in prices.

The two quantity thresholds are demonstrated in the following figure. The mechanism is in fact the "quantity interpretation" of a price collar.

Figure 6 - Demonstration of the Market Stability Reserve functioning based on the EU Commission's proposal



Source: Trotignon et al. (2014)

This mechanism serves to remedy two problems: short-term surplus build-up and long-term credibility issues. The former is clear – the mechanism will essentially remove the surplus because of its asymmetric nature (more allowances are likely to be removed from the auctioning volume than added back) – however, the latter is not so straightforward to address.

The Commission, as with backloading, confesses that it is unable to model the potential price effects of such a mechanism because of the difficulties in modelling dynamic expectations. Furthermore, according to the EC's Impact Assessment (2014d), while all options studied "avoid continuous growth of the surplus" if implemented in phase 2, none would have prevented the rapid accumulation of the surplus in 2011-2012. Trotignon et al. (2014) model dynamic expectations in two extreme scenarios and find that the MSR would result in greater price volatility instead of stabilising the market. Thus, while the surplus would be tackled, no further certainty over future price levels would be provided by this mechanism, thus limiting its ability to bring long-term credibility to the market.

According to Desai et al. (2014), if the EU ETS should be considered as the EU's central climate policy instrument in 2030, the debate on the legislative proposal should not ignore other provisions to ensure greater consistency of climate and energy package. For two reasons: firstly, if the objective of the MSR is to absorb the current surplus, its role is only temporary since the annual amount of allowances "in circulation" should be between 400-800 Mt by 2030; secondly, if the consistency of policies sufficiently limits their potential overlap with the EU ETS' CO_2 objective upstream and, in the absence of unanticipated external shocks, the role of the reserve will remain marginal. In fact, the impact of this measure on the carbon price will likely be limited in the long-term; the price signal is more likely to emerge from the long-term reduction ambition.

A new GHG target delivering new ambition for the EU ETS by 2030

In January 2014, the European Commission (2014a) presented new targets as part of the EU's 2030 Climate and Energy Package. This communication essentially provides three main elements: two new binding targets, a new governance structure and new parameters for the EU ETS. These measures can help bring about some credibility to the system.

Firstly, the EC (2014a) proposes a GHG emissions reduction target of 40% below 1990 levels by 2030 (European Commission, 2014a), doubling the 2020 target. The EU has set a domestic 2030 target for its climate objectives: no international credits will be imported unless an international climate agreement is reached. Secondly, the EC proposes a European-wide target of at least 27% of energy consumption to come from renewable energy (European Commission, 2014a). No individual Member State targets are set. Finally, no explicit energy efficiency target has been put forward (European Commission, 2014a); a review of the energy efficiency directive is expected in mid-2014.

The centrality of the EU ETS as the instrument to meet the GHG target beyond 2020 is clear: according to the EC (2014a), the ETS sectors will have to reduce emissions by 43% from 2005 levels compared to 30% for the non-ETS sector. The EU ETS will be based on revised parameters such a new linear factor of 2.2%, no Kyoto credits and the implementation of a market stability reserve.

Grosjean et al. (2014) argue that credibility issues can have two sources: uncertainty over regulation and the inconsistency related to long-term climate policies. Both of these can depress current carbon prices. According to Blyth and Bunn (2011), policy uncertainty can be reduced by providing more information regarding future targets. In their stochastic simulation model, the authors show that reducing policy risks can reduce price risks as well and result in market-driven prices. In this regard, adopting 2030 targets definitely reduce policy uncertainty as it extends the timeframe of biding GHG targets.

On the other hand, Helm et al. (2003) discuss time inconsistency problems of carbon policies. They claim that multiple objectives, high investor costs and the possibility of *ex post* changing of *ex ante* commitments means that climate policies remain non-credible. The new targets proposed by the European Commission do not address this concern of the time inconsistency problem. Indeed in an uncertain economic environment, it is possible that the market does not take the EU's announcement of further targets as credible (because of the current lack of unanimity amongst European Member States concerning these targets). If so, the time inconsistency problem remains and current prices are likely to reflect this lack of credibility.

The European Council of heads of States, which took place on 20th and 21st March 2014, stated that a final decision on the 2030 framework will be taken no later than October 2014. Finding a compromise between the Member States on this package is challenging after Poland's veto on the "energy" and "towards a low-carbon economy by 2050" roadmaps. This compromise, if there is one, will constitute the EU's contribution to the preparation of the climate conference in Paris in 2015

C. Introducing short-term flexibility in an emission trading scheme: lessons from other ETS

The EC's proposal to introduce short-term flexibility in the EU ETS allowance supply is innovative and unique. However, other emissions trading schemes implemented in other countries or at the legislative proposal level present other kind of provisions which aim to support the long-term credibility of the market. Most of these existing provisions are price based, through especially minimum auction price or de facto pricefloors for the market as illustrates Table 2. The EC's MSR proposal is unique in targeting an "optimal" level of cumulative surplus in the market.

Table 1 – Introducing short term flexibility: experiences of other Emissions Trading Schemes

Emissions Trading Scheme	Prices mechanisms : price floor, price ceiling	Quantity mechanisms
Beijing	Price floor and price ceiling in discussion	
Shenzhen		Cancellation of nearly 3 million surplus carbon permits from the first year.
Guangdong	Price floor : 60 yuans	
Regional Greenhouse Gas Initiative (RGGI) in 9 US States	The auctions include a reserve price, which sets a price floor for emission allowances. The reserve price started at \$1.86 in 2009, increasing to \$1.98 in 2013.28. RGGI states proposed that the 2014 reserve price will be \$2.00, increasing by 2.5% each year thereafter. The cost containment reserve (CCR) consist of a fixed quantity of allowances, in addition to the cap, that would be held in reserve, and are only to be made available for sale if allowance prices were to exceed predefined price levels. CCR Triggers Prices: \$4 in 2014, \$6 in 2015, \$8 in 2016, and \$10 in 2017. Each year after 2017, the CCR trigger price will increase by 2.5%. An annual CCR withdrawal limit of 5 million allowances in 2014, and an annual CCR withdrawal limit of 10 million allowances thereafter.	-
ARB32 – California	Auction price minimum : \$10 per metric ton for both 2012 and 2013 before rising 5% per year (plus inflation) starting in 2014. Strategic reserve: a percentage of allowances, which increases over time from 1% to 7%, will be held in a strategic reserve by CARB in three tiers with different prices: \$40, \$45, \$50 in 2013, rising 5% annually over inflation. Since these prices are not subject to market forces, the strategic reserve will help contain compliance costs.	
Quebec	Auction price minimum: \$10 per metric ton price floor starting in 2012 and rising 5% for each year thereafter (plus inflation)	
South Korea	Price floor and price ceiling in discussion	Possibility to emit new allowances

Source : CDC Climat Research from national legislations.

II. A MULTI-CRITERIA METHODOLOGY TO EVALUATE THE ABILITY OF FLEXIBLE SUPPLY MECHANISMS TO IMPROVE THE EFFECTIVENESS OF THE EU ETS

In order to guarantee a long-term credibility of the emissions reduction target implemented by the EU ETS, a possible avenue of reform would be to change its market design by introducing more responsiveness from the supply of allowances. The Market Stability Reserve proposal is one such option. Other policy options exist. However, each of the policy options are qualitatively different thus difficult to compare by using different "triggers", i.e. thresholds for intervention. The lack of any *ex post* data on all of them and the difficulties in modelling them all in a comparable framework limits the ability to produce an assessment to choose the best option. There has been previous work on comparing flexible supply policy options to improve EU ETS effectiveness. Most importantly, Grosjean et al. (2014) have proposed a "reform space" for all where they demonstrate the various benefits and drawbacks of policy proposals on a two-dimensional plane. However, there are many other dimensions according to which these policy options can have different performance levels.

This multi-dimensional trade-off can be approximated very well through a multi-criteria analysis. We thus propose a mathematical, empirical framework adapted from this decision-theoretic literature that can be used to rank a list of flexible supply mechanisms in their utility in improving EU ETS effectiveness and bringing long-term credibility to it. In this section we introduce this methodology and list the policy options and the criteria through which they are to be evaluated.

A. A multi-criteria methodology to rank the different flexible-supply options

A multi-criteria analysis[7] is used to deal with complex problems that are characterised by a mixture of potentially clashing objectives, of breaking it down into more manageable parts and then reassembling these parts to provide a coherent overall picture to decision makers (Dodgson et al., 2009). We believe that such an analysis can provide decision makers with a comparable framework to make the trade-offs between choosing an option over another.

Based on the methodology developed by Konidari and Mavrakis (2007)[8], we have conducted a multi-criteria analysis on five flexible options and provided the similar aggregation of different stakeholders' preferences in our analysis which presents a greater understanding of the diversity of preferences among the stakeholders of the EU ETS.

In this part of the report, we will elaborate the first two steps by carrying out a literature review on potential flexible supply mechanisms and by exploring the multidimensional problem with the choice of evaluation criteria.

[7] The first exposition of a multi-criteria analysis was given by Keeney and Raiffa (1976). They built the technique on decision theory by incorporating multiple attributes and they provided a theoretic foundation that integrates consequences of multiple objectives into the decision making process (Dodgson et al., 2009). Furthermore, multi-criteria analysis also makes it possible to include political and social criteria within its framework making it attractive to policy makers (Blechinger and Shah, 2011).

