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The Carbon Market in 2020

Volumes, Prices and Gains from Trade

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Abstract

Carbon markets are central to the global effort to reduce greenhouse gas emissions. This paper introduces a new carbon market model that aims to simulate the development of the global carbon market over the next 10-20 years. The model is based on detailed regional and sectoral marginal abatement cost data and takes an "investor perspective". That is, it takes into account market distortions like taxes and accounts for imperfections in policy delivery. We estimate that implementing all the carbon market proposals that are currently contemplated would result in global emission reductions of 7 GtCO2 by 2020 – substantial, but well short of the mitigation effort required for a 450ppm CO_2e pathway. The global carbon price would vary from €30 per tCO_2 in Europe to €15 per tCO2 on the international offset market and in the new US emissions trading scheme currently under discussion.

Keywords: climate change mitigation, carbon markets, CDM, EU ETS

JEL codes : G15, Q47, Q54, Q58

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1. Introduction

Carbon trading has emerged as one the key policy instruments in the fight against climate change. Economists have long argued that putting a price on carbon is an essential and effective way to curtail greenhouse gas emissions.[1] In theory, this can be achieved either through a tax on carbon emissions or a cap-and-trade scheme, where a restricted number of emission allowances is traded on dedicated markets. The relative merits of the two approaches is still debated in the literature,[2] but in practice policy makers have overwhelmingly opted for cap-and-trade.[3] They are swayed by the political economy advantages of carbon trading, for which political support is much easier to build (Hepburn 2006, 2007).

In 2008 the global carbon market was worth $126 billion – twice as much as in 2007 and four times as much as in 2006 (Capoor and Ambrosi 2009). Thanks to growing trading volumes (which offset depressed prices) 2009 promises to be another record year. The biggest market by far is the EU Emissions Trading Scheme (EU ETS), which accounts for over 70% of activity. The Clean Development Mechanism (CDM), the world's biggest baseline-and-credit (or offset) market, accounts for around 25%, most of it secondary market transactions. Smaller schemes like Joint Implementation, international emissions (or AAU) trading or the voluntary carbon market and regional systems, for example, in New England and New South Wales, contribute the rest.

These schemes could all be dwarfed by a new federal US cap and trade scheme that is currently being debated by Congress and which observers expect could be up and running within five years. Carbon trading is also being deliberated in Australia, New

[1] See for example Fisher et al. (1996) for an early articulation, and subsequently Stern (2006), among others.
[2] See Hoel and Karp (2001), Hepburn (2006) and Newell and Pizer (2003). The classic reference is Weitzman (1974).
[3] A prominent supporter of taxation is Nordhaus (2005).

Zealand and – to a lesser extent – Canada, Japan and Mexico, among others. Meanwhile, the negotiations on the international climate change regime post-2012 may well result in an extended scope for global carbon trading, for example through an enhanced CDM and new trading instruments for forest-based carbon or international transport emissions.

This paper asks how the international carbon market may develop over the next ten years if these systems are put in place as currently contemplated. The analysis is based on a new carbon market model, which extends and draws on previous work by McKinsey (2009) on the cost of greenhouse gas mitigation.[4] The model uses differences in marginal abatement costs between countries and sectors to calculate potential trading volumes, gains from trade and the equilibrium price of carbon in different market segments.

Using marginal abatement cost estimates to simulate arbitrage opportunities is a fairly common piece of analysis. Most regionally disaggregated energy-economy models and integrated assessment models function in that vein, using either top-down (production function-based) or bottom-up (engineering-based) cost information.[5]

An important feature of our model versus other (particularly top down) energy models is the granularity of the abatement data, which is modeled by lever/technology, by industry and by region. Detailed and consistent cost information allows us to model individual policy proposals at much higher resolution than other models and isolate the consequences of detailed policy choices, such as constraints on the use of forestry offsets or regulatory policies to force renewable energy uptake (two prominent features of the EU's climate change and energy package).

Further real-world flavor is added by incorporating policy distortions (such as most taxes and subsidies), firm-level constraints (such as high costs of capital) and limits to the uptake of some abatement options (for example due to insufficient or poorly

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[4] Other sources of "bottom up" marginal abatement cost data include for example AIM (Kainuma et al. 2007), GAINS (Amann et al. 2009b), IMAGE (Bouwman et al. 2006) and POLES (European Commission 1996, Russ et al. 2009). See also Amann et al. (2009a).

[5] See for example the results of the EMF-22 model comparison (Clarke et al. 2009) and the IPCC mitigation cost discussion (Barker et al. 2007a). For a critical assessment of the use of MACs see Morris et al. (2008).

executed policies). In other words, our analysis takes an *investor perspective*, rather than the social planning perspective typical of economic models. We are less interested in the theoretical economic potential of carbon trading than in the actual financial flows, trade volumes and carbon prices that may materialize in the real world.

We start our discussion, in the next section, with a brief description of the carbon market model on which the analysis is based. Section 3 then looks at likely carbon market developments up to 2020, based on the implementation of the policy proposals on the table in summer 2009. These proposals are still in flux and bound to evolve. Section 4 therefore highlights the sensitivity of market developments to some pertinent policy choices, in particular the overall level of ambition and the degree of trading flexibility over space (through linking) and time (through banking / borrowing). Section 5 concludes.

2. Modeling the carbon market

Trade in carbon emissions is driven by differences in abatement costs. The larger the differences in costs, the larger the scope for trading and the bigger the gains from trade. At the core of our carbon market model are the detailed marginal abatement cost data gathered by McKinsey and summarized in version 2 of its global cost curves (McKinsey 2009).

McKinsey's cost curve model is a bottom up, microeconomic model that assesses the technically available abatement potential versus a business-as-usual (BAU) reference case solution. It does so at a granular level – covering approximately 200 technologies, in 13 sectors, and 21 regions. The G8+5 nations are covered individually, with a further 8 regional assessments ensuring global coverage.

The carbon markets model splits the original cost data further into different carbon market segments: international emissions trading among governments (the AAU market), domestic cap-and-trade markets in Annex 1 countries (including the EU ETS, and the new US trading system) and the international offset market (a reformed and expanded CDM, say). Separate cost curves were derived for "traded sectors" that are expected to be covered by the various carbon markets and non-traded sectors that are likely to remain outside. The analysis also accounts for regulatory policies that mandate particular abatement options, such as energy efficiency standards in buildings and renewable energy targets.

The original McKinsey cost curves are estimates of the economic potential for cost-effective GHG mitigation. For the current purpose, this economic perspective was replaced by an investor perspective. This required two adjustments.

First, economic costs were translated into financial costs by introducing existing policy interventions like fuel taxes and energy subsidies (such as feed-in tariffs). Financing constraints were introduced by replacing the social discount rate of the original cost curves (4 % real) with a higher, differentiated rate (on average 11%) that reflects firms' actual costs of capital – varying by industry and geography.[6]

The net effect of these corrections typically is to make the cost curves steeper. Energy efficiency measures with negative costs tend to become even more attractive if energy is subject to tax,[7] while the higher cost of capital increases the cost of capital-intensive investments like renewables. There are also some changes in the merit order, as measures with particularly high upfront costs become more expensive and move further up the cost curve.

The second adjustment acknowledges limits in policy effectiveness. Rather than assuming the full implementation of all cost-effective mitigation options, as the original cost curve implicitly does, our analysis recognizes that the uptake will be less than perfect as a result of insufficient policy ambition, ineffective policies and poor execution. This is similar to the approach taken by the UK Committee on Climate Change, which also distinguishes between technical / economic potential and actual uptake, which is a function of the policy environment (CCC 2008).[8]

[6] Discounting is one of the most controversial issues in climate change economics. A good synthesis is Dasgupta (2008).

[7] The inverse happens in countries with energy subsidies, still a frequent occurrence in many parts of the world.

[8] Of course, policy makers anticipating an imperfect uptake of policies may ramp up their measures to counterbalance that effect.

To do so we made an assessment of the current policy proposals in each of the 21 regions and 13 sectors of the model. Each of those proposals was rewarded a policy ambition score, which scaled the abatement potential (see Chart 1). These policy ambition scores are based on a literature study of the effectiveness of climate change policy. Further, each country was awarded a policy execution score, which is based on McKinsey staff assessments informed by a range of governance indicators.[9] The technical abatement potential was then multiplied with the two factors in order to derive an assessment of the achievable abatement, given expected government policy effectiveness. Note that this does not include the expected outcome of the carbon market, which effectively provides the financing for the positive cost measures.