[8] This method consists of the use of two separate MCA techniques: the Analytical Hierarchy Process (AHP) and the Simple Multi-Attribute Ranking Technique (SMART). This method was selected because of its widespread use in climate policy issues including a paper on the structural reforms of the EU ETS (Clo et al., 2013). Furthermore, this technique provides the added benefit of handling a lack of input-data for environmental policy decisions and the possibility of including different stakeholders in the process (Blechinger and Shah, 2011). Blechinger and Shah (2011), moreover, also allow for an aggregation of individual preferences into a group decision.

Detailed description of the multi-criteria analysis application

A multi-criteria analysis requires carefully following a set of steps to provide a meaningful analysis into the problem at hand. Our **main objective is to evaluate the ability of different flexible supply mechanisms in improving the EU ETS' effectiveness**. The analysis made in this report with respect to our overall objective was done by following these steps:

Step 1: Selection of flexible supply mechanisms : 5 policy options

↓

Step 2: Selection of evaluation criteria to apply to the policy instruments : the criteria tree

↓

Step 3: Weighing the evaluation criteria : a survey on an experts' panel

↓

Step 4: Evaluation of the flexible supply mechanisms through an expert panel

↓

Step 5: Calculation of weighted grades for all flexible supply mechanisms : policy options ranking

↓

Step 6: Sensitivity analysis

Step 1: Selection of flexible supply mechanisms

Through a literature review and discussion with stakeholders, we studied a list of flexible supply mechanisms that can be introduced into the EU ETS to improve its effectiveness and increase long-term credibility. These mechanisms are described in detail in the next sub-section.

Step 2: Selection of evaluation criteria to apply to the policy instruments

An evaluation tree was formulated using Konidari and Mavrakis (2007), Blechinger and Shah (2011) and Clo et al. (2013). The criteria were modified and chosen according to the decision problem. The criteria tree is described in detail in this section of the study.

Step 3: Weighing the evaluation criteria

The evaluation criteria selected were weighted by a panel of experts selected by us. An anonymous survey was sent and yielded 33 responses. These experts consisted of public sector affiliates, industry affiliates and academic experts. One response was that of an NGO affiliated expert. They ranked each criterion and sub-criterion. Aggregate performance was measured for all criteria using a modified version of the methodology devised by Frei and Harker (1998) and the Analytical Hierarchy Process (AHP) defined by Saaty (1990, 2006, and 2008). Results are presented in the next section.

Step 4: Evaluation of the flexible supply mechanisms through an expert panel

The same expert panel ranked all mechanisms using the Simple Multi Attribute Ranking Technique (SMART) scale (0-10) with respect to all criteria and subcriteria.

Step 5: Calculation of weighted grades for all flexible supply mechanisms and policy ranking

The grades from step 4 were weighted and summed up for all flexible supply mechanisms. On the basis of these weighted averages, a policy ranking was carried out. These results are presented in the next section.

Step 6: Sensitivity analysis

A sensitivity analysis was conducted by changing the weights of criteria to check for robustness of the policy ranking.

B. A list of potential flexible supply mechanisms

There exist many ways that the EU ETS can structurally reform its design by introducing “flexibility” to the allowance supply. We interpret flexibility as the ability of the supply curve to react to exogenous factors and changes in demand. With such a definition, potential options can be divided in three types: price based, financial instruments and quantity based.[9] Price and quantity-based options use specific triggers to determine the level of supply in a given year. Financial instruments on the other hand are approximations that aim to deliver an ex-post efficient level of supply at the lowest price possible.

Based on an extended review of lilerature, our analysis is based on the assessment of 5 options:

1. Auction Reserve Price
2. Allowance supply rule based on cumulative surplus (Market Stability Reserve)
3. Allowance supply rule based on economic activity
4. Allowance supply rule based on overlapping policies
5. Rolling Emissions Cap

These specific options are chosen because: an auction reserve price summarises most price-based options as well as financial instruments since all other options are just different ways to establish a price collar; three different allowance supply rules are chosen to reflect the preferences of the EC and to address policy overlap; and finally the rolling emissions cap is chosen because it is a quantity mechanism that offers a different kind of flexibility and has not yet been fully explored in the debate so far. The Annex A provides a brief synthesis of all options covered in the literature review.

C. The multidimensionality of the decision problem: the definition of the criteria tree

The problem in choosing between these policy options is that they have positive and negative characteristics (as outlined in the table of synthesis). The decision problem arises from the fact that since there is no data available or a comparative simulation framework it is difficult to choose between them. In effect, there are various dimensions in the choice problem, and some instruments possibly do better in some and worse in others.

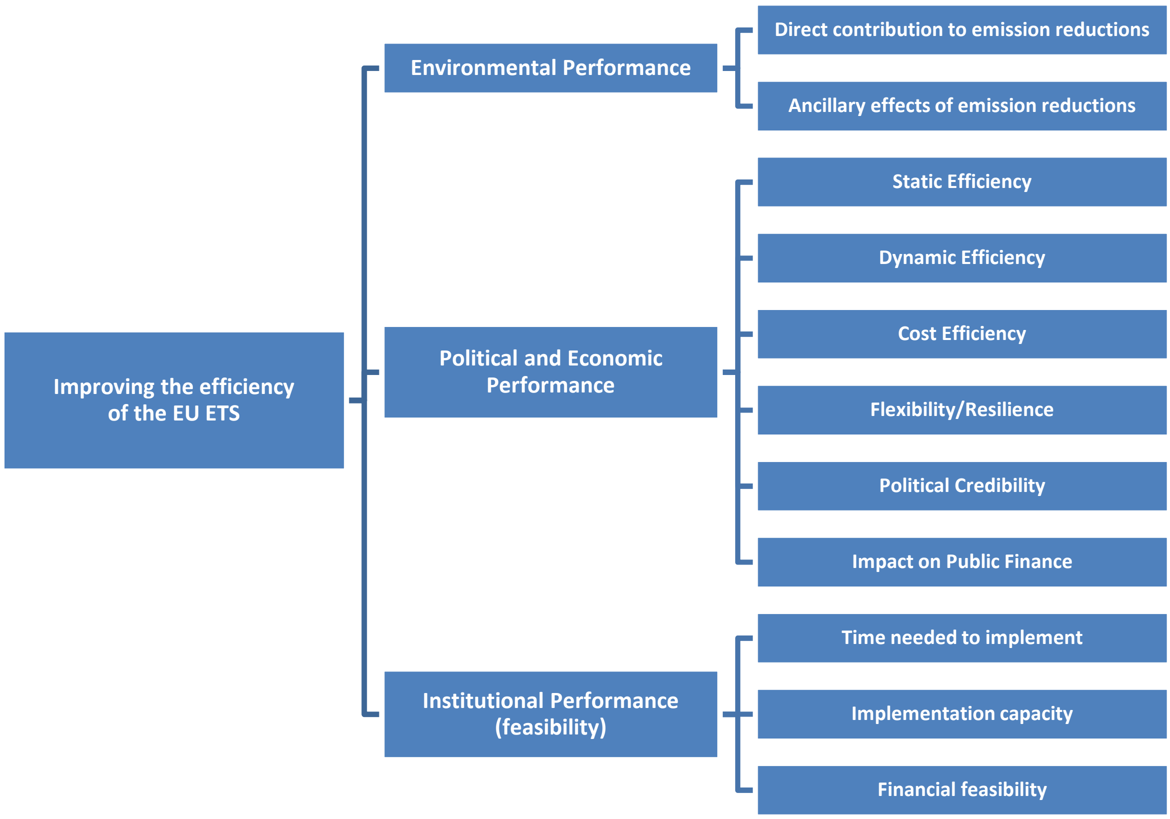
To proceed to the definition of the choice problem, we first establish the main objective: improve the effectiveness of the EU ETS and establish long-term credibility in the system. Then, based on the tree of Konidari and Mavrakis (2007) and papers by Blechinger and Shah (2011) and Clo et al. (2013), we divide the main objective into three different criteria:

- Improving environmental performance
- Improving political acceptability (which depends on political and economic performance)
- And being institutionally feasible.

These three categories can be further divided into subcategories. The following figure describes the resulting tree.

[9] Refer to the appendix to get a theoretical review into all these policy options.

Figure 7 - Criteria tree



Source : CDC Climat Research adapted from Konidari and Mavrakis (2007)

Thus, an instrument to reform the EU ETS should be chosen according to its performance over all criteria listed above.

The definition of all criteria and subcriteria

1. **Environmental Performance:** This is defined as the overall environmental contribution of the instrument towards the goal of emissions reduction. An instrument that improves the effectiveness of the EU ETS at the expense of other environmental goals (by implicitly loosening the cap) is not a desirable policy option. Assessment of the instrument under this criterion takes place through two sub criteria:

a **Direct contribution to emission reduction:** The magnitude of emissions reductions achieved under this policy option. Does the implementation of the policy option imply that emission reduction goals might be compromised? An increase in GHG emission reductions is graded positively, and vice versa for a decrease of GHG emissions.

b **Indirect environmental effects:** Ancillary environmental outcomes attributed to emission reductions. These could include ancillary health benefits, ecosystem benefits, avoided abatement costs etc. Ideally, both sub-criteria are graded similarly, because the second is a result of the first.