The result of this adjustment was to reduce the uptake of cost effective measures to 24 GtCO2 in 2030, compared with a technical potential of 38 GtCO2 in the original analysis (see Chart 2). Alternative assumptions on policy effectiveness will be introduced in section 4.

The model is solved over four steps (see Chart 3). The first step is to balance supply and demand in the international offset market. Second, the regional cap-and-trade systems are balanced using the market-clearing offset price calculated in step one. Third, the AAU price is set equal to the offset price. These steps allow us to calculate the prices in each of the markets, the amount of (domestic) abatement achieved as well as the trading with other markets (typically import of international offsets).

In the fourth step banking and borrowing is introduced, assuming a five-year time horizon for companies under a cap. That is, companies are assumed to bank (borrow) allowances, if the expected price five years later is much higher (lower) than in the current year.

Since banking and borrowing of allowances can increase or reduce the offset demand in the given year, an iterative algorithm is used. Linkage of carbon markets (beyond the international offset market) is possible, but not set in the default model.

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[9] UNDP (2004) provides a useful survey of available governance indicators.

The international offset market is the key market mechanism in the model, balancing global supply and demand across markets. The offset supply curve depends on sectors and regions participating in the offset market, policy effectiveness, and rules governing eligible offsets (for example, NPV-positive levers may be excluded as non-additional).[10]

For each of the regional cap-and-trade systems, the demand for international offsets is dependent on the offset price assuming that companies will always choose the cheapest option between regular allowances, abatement under the cap-and-trade system, domestic offsets, international offsets and, where applicable, strategic reserve allowances. The offset demand on a country level (as opposed to the cap-and-trade system) is assumed to be inelastic and is calculated as the gap between a country's reduction target and the abatement achieved through domestic actions (both inside and outside a cap-and-trade system) after perfect AAU trading.[11]

3. The carbon market in 2020

The first application of the model was to analyze carbon market developments under a "Follow me" scenario, that is, the expectation that the low range of all currently announced or proposed policies will be implemented. More specifically, we considered carbon market policies as contemplated in summer 2009 (see Table 1 for details). The scenario was derived from a range of policy documents, including the December 2008 climate change and energy package of the EU and the Waxman-Markey bill (version passed by the House of Representatives) in the US.

The scenario foresees the establishment or expansion of national cap -and-trade schemes in Europe (EU and neighboring states like Iceland, Norway and Switzerland), the US, Australia and Canada. It foresees an expanded global baseline-and-credit (or offset) market modeled on a reformed CDM and the continuation of international emissions (or AAU) trading between Annex I governments. The various cap-and-trade markets are not linked, although they are all connected to the global

[10] See IETA (2008), Michaelowa and Pallav (2007), Michaelowa and Umamaheswaran (2006), Streck and Lin (2008) and Wara (2007) for a discussion of CDM additionality and CDM performance.
[11] We ignore the effect of penalties for non-performance.

offset market and AAU trading, which creates an indirect link. Importantly, we assume that avoided deforestation (so called REDD) offsets are only eligible and available to a limited extent.

The main results are summarized in Chart 4. In the AAU market, the Annex-I cap-and-trade caps total an estimated 16.7 GtCO2 in 2020 and 12.6 GtCO2 in 2030. Of the abatement required to meet these targets in the developed world, about two thirds will be realized domestically, with the remainder through offsets. Offsets are the price-setting (i.e., marginal) supplier of abatement to developed world, suggesting that AAU prices will be equal to offset prices.

The EU ETS has 1.7 GtCO2 of emission allowances in 2020 and potentially 1.4 GtCO2 in 2030. The majority of the required abatement to meet these targets is realized domestically, as the offset quotas are tight (about 1.6 GtCO2 over 2008-12). The tight targets and offset quotas means the EU ETS has the highest prices of all carbon markets, peaking at €40 per tCO2 in 2025. The price-setting abatement capacity is domestic. Banking of offsets can reduce the risk of price drops, but unlike the US ETS there are no other stabilization mechanisms in place.