2. **Political and Economic Performance:** This criterion evaluates the political acceptability as well as the economic benefits for policy makers to pursue the instrument. The sub criteria below include both political and economic criteria because it is both of these that are instrumental in determining the political acceptability or the political feasibility of the mechanism.

a **Static Efficiency:** This criterion looks at the reaction of the carbon price to short-term drivers such as economic growth, weather, energy prices etc. As such, the criterion evaluates whether the instrument will deliver a carbon price that will react to short-term drivers in an optimal fashion.

b. Dynamic efficiency: This criterion looks at the long-term considerations of the EU ETS as a carbon market. Thus, the main evaluations to be made will be along the lines of long-term market credibility and price signal. Does the mechanism give long-term credibility to the EU ETS and provide a way for market participants to factor in long-term expectations in their current decisions? Does the instrument provide a long-term price signal to participants in the market and induce desired and profitable investments in low carbon technology? If the mechanism provides a clear long-term price signal then it is assumed that it is contributing to establishing dynamic efficiency.

c. Cost efficiency: This criterion concerns mostly installations and firms. Taking into account the fact that the EU ETS and carbon markets in general are supposed to be the most cost-effective way of reducing emissions and making the transition to a low-carbon economy, an taking into account also, that there are carbon leakage concerns for industries that face international competition, these concerns need to be taken in consideration. This criterion is aimed at evaluating the instrument's additional cost burden or cost efficiency on firms.

d. Political Credibility: All mechanisms will require a level of intervention by the regulator. This criterion aims to evaluate whether these interventions are welcomed by the participants in the ETS and whether the intervention is deemed credible over the long term.

e. Resilience/Flexibility: Remember that the instrument is designed to respond to external shocks. This criterion aims to evaluate how the mechanism will adapt to unanticipated changes. Will it be too rigid or will it adapt accordingly? If the timing of the instrument is slow or if the mechanism is too rigid to adapt to swift changes, it will be graded lower than mechanisms that are very flexible to future changes.

f. Impact on Public Finance: As allowances are largely no longer freely allocated but auctioned, any supply decision over allowances is likely to have an effect on government auction revenues. Thus, an instrument should be graded on its potential effect on auction revenue schemes.

3. Institutional feasibility: This criterion evaluates whether the EU is equipped to deal with the mechanism and introduce it in the ETS. We analyse the institutional compatibility of the mechanism with regards the current EU decision-making rules and implementation capacity.

a. Time needed to establish the mechanism: This subcriterion deals specifically with the delay required for its implementation. As such, it is an analysis of what EU decision procedures need to be followed for establishing the chosen mechanism. How long would it take for this mechanism to be implemented?

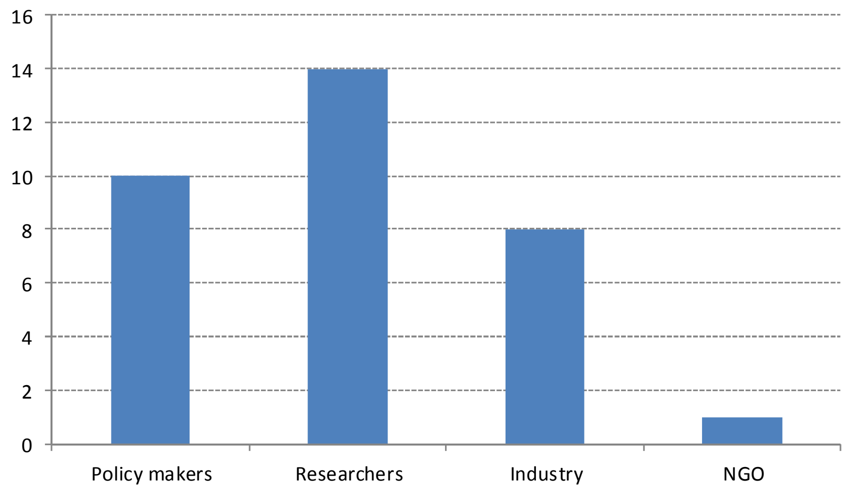
b. Implementation capacity: This criterion investigates the EU's capacity to implement such a mechanism. The questions that need to be answered are as follows: does the mechanism require the creation of new authorities? If it doesn't, which European authority would be in charge of implementation? If it does, how will it affect the European governance structure? Who will the authority report to? If the EU is currently capable of implementing this instrument, it is graded higher.

c. Financial feasibility: This criterion evaluates the financial and administrative aspects of implementation. Will it be an expensive mechanism? If the financial costs of implementation are low, the instrument is graded higher.

D. A survey on an experts'panel to weight the evaluation criteria and to grade the policy options

In this objective, we conducted an independent and anonymous survey circulated amongst a targeted panel of experts on the EU ETS. Responses were anonymous but aggregated in the following groups: public sector, researchers, industry and NGO/Environmental group. The survey elicited 33 responses, of which 10 individuals professing an affiliation with the public sector (policy makers), 14 researchers, 8 individuals from industry and 1 NGO affiliated respondent.

Figure 8 – The EU ETS experts' panel



Source : CDC Climat Research (2014)

Step 1: to weigh the criteria to assess the capacity of policy options in improving the EU ETS effectiveness

The criteria tree presents 14 criteria and subcriteria to assess the capacity of flexible supply mechanisms in improving the EU ETS' effectiveness. Based on the methodology developed by Konidari and Mavrakis (2007), we have provided the similar aggregation of different stakeholders' preferences in our analysis which presents a greater understanding of the diversity of preferences among the stakeholders of the EU ETS.

According to Konidari and Mavrakis' (2007) AMS methodology, the weighting is done using the Analytical Hierarchy Process (AHP). The Analytical Hierarchy Process (AHP) compares all options pairwise on a scale from 1-9. These values are used to calculate weight coefficients[10].

Table 2 - Analytical Hierarchy Process scale

Preference score	Definition
1	Equally important or preferred
3	Moderately important or preferred
5	Strongly important or preferred
7	Very strongly important or preferred
9	Extremely important or preferred
2, 4, 6, 8	Intermediate values

Source : CDC Climat Research

In the AHP, decision makers are asked to compare pairs of criteria using the scale presented above. The methodology is a little complex and demands much from the survey respondent. It is for this reason we instead asked respondents to grade each criterion on a scale from 0-5, with 0 denoting "no importance" and 5 denoting "extreme importance". Thus, in our survey, respondents did not compare all criteria pairwise.

[10] As previously, you can refer to the appendix for a more detailed explanation.

Table 3 - Survey criteria grading scale

5	4	3	2	1	0
Extremely Important	Very Important	Moderately Important	Slightly important	Not important	Absolutely not important

Source : CDC Climat Research

However, their responses were then aggregated using an adapted version of Frei and Harker (1998) who use a tournament ranking scheme, and converted to the 1-9 scale in Table 2. Thus, even though the respondents did not compare the criteria pairwise, we used their responses and compared them pairwise and aggregated and converted them to the scale in Table 2. We could then apply Konidari and Mavrakis' (2007) methodology.

Step 2 : to grade the policy options to identify the most appropriate option to improve the effectiveness of the EU ETS

Normally objective data is used to appraise all policy options. However, because of the lack of such data, we asked respondents to grade the mechanisms on a 0-10 scale. This scale is called the Simple Multi Attribute Ranking Technique (SMART) and ranges from 0 for "null" to 10 for "excellent". The exact scale is provided below. It enables the decision makers to grade each policy instrument for each sub criterion thus allowing a parsimonious analysis of all policy options.

Table 4 - SMART grading scale

Assessment of performance	Grade of mechanism
Null	0
Slightly more than null, less than very bad	1
Very bad	2
Bad	3
More than bad, less than moderate	4
Moderate	5
More than moderate, less than good	6
Good	7
More than good, less than very good	8
Very good	9
Excellent	10

Source : CDC Climat Research

The grades were averaged across all respondents before calculating the final score.

The following section presents the results based on the input received and provide a general picture of preferences on the instruments selected for analysis.

III. THE EVALUATION OF CRITERIA AND POLICY OPTIONS

How to choose between these 5 policy options? What is the best option to restore the long term credibility of the EU ETS in the short term? This is a multidimensional question, as some mechanisms are more effective in certain areas than others. We evaluated five options that could introduce some flexibility and ensure long-term credibility based on the multi-criteria methodology.

Results of this multi-criteria analysis are presented in this section. Firstly, based on preferences of the EU ETS experts' panel on performances of these policy options, we calculated weights, using a modified version of the tournament ranking technique of Frei and Harker (1998) and the AHP method devised by Saaty (1990, 2006, and 2008)[11]. Secondly, we apply these weights on the average grades for each policy measure and formulate a ranking. Thirdly, we test the robustness of the ranking by conducting a sensitivity analysis by changing the main criteria weights. We also present the group-specific results to see whether the ranking changes by group.

A. The capacity of policy options in improving the EU ETS effectiveness: a preference for environmental and political and economic performances

The result of the survey conducted on the EU ETS experts' panel reveals that they expressed an equivalent importance on the environmental (36%) and political performance (36%) criteria and a little less on institutional feasibility (28%).

Table 5 presents all results: the primary concerns of our respondents concerning environmental performance was the direct effect on emission reductions. Respondents also graded dynamic efficiency and political credibility as the most important political and economic aspects of the problem. Institutionally, the respondents believed that implementation capacity (the ability of the EU as an institution to implement the mechanism) was the most important factor. However, it is important to point out that overall the emphasis is on the direct effect on emission reduction, as it counts for 24% of the final grade.

Table 5 - Weighting of the evaluation criteria

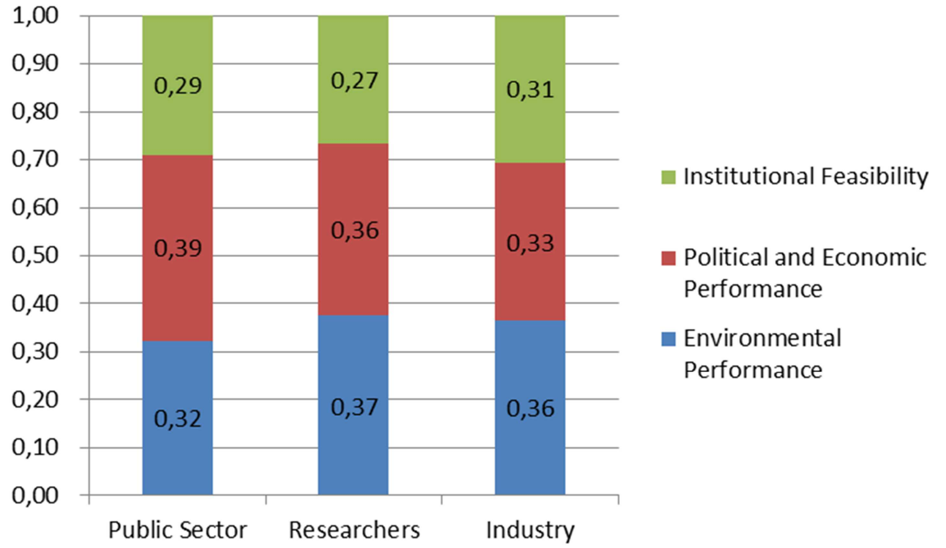
		Criteria	Weight	Adjusted Weight
1.		**Environmental Performance**	**0,36**	
	a.	*Direct effect on emission reductions*	0,67	0,24
	b.	*Ancillary effects of emission reductions*	0,33	0,12
2.		**Political and Economic Performance**	**0,36**	
	a.	*Static Efficiency*	0,14	0,05
	b.	*Dynamic Efficiency*	0,22	0,08
	c.	*Cost Efficiency*	0,15	0,05
	d.	*Resilience/flexibility*	0,18	0,06
	e.	*Political Credibility*	0,21	0,08
	f.	*Impact on Public Finance*	0,10	0,04
3.		**Institutional Feasibility**	**0,28**	
	a.	*Timing of mechanism*	0,31	0,08
	b.	*Implementation capacity*	0,42	0,12
	c.	*Financial feasibility*	0,27	0,08

Source: based on authors' calculations

[11] Refer to the appendix for a more detailed explanation of the methodology.

The weights for the three groups of respondents, presented some differences, but remained small in magnitude.

Figure 9 - Main criteria weights over the three groups



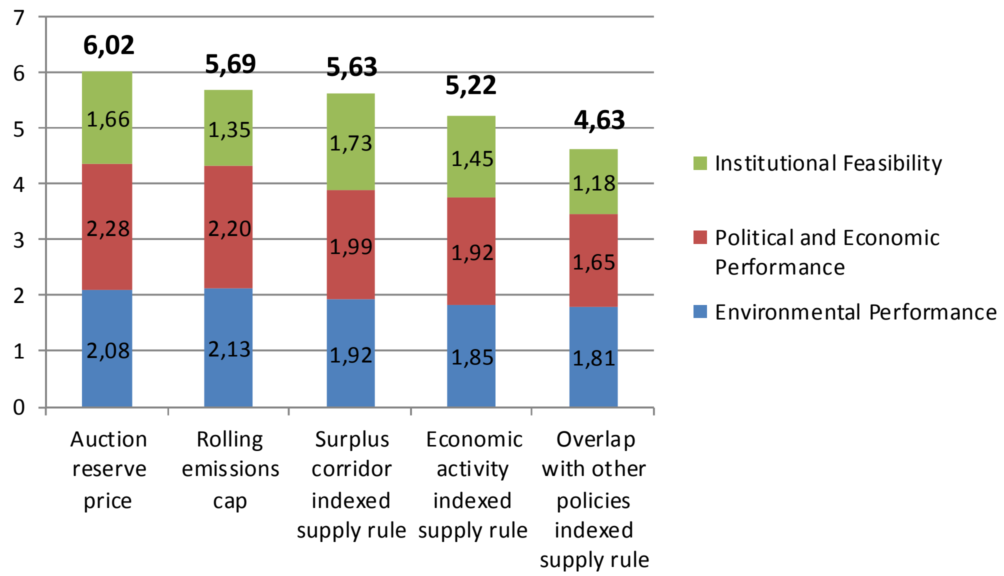
Source: based on authors' calculations

Researchers believe that the environmental performance is the most important decision; public sector-affiliated respondents emphasise the political and economic performance; while industrialists believe institutional feasibility is more important than the other two groups.

B. Ranking of policy options: the auction reserve price at the first position

Based on the weights of each criteria defined by the panel survey, the ranking of the 5 policy options is done in two steps. We first multiply the specific instrument's average grade with the criteria's weight. We then sum up all criteria for all mechanisms. The result is a final weighted grade. The instruments are then ranked according to the final score.

Figure 10 - Overall grades for all policy options



Source: based on authors' calculations

As seen in Figure 10, it is evident that an auction reserve price is considered to be the policy option that is seen as the most effective in bringing supply side flexibility to the EU ETS. It has the highest score of 6.02 and dominates all other options with regards to political and economic performance (with a score of 2.28) and is a very close second for both environmental performance (2.08) and institutional feasibility (1.66). What this means is that in the extreme cases where political and economic performance were the *only* aspect that mattered, an auction reserve price would be the best option. Even if *only* environmental performance or institutional feasibility mattered, an auction reserve price would be very close behind a rolling emissions cap (with an environmental performance score of 2.13) and a surplus corridor indexed supply rule (with an institutional feasibility score of 1.73). These results indicate a clear preference for an explicit price-based mechanism.

Table 6 provides more information about scores and can give a more comprehensive picture of results for all policy options. Thus, the auction reserve is seen to do well (either 1st or 2nd) on all sub criteria except for static efficiency. Furthermore, in comparison to a surplus corridor-indexed supply rule (the policy mechanism that mirrors most closely the EC's legislative proposal), an auction reserve price is always considered better except for cost efficiency, timing of the mechanism and implementation capacity. A rolling emissions cap is considered to be the best performing mechanism for environmental reasons but is the least-performing option when it comes to institutional feasibility. A surplus corridor indexed supply rule is third for environmental and political and economic performances, but scores the highest (but not by much) when it comes to its institutional feasibility. The other two supply rules are consistently 4th and 5th.

Table 6 - Score matrix and final ranking

	Auction reserve price	Surplus corridor indexed supply rule	Economic activity indexed supply rule	Overlap indexed supply rule	Rolling emissions cap
Environmental Performance	**2,08**	**1,92**	**1,85**	**1,81**	**2,13**
Direct effect on emission reductions	1,48	1,35	1,28	1,24	1,50
Ancillary effects of emission reductions	0,60	0,57	0,57	0,57	0,63
Political and Economic Performance	**2,28**	**1,99**	**1,92**	**1,65**	**2,20**
Static Efficiency	0,28	0,27	0,29	0,23	0,30
Dynamic Efficiency	0,58	0,43	0,41	0,39	0,53
Cost Efficiency	0,27	0,28	0,27	0,23	0,31
Resilience/flexibility	0,43	0,39	0,38	0,29	0,43
Political Credibility	0,49	0,45	0,38	0,32	0,44
Impact on Public Finance	0,24	0,17	0,18	0,17	0,19
Institutional Feasibility	**1,66**	**1,73**	**1,45**	**1,18**	**1,35**
Timing of mechanism	0,44	0,48	0,42	0,34	0,38
Implementation capacity	0,67	0,74	0,59	0,47	0,52
Financial feasibility	0,54	0,51	0,44	0,37	0,45
TOTAL	**6,02**	**5,63**	**5,22**	**4,63**	**5,69**
RANKING	**1**	**3**	**4**	**5**	**2**

Source: based on authors' calculations

Thus, an auction reserve price seems to be the first-best policy option given the preferences of respondents. It scores very well on all three fronts. The implications of these results will be discussed in subsection D.

C. Sensitivity analysis of policy ranking: the auction reserve price still in a good position

A sensitivity analysis allows to assess to what extent changes in the weight coefficients could modify the final ranking of policy options, and first how policy ranking could change depending on the group analysing the decision problem.

In the first part the robustness of the ranking will be checked by changing weight coefficients. Two different analyses will be carried out. Three extreme scenarios where only one performance-type is important, either environmental performance, political and economic performance or institutional feasibility (100% weight to any of the three main criteria) will be described. A traditional sensitivity analysis will be then carried out: the weight of one main criterion will be decreased and added to another while keeping the third one constant. This will be done for all possible permutations (there are 6 in total). In the second type of sensitivity analysis group, specific scores and rankings will be introduced. The overall results and sensitivity analysis results will be discussed in the final subsection.

Weight sensitivity analysis: extreme preferences change the ranking

Extreme Scenarios

What would be the ranking of policy options in case the performance of each policy option is evaluated only against one criteria: its environmental performance, its political and economic performance or its institutional feasibility performance? The three "extreme" scenarios are as follows:

- **Environmental scenario:** 100% importance to environmental performance.
- **Political and economic scenario:** 100% importance to political and economic performance.
- **Institutional scenario:** 100% importance to institutional feasibility.

The grades and ranks for all instruments considered are presented in Table 7.