The US ETS (as proposed in the Waxman-Markey bill) is assumed to be operational as of 2012. The market has 5.1 GtCO2 of emission allowances in 2020 and 3.5 GtCO2 in 2030. Initially most abatement is realized through domestic and international offsets (1 GtCO2 out of 1.4 GtCO2 in 2015), but over time domestic abatement starts to play a larger role (2.5 GtCO2 out of 4.1 GtCO2 in 2030). The US ETS market price will be set by offsets, even after taking into account the 4:5 discount rate that is currently contemplated.

The offset market is assumed to continue in the future, with avoided deforestation offsets remaining limited to 20-40% of global offset supply. Demand for offsets comes mainly from the US ETS and AAU countries.

Overall, carbon trading is estimated to trigger incremental investments of almost €800 billion between 2016 and 2020, much of it in electric power and transport, and over three quarters of it in China, the US and the EU.

Chart 5 displays price developments. It shows a substantial price differential between the EU ETS, where the allowance price could rise above €35 in 2025, and the international offset and US allowance prices, which we expect to increase to €23 by 2030. In Europe, where the use of offsets is constrained, the carbon price is determined by the marginal cost of domestic abatement, assumed to be various renewable energy technologies (for example, wind alongside fuel switching in 2015, solar alongside small hydro in 2020). In the US, which currently foresees a more liberal use of international offsets, the allowance price is expected to follow the (discounted) offset price, since offset purchases are the preferred abatement activity at the margin.[12]

It is important to note that in both markets, a large share of the abatement will be covered and achieved through mandated policies like the EU's Renewable Energy Directive. Chart 6 shows this in more detail for the case of the EU ETS. The chart shows the EU marginal abatement cost curve, reordered to give priority to mandated actions and to factor in the contribution of offsets. The chart also shows how the prevalence of cheap abatement opportunities encourages banking. We will come back to this issue in section 4.

The offset price, in the meantime, is kept low by a steady flow of low cost emission reductions in sectors like electric power, industry, forestry and waste (two thirds of it from China). In fact offset prices could remain almost constant over time as the growth in offset supply is in line with growing demand (see Chart 5 above). But even at this relatively low price offset trading is a financially attractive activity, creating substantial trade flows and yielding substantial benefits. Chart 7 shows the net trade flows in the offset market and the gains from trade.

4. The impact of different policy designs

Although currently announced initiatives provide a good indication of how policy might develop, the debate is clearly still in flux and much will change as options are

[12] See Goettle and Fawcett (2009) for a detailed analysis of cap and trade impacts in the US.

reviewed and political consensus is built. The academic debate on the merit of different design mechanisms is also ongoing and will influence policy choices (see for example Fankhauser and Hepburn 2009). In this section, we ask how different policy choices would affect the price and volume dynamics in the carbon market. In particular, we look at four design options: (i) a change in policy effectiveness and abatement ambition (ii) the linking of regional markets and (iii) changes to the rules on banking and borrowing.

4.1 Different levels of ambition

The policies currently announced, which form the backbone of section 3, would result in global emission reductions of 7 GtCO2 in 2020 and 15 GtCO2 in 2030. This is well short of the 25-40% reduction in global emissions that the IPCC called for in its fourth assessment report (Barker et al. 2007b) and the 17 GtCO2 of reductions that Project Catalyst (2009) estimates will be needed by 2020 to stabilize concentrations at around 450ppm CO_2e, and thus have a fighting chance of limiting global warming to 2oC. However, even the low targets used in the "Follow me" scenario are not ratified yet.

We also looked at two other carbon market scenarios reflecting different degrees of ambition. The first scenario, labeled a “High ambition”, includes a stricter, 20% reduction target, relative to 1990, – with correspondingly tighter domestic caps and offset limits – and increased policy effectiveness: 100% of technical potential mandated in Annex I countries in non-market sectors and increased ambitions in the developing world.

The second alternative is a pessimistic “Head in the sand” scenario, where only policies that are already into effect (for example the EU ETS) are included. Crucially, this excludes federal carbon trading in the US. The two scenarios are detailed in Table 2.

Chart 8 shows difference in carbon prices for the two scenarios, and Chart 9 displays the impact on global emissions reductions. Higher levels of ambition have a strong impact on carbon prices, in part offset by improved policy effectiveness, which increases supply. In the "Head in the sand" scenario, offset prices could fall to around €5 per tCO_2 by 2020 without the US joining the global carbon markets.