Table 7 - Preferences changes : three extreme scenarios

	Total preference on the environmental performance		Total preference on political and economic performance		Total preference on the institutional feasibility	
	Score	**Rank**	**Score**	**Rank**	**Score**	**Rank**
Auction reserve price	5,81	2	6,35	1	5,88	2
Surplus corridor indexed supply rule	5,34	3	5,53	3	6,14	1
Economic activity indexed supply rule	5,14	4	5,33	4	5,16	3
Overlap with other policies indexed supply rule	5,04	5	4,58	5	4,19	5
Rolling emissions cap	5,93	1	6,13	2	4,81	4

Source: based on authors' calculations

As presented in Table 7, the auction reserve price remains in first position in the political and economic scenario and in second position in both the environmental and institutional scenario. Thus, according to our results, overall it is an instrument that does reasonably well in all dimensions. A rolling emissions cap rivals it in the first two criteria, however, falls very far behind in the institutional scenario, thus suggesting that while it is a policy that could deliver political and economic performance and environmental performance, our panel viewed it as institutionally difficult to implement. The surplus corridor-indexed supply rule comes first in the institutional scenario because of its good evaluations on that criterion, but third in the environmental and political acceptability scenarios. Therefore, this sensitivity analysis suggests that in the single dimensional analysis, an auction reserve price would still be either the best or the second-best policy instrument to respond to our overall objective of improving the efficiency of the EU ETS by introducing supply flexibility.

On the other hand, we need to evaluate whether a change in priorities through the increase of a criterion's importance happens at the *expense* of another criterion. This would show if the policy ranking changes in a situation where one criterion was more important than another. We could then see if our results would be robust to other potential preference profiles.

Traditional sensitivity analysis

In this analysis, the weight coefficients of the main criteria are changed in the following fashion: we reduce the weights of one of the three main criteria gradually to 0 and add the reduced amount to another criterion while holding the third criterion constant. This could show if the original policy ranking was robust to a marked change in priorities. The coefficients of only the main criteria are changed because they influence the sub criteria weights indirectly thus making it unnecessary to change them as well (Blechinger and Shah, 2011). As mentioned above, there are 6 possible permutations. The following table summarises all 6 cases:

Table 8 – Weight coefficients changes: six scenario

Criterion	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
Environmental performance	-	-	0	0	+	+
Political and economic performance	+	0	+	-	-	0
Institutional feasibility	0	+	-	+	0	-
Change in ranking	No	Yes	No	Yes	No	Yes
Change of rank	-	2 &3	-	2 & 3	-	1 & 2
% after	-	9%	-	8%	-	100%
Change in optimal (rank 1) instrument	No	No	No	Yes	No	Yes
% after	-	-	-	100%	-	100%

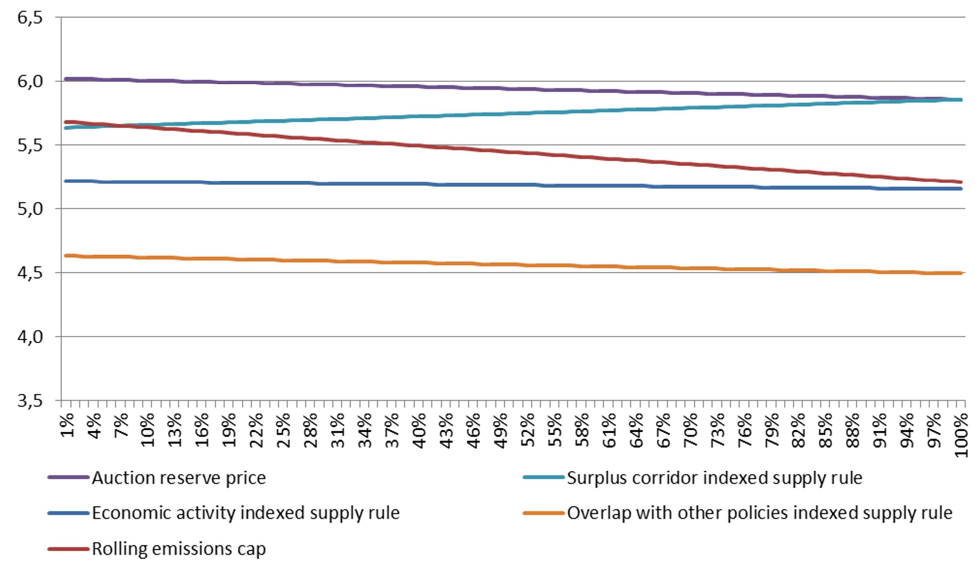
LEGEND: "–" criterion weight being reduced; "+criterion weight being increased; "0" criterion weight held constant

Source: based on authors' calculations

Table 8 reveals that results are quite robust with no changing in rankings reported for 3 cases and changes in the first best policy option in only 2 cases and that too with a 100% change. More specifically, most of the ranking change is between a rolling emissions cap and a surplus corridor-indexed allowance supply rule because of their relative closeness in terms of the final score (refer to Table 6). A rolling emissions cap is the second-worst policy option in terms of institutional feasibility while a surplus corridor-based supply rule is the best option in that criterion. Thus, in cases 2 and 4, where the weight of institutional feasibility is increased with respect to environmental performance and political and economic performance respectively, the supply rule climbs up the ranking.

However, neither a rolling emissions cap nor a surplus corridor-based supply rule dethrones an auction reserve price in 4 out of 6 cases. The following graphs describe the two cases where the first-choice policy option changes.

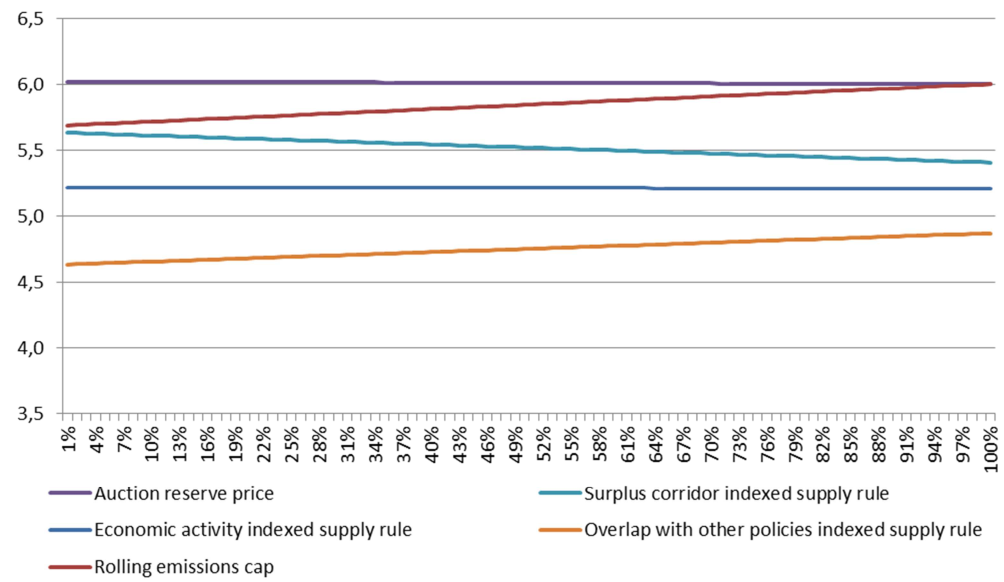
Figure 11 - Case 4: Increasing institutional feasibility's weight at the expense of political and economic performance (environmental performance weight held constant)



Source: based on authors' calculations

In the case where institutional feasibility is considered more important at the expense of political and economic performance (case 4), *only* when the second criterion's weight is decreased by 100% can a surplus corridor based supply rule overtake an auction reserve price. This is demonstrated in the above figure: the gains made by a surplus corridor indexed supply rule due to the increasing importance of institutional feasibility are not enough to offset the higher environmental performance of an auction reserve price.

Figure 12 - Case 6: Increasing environmental performance's weight at the expense of institutional feasibility (political and economic performance weight held constant)



Source: based on authors' calculations

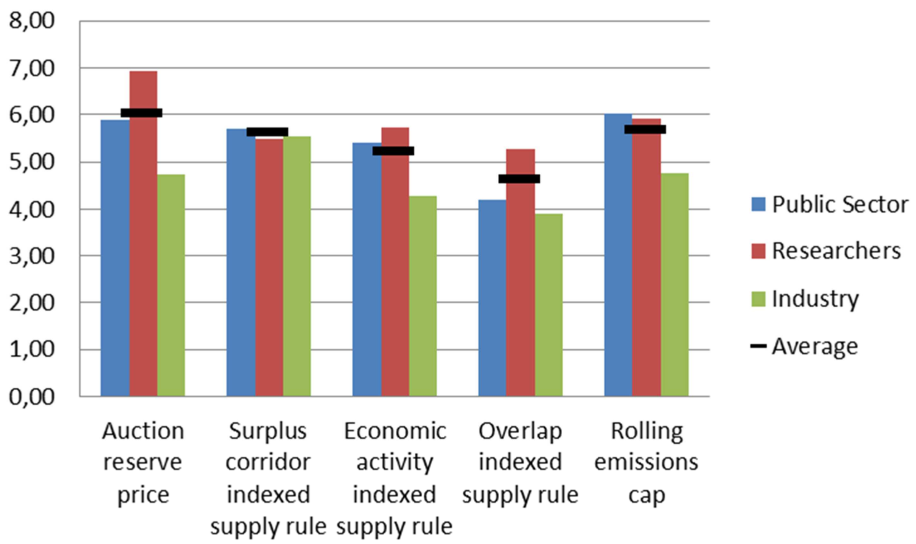
Similarly, in the case where environmental performance is considered more important at the expense of institutional feasibility, a rolling emissions cap can overtake an auction reserve price *only* when the third criterion's weight is decreased by 100%. This reflects the inability of a rolling emissions cap to offset an auction reserve price's higher political and economic performance even with high gains from environmental performance.

Thus, results are fairly robust and indicate that even with extreme changes of priorities, an auction reserve price would still be a high performing instrument in delivering supply flexibility and increasing the long term credibility of the EU ETS as an economic instrument to mitigate climate change.

Group sensitivity analysis: the policy ranking seems to depend on the stakeholder groups

The survey was sent to a large number of experts so that the average grade given to each policy option would be representative of the diverse preferences. However, it is entirely possible that different groups of stakeholders in the EU ETS evaluate the policy options differently. In this section we present the group specific results to examine whether the policy ranking survives for each stakeholder group.

Figure 13 - Results for each policy option by stakeholder group



Source: based on authors' calculations

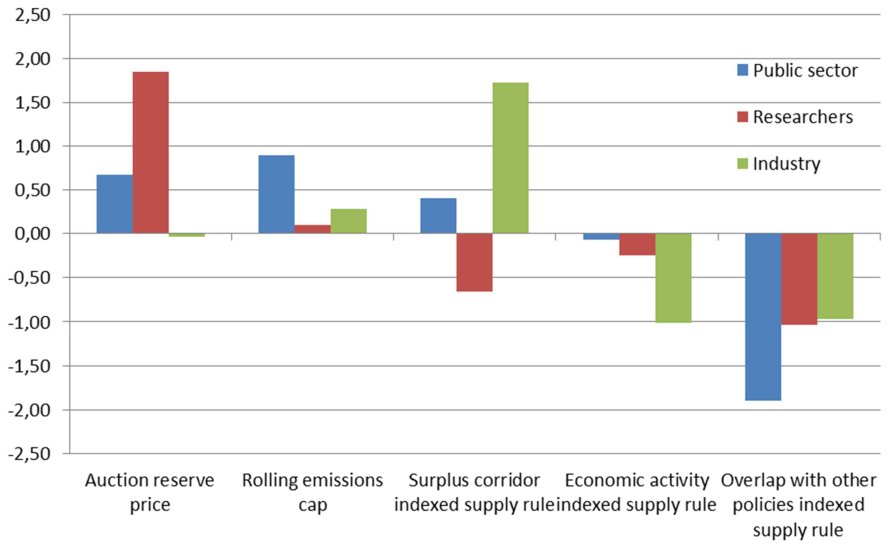
The above figure shows clearly that there is clearly a discrepancy between all three groups. The black bar is the average of all groups' results and the coloured bars indicate the group specific final score. The individuals having identified themselves as researchers have a *clear* preference for an auction reserve price (a score of almost 7). A comparison within groups, shows that the nearest competitor to an auction reserve price (a rolling emissions cap) is a distant second (with a score of almost 6).

On the other hand, industrialists view all policy options negatively but a surplus corridor indexed supply rule is evaluated as having a moderate to good performance. More importantly, an auction reserve price has a low score for this group with a rolling emissions cap being the second preferred policy option. Respondents identifying themselves as public sector also have a lower score for an auction reserve price than researchers but still relatively positive (a score of around 6). However the first best policy option for public sector representatives seems to be the rolling emissions cap, but not by much.

It is also interesting to note that all three groups have a fairly similar final score for a surplus corridor indexed supply rule but differ in their appraisals for all other measures, with either the industry group giving a lower score than researchers and the public sector (for an economic activity indexed supply rule and a rolling emissions cap) or researchers giving a higher score than the other two groups (overlap indexed supply rule). However, an auction reserve price is the only policy option where all three groups score differently.

This comparison however is basic. The three aggregated groups grade differently: the industry affiliated applicants generally grade lower than the others while the researchers grade higher than the other groups. Thus, it is of interest to standardise the scores.[12]

Figure 14 – Standardised scores



Source: based on authors' calculations

In the above figure, a negative score indicates that the stakeholders view the policy option as below average, while a positive score indicates that the stakeholder groups view the policy option as above average. What we can see is that the groups agree with each other regarding an economic activity indexed supply rule, overlap indexed supply rule and a rolling emissions cap even though the magnitudes are different. On the other hand, there is a marked preference for an auction reserve price for researchers and a marked preference for industrialists for a surplus corridor indexed supply rule. Furthermore, there is a pronounced preference against a surplus corridor indexed supply rule for researchers.

Finally, we also present an individual based standard deviation analysis:

Table 9 – Average grades and standard deviation

Instrument	Auction Reserve Price	Rolling Emissions cap	Surplus corridor indexed supply rule	Economic activity indexed supply rule	Overlap indexed supply rule
Average grade	6.02	5.69	5.63	5.22	4.63
Std. deviation	1.89	1.26	1.38	1.76	1.75

Source: based on authors' calculations

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[12] We utilize the following standardization scheme:

$$\frac{X-\mu}{\sigma}$$

where X is the variable, μ is the mean of the score for the group and σ is the standard deviation of the scores.Thus we standardize scores for all groups to mean 0 and standard deviation 1. This can allow us to make comparisons between groups because now the scores are on the same scale.

We calculated the final scores for each individual and report the average and the standard deviation for each policy instrument. The averages are the same as before. The standard deviation figures provide an interesting insight: an auction reserve price has the highest mean, but the highest variance as well.

Thus, scores really depend on stakeholder groups. An auction reserve price especially arouses a vast difference in opinion and thus its first position in the policy ranking could be compromised. These results will be analysed in the following sub section.

D. How to reform the EU ETS: the complex choice for the European Commission

As the three most preferred options are the auction reserve price, a rolling emissions cap and a surplus corridor indexed supply rule, only these policy instruments will be discussed in this section. The other two options are always 4th and 5th and thus, to save space and time, we have chosen to omit them from further discussion.

Certainty preferred to ambiguity and automation preferred to discretion…

According to the results of our study, an auction reserve price responds best to the overall objective of increasing the efficiency of the EU ETS through the introduction of flexibility in supply. This is mainly so because of its good grades overall. An auction reserve price is graded very well for its environmental performance. This is so because it would increase the allowance price unambiguously, thus inducing more emission reductions now instead of in the future. A reserve price that is higher than current prices would have a smoothing effect on emission reductions. It would become optimal to reduce more now versus later. It also receives high grades for dynamic efficiency, which in our study is defined as the ability of the carbon price to integrate future expectations. This is so because the soft price collar that an auction reserve price establishes would provide an "optimal" pathway for the carbon price that would align future expectations accordingly. A reserve price is also seen as resilient as it unequivocally targets price, independently from the state of the economy. Furthermore, a higher grade for political credibility was also observed, implying that a carefully chosen reserve price would be credible in the market and also signal regulators' commitment to the EU ETS, thereby increasing the long-term credibility of the mechanism. Finally, this policy instrument also receives higher than average grades for its impact on public finance because of its potential to deliver higher auction revenues. On the institutional side, the instrument receives lower grades than a surplus corridor indexed supply rule for timing and implementation capacity, but receives *higher* grades for financial feasibility. This could perhaps be because the respondents view an auction reserve price to be a simpler instrument to implement even if institutional capacity is low at the moment.

The explicit price certainty that this instrument offers is a definite reason as to why it does well overall. The ability to target a price pathway greatly reduces uncertainty and the regulators' commitment that this price certainty implies, goes a long way in delivering much needed credibility in the system. This is also a measure that most ETS systems in the world follow, and the EU ETS is one of the few schemes that doesn't. The implementation of a different instrument could cause further complications when linking with other ETSs. On the other hand, while its institutional performance is lower than a surplus corridor, an auction reserve price does better than expected on this criterion. We see several reasons for this. Firstly, the difficulty in choosing the "right" price pathway is obvious and results in lower grades in implementation capacity. Secondly, due to this difficulty in choosing the right prices, a reserve price is expected to take longer to implement. However, because of its simpler nature and the lack of a need to collect vast amount of data it gets a much higher grade for financial feasibility.

A rolling emissions cap is second according to our analysis. Good scores on environmental performance and political and economic performance prop its position in the ranking. The ability to change the cap could result in a similar environmental performance than an auction reserve price but through changes in the total emissions allowed. A cap that is tighter now than it was a few years back would automatically reduce allowance supply and constrain the market thus reducing the surplus. A rolling emissions cap also receives higher grades for dynamic efficiency as the possibility of refreshing the cap results in the carbon price reacting optimally to current and future scarcity. Furthermore, this option also receives good scores for cost efficiency suggesting that the carbon price increase would be more gradual than that for an auction reserve price. This instrument is also seen to be very resilient because the total quantity of allowances available can respond to external shocks and can be updated yearly. On the other hand, it is not viewed as institutionally feasible getting the 4th best grade out of 5 instruments. It does worse on all three sub-criteria than an auction reserve price and a surplus corridor indexed supply rule.

Similarly to the auction reserve price, a rolling emission cap owes much of its performance to the quantity certainty that it provides. Instead of providing a price pathway as a reserve price, a rolling emissions cap would instead provide the optimal interventions on the emissions pathway by updating annually the number of allowances available over the entire time period. This is different than a supply rule because for the latter the total allowances available (decided through the cap) is the same while the amount of allowances in the market changes according to the rule. For a rolling emissions cap, the cap itself changes. This is a much more direct intervention and aligns the market's long term expectations accordingly. On the other hand the abysmal grades for institutional feasibility can be attributed to the fact that this instrument requires a much higher amount of delegation. While the auction reserve price requires some delegation because of the need to choose the price, a rolling emissions cap on the other hand is much more discretionary because of the need to update the cap manually each year. It is perhaps for this reason that it ranks lower in institutional feasibility.