In contrast, the effect of more ambitious scenarios on overall emission reductions is relatively limited (Chart 9). Under a “High ambition” scenario only about 60% of the theoretical potential is taken up. This is mainly due to the fact that emissions will continue to grow strongly in countries that are currently at a low level of development, including India. To change that and move closer to the 450ppm pathway, much more comprehensive targets that cover most countries would be required, as well as more aggressive policies on sectors like forestry and agriculture that are not covered by the carbon market.

4.2 Linking of markets

Key design question is to what extent regional markets will be linked up. This particularly concerns the link between the world’s two biggest carbon markets in the US and the EU. In our main results, we assumed that the two markets would be linked only indirectly through the international offset market, on which they both draw.

It is instructive to explore what would happen if the two markets were more closely integrated, at the extreme through the unrestricted exchange of allowances between the two jurisdictions. It is an aspiration among many European policy makers to achieve such a link as early as 2015 (Lazerowicz 2009).

The enthusiasm for linking is understandable. Conceptually, flexibility in space is key to keeping down compliance costs. In practice, a number of preconditions will have to be met before such a link becomes realistic (Fankhauser and Hepburn 2009). Chief among them are consistent levels of ambition between the two policy spheres. Linking a system that is designed to be high price with a low-price scheme would create policy tensions as trading will inevitably equate prices across systems. In addition there is a need for coordination on regulatory arrangements, including the use of, and quality standards for, offsets.

A linked market would result in prices very close to the prices in an autarkic US market (chart 10). This can be explained by the much smaller size of the EU ETS compared to the US system and the generous US offset limit that is not exhausted in the autarky case.

4.3 Banking and borrowing

Banking and borrowing (or flexibility over time, in the terminology of Fankhauser and Hepburn 2009) is similarly important. Complete flexibility to allocate abatement effort over time would allow firms to smooth short-term fluctuations (for example, related to fuel prices) and coordinate emission reductions with the investment cycle and the replacement of the capital stock.

For example, the summer 2009 drop in the EU allowance price would have been much sharper if it had not been possible to bank surplus emissions into the post-2012 period. Conversely, the price collapse in the first phase of the EU ETS would have been avoided if surplus emissions could have been banked into the second trading period. In fact, self-contained trading periods without banking or borrowing lead, by design, to price spikes or troughs at the end of that period unless installations are able to plan their emissions to perfection.

Despite its conceptual advantages, most systems constrain intertemporal flexibility. Banking from one commitment period to the next is generally allowed, but there tend to be limits to the amount of borrowing that is permitted, both between commitment periods and within individual periods. This is due to a (political) preference for timely abatement, but also concerns about time inconsistency – that is, the possibility that delayed commitments may not be honoured in full (Fankhauser and Hepburn 2009).

The simulation results show how banking and borrowing can soften price fluctuations. The effect is particularly strong in the EU ETS, where tight targets and limited offset quotas may lead to a price spike in 2025 in the absence of intertemporal flexibility. Borrowing between trading phases is not allowed in the EU ETS, but banking alone is capable of reducing the spike from €65 per tCO_2 to €38 per tCO_2 (Chart 11).

The US ETS, as currently envisaged, would allow borrowing one year ahead for free and from subsequent years at an 8% interest rate. This is anticipated to have minimal effect however, as the offset price is the predominant driver of the US ETS price.

5. Conclusion

The global carbon market could grow spectacularly over the next ten years. If current proposals are implemented – and this crucially includes a Waxman-Markey-style federal trading scheme in the US – the market volumes might reach $800 billion by 2020, compared with $126 billion in 2008.

In our main scenario, which is based on 'current proposals', we see the EU ETS prices rise from €13 in 2015 to €38 in 2025 before falling back to about €30. The high price is driven primarily by limited offset quotas. In the US, where offset quotas are more generous, prices stay much closer to the offset market price – rising from €13 in 2015 to €23 in 2030.

However, 'current proposals' result in an abatement outcome of just 7 GtCO2, bringing emissions down from a business-as-usual level of 61 GtCO2 in 2020 to 54 GtCO2. This compares to 17 GtCO2 that might be needed by 2020 to stabilize concentrations at 450ppm, according to Project Catalyst (2009), and underscores the fact that the unilateral commitments in both developed and developing countries remain insufficient. Even in our most aggressive "High ambition" scenario, only about 60% of the theoretical emission reduction potential is taken up. To change that, much more comprehensive targets would be required that cover most countries, as well as more aggressive policies on forestry and agriculture.