A surplus corridor-indexed supply rule is generally third after a rolling emissions cap and an auction reserve price. It gets moderate grades with respect to environmental and political and economic performance but does better for institutional feasibility. More specifically, while it gets moderate evaluations, its performance regarding direct emission reductions, dynamic efficiency, impact on public finance and resilience is lower than that of a rolling emissions cap and an auction reserve price. Politically, it is seen equivalently credible as a rolling emissions cap but lower than an auction reserve price. Institutionally, this mechanism does better than all others, but receives a marginally lower grade for financial feasibility than an auction reserve price.

This is because a supply rule that is indexed to cumulative surplus does not provide either quantity certainty (like a rolling emissions cap) or price certainty (like an auction reserve price). This results in ambiguous evaluations regarding political and economic performance. While it would be easier to implement because of the automation inherent in the mechanism, the effects on price are hard to quantify, and since the cap remains the same but allowances are added to a reserve, total quantity available to the market is also not very easy to predict.

Thus, overall we can conclude that the respondents to our survey showed a preference for certainty over ambiguity. That is, they preferred instruments that offered flexible supply *and* price or quantity certainty, over instruments that provided a blurred influence on price or quantity. Furthermore, the high institutional feasibility grades for a surplus corridor supply rule and an auction reserve price compared to a rolling emissions cap means that automation is preferred to discretion.

But not for everyone: the difficult consensus to achieve between stakeholders!

As noted in the sensitivity analysis, these results may not hold for all stakeholder groups. For the public sector, rolling emissions caps are marginally better than an auction reserve price. This is because an auction reserve price does much worse on environmental performance, cost efficiency and static efficiency but does better on institutional feasibility. This could signal a preference for measures that are not based on price since they are seen to distort market fundamentals (thus lowering static efficiency, i.e. the ability of the carbon price to react to short-term drivers) and increasing carbon leakage concerns (thus a low performance for cost efficiency). Thus, the public sector respondents signalled a preference for quantity certainty over price certainty.

For industry respondents, on the other hand, an auction reserve price and a rolling emissions cap both do worse than a surplus corridor indexed supply rule on *all* criteria. Rolling emissions caps and auction reserve prices are also not seen to be politically credible. This indicates a deep mistrust of measures that need human input to choose the right price or quantity. They would instead prefer an automatic rule-based measure, specifically one that is indexed to the cumulative surplus. This implies a preference for ambiguity over certainty as a supply rule has a way more indirect effect on prices and does not change the cap at all.

Finally, there is one important point to be made: overall an auction reserve price does so well because of two reasons. Firstly, there are more researchers in the final panel than the other two groups. This means that their preferences are overrepresented in the final result. However, as the standardised scores show, even with an equivalent number of respondents from all groups, an auction reserve price would be likely to do better than a surplus corridor indexed supply rule. Secondly, there is a possible selection bias in our survey: it is possible that people who are against the commission's legislative proposal (that is very alike to the cumulative surplus indexed supply rule) or in favour of a price based mechanism were more likely to agree to respond to this survey.

Thus, while there is considerable support for a price based flexible supply mechanism and it does have attractive features that respond to dynamic efficiency, resilience, political credibility, timing of mechanism, financial feasibility and direct effect on emission reductions, one must remain cautious because a significant group of stakeholders consider it difficult to choose the right credible price that could improve EU ETS effectiveness without placing unnecessary additional burden. Finally, we can also suggest that an auction reserve price is not incompatible with an adjustment mechanism based on overallocation. A combination of both measures would need some clarification on the way unsold allowances at an auction would be quantified to evaluate the surplus on the market, but could reinforce both certainty on the future carbon price and credibility of the all cap and trade system:

IV. CONCLUSION

This study has proposed a novel methodology to evaluate the structural reform options of the EU ETS inspired by previous literature on multi criteria analysis methods. We sent out a survey based on our multi-criteria analysis methodology to a panel of experts of the EU ETS (members from the public sector, industry, researchers and NGO's). From the 33 responses that we have received, we have analysed their individual preferences on the priorities of the main objective of improving the effectiveness of the EU ETS by introducing supply flexibility and the instruments that can be used to achieve the same.

Main conclusions

The primary conclusion of our study is that an auction reserve price is evaluated as the best instrument to improve EU ETS effectiveness by introducing flexibility in the supply of allowances. This contributes to the debate on the best policy instrument to reduce carbon emissions. While traditionally economists have focussed on the choice between a carbon tax and a cap-and-trade scheme, recently some have also introduced a "hybrid" instrument. This hybrid instrument is our first policy option: a cap-and-trade system coupled with a soft price collar. It has been argued (Goulder and Schein, 2013; Philibert, 2009) that such a hybrid system would outperform a plain vanilla cap-and-trade system. Our results reinforce this belief. This is because this instrument would enforce a clear price pathway by managing supply accordingly. This greatly reduces uncertainty and could inducemore investments required to transition to a low carbon economy. Another important point about a price-based mechanism is that if linking with other ETSs is a future goal, the EU ETS may be one of the only ETSs without a price-based flexible supply mechanism, which would significantly hamper the process. Our results provide policy makers with some food for thought.

There is thus support for a price-based instrument according to our results. However, there is also reasonable support for an instrument that provides more quantity certainty. Rolling emissions caps do as well as an auction reserve price on environmental performance and political and economic performance. This is because of their good performance regarding direct effect on emission reductions, static efficiency, dynamic efficiency, cost efficiency and resilience. However, it is not evaluated to be institutionally feasible. This is important as well, because a rolling emission cap is the only active discretionary instrument that we have considered.[13] Our results indicate that a measure that provides for flexible cap setting is considered quite effective but would be hard to implement.

A surplus corridor indexed supply rule is the instrument from our analysis that is closest to the one suggested by the EU Commission with its legislative proposal of Market Stability Reserve on 22nd January 2014. As such, there is very little academic literature behind such a rule and thus not many frameworks through which its effects can be analysed. From our study, we conclude that the respondents view this policy as ambiguous in its effect on price, and thus on direct effect on emission reductions and dynamic efficiency, and ambiguous in the total quantity that it supplies (since the cap does not change but short term supply does), which affects its grades regarding resilience and political credibility (as it is not as well equipped to deal with exogenous shocks as the previous two policies).

Limitations and future research

On the other hand, there are some caveats to our analysis. Firstly, if institutional feasibility was the most important criterion, the current EC legislative proposal would match the preferences of our respondents. Furthermore, our results are not completely robust to group heterogeneity. Industry respondents evaluate the option most close to the EC's proposal the best, so ranking depends on the composition of the sample. However, as argued by Hepburn (2006), industry has a strong preference for instruments that "transfer income towards (at least not away) from its shareholders and enhance market power". Thus, it could perhaps be that industrial stakeholders *prefer* ambiguous instruments against policy instruments that provide explicit price and/or quantity certainty.

Continuing on the previous point, the makeup of our panel probably did bias the result in favour of a reserve price. Researchers outnumbered public sector and industry affiliated respondents and they overwhelmingly preferred an auction reserve price to all other policy instruments. This is to an extent tackled by the standardisation of scores: even with an equal number of researchers and industrialists an auction reserve price would still be very likely to do better than a surplus corridor indexed supply rule. Furthermore, there is an issue of selection bias: people who preferred a price mechanism or disagreed with the EC's proposal were perhaps more likely to respond to our survey thus driving our results.

Finally, our study is a multi-criteria analysis, which means it doesn't decide, but provides a clearer framework to help decision-makers decide. In that light, according to the preferences of our respondents, a price based mechanism aggregates all individual preferences quite well. The point of the study is not to provide a representative sample, but we did target it to well-known experts from all groups. The end result provides valuable feedback in the ongoing debate of the structural reform of the EU ETS.

Further research is however needed to develop an economic framework through which all potential instruments can be analysed and compared. We rely on subjective evaluations by survey respondents since objective data is not available. However, survey responses remain a second best option. Trotignon et al. (2014) provide some scenarios where they analyse a cumulative surplus indexed supply rule, but because of the difficulty in modelling market expectations and behaviour, a comprehensive framework for modelling that particular instrument is lacking. Furthermore, it is also difficult to model discretionary mechanisms, which means a rolling emission cap is also difficult to model. However, with the development of such a framework, all instruments mentioned in this study could be analysed and the results compared, either using a multi criteria analysis methodology or simple comparison.

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[13] As explained earlier, this is because it is hard to compare institutions to mechanisms. A rolling emission cap is a mechanism that requires a specific institutional structure that possesses a lot of discretion, and is thus, as such, the mechanism in our analysis closest to the Carbon Central Bank as suggested by de Perthuis and Trotignon (2013).

V. APPENDIX

A. Synthesis of various flexible supply mechanisms

	Soft price collar: the price ceiling/floor		
	Definition	**Advantages**	**Disadvantages**
Price mechanisms	• A range of prices around which the actual price of carbon permits is allowed to oscillate. • Buyers are subject to a minimum auction price, below which no auctions will be held. • Allowances not auctioned off are moved to a reserve which auctions them back in case a ceiling price is hit.	• Establishes a symmetric price collar thereby providing price certainty and giving firms and industry a clear long-term carbon price signal, thus delivering dynamic efficiency (Frankhauser and Hepburn, 2010). • Can guarantee minimum abatement efforts, at a price floor and can cap costs at a price ceiling (Wood and Jotzo, 2011). • Price ceilings enhance credibility because it caps the costs of compliance (Frankhauser and Hepburn, 2010). • No price floor is established but secondary market prices are "guided" towards the "optimal" levels (Wood and Jotzo, 2011)	• The decision on establishing the optimal price floor and ceiling is very political in nature and subject to lobbying and rent seeking (Frankhauser and Hepburn, 2010). • This method would defeat the principle of market price discovery and could potentially distort markets. • This method only works if a significant amount of permits are auctioned (Wood and Jotzo, 2011). • There are potential problems in linking two ETS's together if they do not both have an auction reserve price (Frankhauser and Hepburn, 2010).
	Hard price collar		
	Definition	**Advantages**	**Disadvantages**
	• Same as above, but now reserve sizes are infinite: regulator commits to adding or removing an infinite amount of permits from/to the market.	• There are little additional benefits compared to the first policy option (Burtraw et al., 2010).	• If the price remains at the ceiling for long, it implies a loosening of the cap, and if the price remains at the floor for long, it implies a tightening of the cap. Thus, this policy could change the ambition level.
	Call and Put Option Contracts		
	Definition	**Advantages**	**Disadvantages**
Financial mechanisms	• Regulator offers free allocation of permits and a menu of plain vanilla call and put options to installations. • This menu approximates the marginal damage function and results in a flexible supply contract.	• Perfectly mitigates the inherent uncertainty in the market and approximates a flexible supply curve which is the same as the marginal damage function for single periods (Unold and Requate, 2001). • Ensures sufficient liquidity and a high degree of flexibility (Unold and Requate, 2001). • Provides the most cost efficient method for firms to abate their carbon emissions (Unold and Requate, 2001).	• Requires complete overhaul of the EU ETS. • Question of who issues and converts these options into permits is not clear. • Firms will only execute those options with the striking price lower than or equal to the equilibrium permit prices: if equilibrium permit prices are low, they are not bound to increase by much (Unold and Requate, 2001).

	Put Options for low carbon technology investors		
	Definition	**Advantages**	**Disadvantages**
	• Regulator offers investors in low carbon technology put options to guarantee a high enough future carbon price for their investments.	• A higher current carbon price if market participants rationally update their expectations of future ETS credibility. This will result in lower risk premia because of lower regulatory uncertainty (Zachmans, 2013).	• Implies “choosing” low carbon technology ex-ante • Can have a negative effect on the taxpayer (if the difference between the striking price and the carbon price is large and positive).
Quantity mechanisms	**Emission based permit supply rules**		
	Definition	**Advantages**	**Disadvantages**
	• Yearly permit supply is defined by a function based on verified past data on allowance surplus/shortfall and emissions. • If the cumulative surplus in the entire market is above a threshold, allowances are removed from the market and added to a reserve. If the cumulative surplus is below a certain threshold, the reserve releases allowances back into the market.	• As supply is determined by an adjustment rule, firms face certain expectations, thus reducing the uncertainty in the market. This contributes to the establishment of a price signal as well (Newell et al., 2005). • Allow sufficient liquidity on the market so that utilities can hedge demand concerns (IETA, 2013). • Automatic adjustment based on a rule, thus credible (as long as rule not changed) and requires much less discretion. • This mechanism would be easier to implement institutionally.	• A simple correction mechanism that does not take into account price effects of past supply decisions would result in over or under correction (Newell et al., 2005). Permit supply rules could render carbon prices counter-cyclical (Sartor, 2012). • To establish the right thresholds for intervention would require additional data from industry that would be time consuming to collect but also difficult to procure, keeping in mind firm level considerations (IETA, 2013). • The provision of a long term price signal is dependent on whether actors form rational expectations that the price would rise in the future (Murray et al., 2009).
	External variable based permit supply rules		
	Definition	Advantages	Disadvantages
	• Adjusts permit supply on the basis of external triggers such: GDP figures, industrial production figures, energy prices. • Triggers will be defined for each of these external variables and permit supply will be adjusted accordingly.	• There is better data available on external factors such as GDP with more frequency thus helping the permit supply decision. • If the correlation between the external variable and ETS emissions is high enough, indexed quantities (permit supply rules based on external variable) will be strictly preferred to price policies (carbon tax) or pure quantity policies (emissions cap) (Newell and Pfizer, 2008).	• Risks procyclical policy: less supply in years of recession and more in years of booms. • Potential high negative impacts: if variable GDP, competitiveness might be hurt. • Very few variables with a high correlation with emissions (not industrial production or economic activity). • Institutionally could be hard to implement if external variable a very sensitive one such as GDP.

	Rolling Emissions Cap		
	Definition	**Advantages**	**Disadvantages**
	• Fixed 5-year emissions cap, which is annually updated 5 years in advance for each subsequent year • But always consistent with a longer-term reduction target already fixed by the regulator/parliament. • Feature of the Australian ETS attempts to combine a lagged flexibility to respond to unforeseen events by supply-side adjustment with some kind of predictability and credibility about the emissions pathway.	• Provides a clear long term commitment to carbon markets. • Thus, improves considerably on dynamic efficiency. • Can improve environmental goals if emission caps are increasingly strengthened, and by providing a long term target.	• Very discretionary and thus vulnerable to political pressure and rent seeking. • If caps are not consistent, credibility could be lost. • Institutionally very infeasible because of the discretionary nature of the mechanism.

Source : CDC Climat Research, 2014

B. Multi-criteria methodology adapted for this application

Decision theory assumes that decision makers (DM's) wish to remain logical and coherent in their decision making processes. That is, preferences are consistent (Dodgson et al., 2009), and expanding on this notion of consistency, other principles of well-defined preferences are put forth. Using the set of axioms established by these principles, Keeney and Raiffa (1976) establish three theorems of decision theory:

- The first theorem establishes the existence of probabilities that define the likelihood of an event occurring.
- The second theorem establishes the existence of "utilities", the "well being" or "subjective value" that an instrument offers to the decision maker.
- The third theorem establishes that the decision maker should choose the instrument that provides the greatest sum of weighted utility.

Thus, there are two things that one needs to establish in an MCA: the probability and the utility. Then a weighted sum over all possible consequences of a course of action provides the expected utility for that course of action.

We used the AMS methodology developed by Konidari and Mavrakis (2007) to analyse environmental policy decisions. Since that has been covered in great detail in their paper and in Blechinger and Shah's (2011) paper as well as Clo et al.'s (2013) study, we provide only a cursory description here. However, to aggregate individual preferences on the criteria we had to adapt another method inspired from Frei and Harker (1999). This shall be explored in much greater detail.

AMS methodology

The MCA used in this paper consists of the analytical hierarchical process (AHP) to weigh the criteria and the sub criteria and the Simple Multi Attribute Ranking Technique (SMART) to grade the mechanisms. This technique was selected mainly because of its prior application in climate policy decision problems, including Clo et al.'s (2013) study on the reform of the EU ETS, as well as a low need for input-data and the ability to involve a panel of stakeholders.

The AHP procedure is used to compare all criteria pairwise using the scale as presented in the following table:

Table 10 - Analytical Hierarchy Process scale

Preference score	Definition
1	Equally important or preferred
3	Moderately important or preferred
5	Strongly important or preferred
7	Very strongly important or preferred
9	Extremely important or preferred
2, 4, 6, 8	Intermediate values

For example, if comparing two criteria x1 and x2, the decision maker deems x1 to be moderately important or preferred to x2, he/she will mark a 3. In case x2 is preferred to x1, the multiplicative reciprocal, i.e. 1/3 will be marked. The decision maker will do this pairwise ranking for all n criteria. All responses will then be used to construct an nxn matrix. Using Saaty's (1990, 2006, and 2008) method we can then calculate the weights.

However, we decided that the survey would be too complex to compare all criteria pairwise. Instead, using Blechinger and Shah's (2011) 0-5 scale presented in the following table, we asked respondents to grade each criteria separately.

Table 11 - Survey criteria grading scale

5	4	3	2	1	0
Extremely Important	Very Important	Moderately Important	Slightly important	Not important	Absolutely not important

Using Frei and Harker's (1998) method, we modified the responses as follows:

We compared the grades of two criteria on the same branch (for example environmental performance and institutional feasibility). Let us denote them by x1 and x2. If the difference between x1 and x2 (x1-x2) was:

- 5, we marked 2 under x1-x2
- 4, we marked 1.8 under x1-x2
- 3, we marked 1.6 under x1-x2
- 2, we marked 1.4 under x1-x2
- 1, we marked 1.2 under x1-x2
- 0, we marked 1 under x1-x2
- -1, we marked 0.8 under x1-x2
- -2, we marked 0.6 under x1-x2
- -3, we marked 0.4 under x1-x2
- -4, we marked 0.2 under x1-x2
- -5, we marked 0 under x1-x2

We call these figures the win/loss count. A value of greater than 1 indicates a victory and a value lower than 1 indicates a loss. The magnitude of victory and loss is also recorded (by 0.2 increments). We did this for all possible combinations and for every panel member. We summed up these figures for all panel members and constructed an *nxn* matrix (*n* is the number of criteria in that particular branch of the criteria tree) using the sums. We then used Frei and Harker's (1998) formula[14] to convert the win/loss sums to the AHP scale. We then proceeded as Saaty (1990, 2006, and 2008) and calculated the weights.

After having calculated the weights, we calculated the final score for all instruments by:

- calculating the average grade given to each instrument on each criteria
- multiplying the arithmetic average of the grades on each criteria to the weight calculated
- adding all terms up over all criteria.

[14] The reader is requested to read the original paper for more details. The formula is as follows:

$$e^{\ln(9)\frac{w_{ij}-w_{ji}}{w_{ij}+w_{ji}}}$$

where w_{ij} and w_{ji} are the sums of x_i-x_j and x_j-x_i respectively. This formula scales the win/loss matrix to the AHP scale.

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