The shortfall in all our scenarios also underscores that carbon markets, while central to the global mitigation effort, are on their own not enough. The carbon market will only provide about 40% of the total abatement effort. Carbon trading has to be complemented by additional policy instruments to address non carbon price-related externalities. They may include standards (for example, renewable electricity standards, building codes and fuel efficiency standards), targeted revenue support (such as feed-in tariffs) and technology support in the form of subsidies for R&D and pilot programs. Moreover, additional public finance will be needed to provide a strong, additional impetus for abatement in developing countries, particularly those currently not covered by the carbon market.

Much will depend on how carbon markets are designed – how comprehensive they are, how ambitious, how well they are regulated and so on. This will determine to a large extent how much abatement we can achieve and at what overall cost. Particularly pertinent will be links to other markets, including the amount of offsets allowed and direct linking with other developed country schemes. The banking and borrowing mechanisms will determine the inter-temporal price development, and could influence price strongly as abatement will become cheaper over time when the abatement potential increases.

The model we used to derive these conclusions is relatively simple in terms of its economic structure, but very rich in terms of the country and sector level mitigation strategies it details. These data were taken from the McKinsey cost curves, which provide comprehensive, internally consistent cost data for a wide array of countries and sectors. Cost data are of necessity uncertain, but even accepting these uncertainties it is clear that there is substantial scope for efficiency gains from carbon trade. Carbon markets can make an important and effective contribution to the global transition to a low carbon economy.

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Table 1: Assumptions for 'Follow me' scenario

AAU	ETS	Offsets
2020 reduction targets ▪ EU: 20% (of 1990) ▪ US: 20% (2005) ▪ Canada: 20% (2006) ▪ Japan: 15% (2005) ▪ Russia: 10% (1990) ▪ Ukraine: 20% (1990) ▪ Australia: 5% (2000) ▪ NZ: 25% (1990) ▪ South Korea[1]: 108% (2005) ▪ Annex I: 10% (1990) **2050 reduction targets** ▪ EU: 80% (of 1990) ▪ US: 83% (2005) ▪ Canada: 60% (2006) ▪ Japan: 60% (2005) ▪ Russia: 60% (1990) ▪ Ukraine: 50% (1990) ▪ Australia: 60% (2000) ▪ NZ: 50% (1990) ▪ Annex I: 70% (1990)	**EU ETS** ▪ 2.02 Gt emissions in 2005 ▪ Targets: 1.72 Gt in 2020 and 1.36 Gt in 2030 ▪ Sector scope: power, cement, steel, petroleum, other industry ▪ Offset limits: 0.12 Gt in 2015 and 2020, no offsets thereafter. 0.6 Gt offsets banked in 2008 - 2012 ▪ Banking allowed (5 year business foresight) **US ETS (Waxman Markey)** ▪ 6.09 Gt emissions in 2005 ▪ Targets: 5.06 Gt in 2020 and 3.53 Gt in 2030 ▪ Sector scope: power, industry, transport, buildings ▪ Domestic offsets: 0.3 – 0.7 Gt p.a. in 2015 - 2030 ▪ Int'l offset limits: 1.5 Gt in 2015 and 2020, 1.4 Gt in 2025, 1.3 Gt in 2030[2] (discount of 80% as of 2017) ▪ Banking and borrowing allowed (5 year business foresight) ▪ Minimum price of $10/t in 2012 rising by real 5% annually **Australian and Canadian ETS** ▪ 75% of country emissions in scope for Australia, scope as in US for Canada ▪ Targets in line with country targets ▪ No offset limits	**Sectors in scope** ▪ Power ▪ Industry ▪ Waste ▪ Afforestation ▪ Limited avoided deforestation[3] **Rules** ▪ No NPV positive projects allowed in general ▪ Mandatory projects eligible (L- rule) ▪ NPV positive power levers affected by feed-in tariffs allowed (E- rule)

1 Targets growing with BAU CAGR after 2020
2 Domestic and international offsets together must not exceed 2 G
3 Total offset supply of 0.3 Gt in 2015, 0.7 Gt in 2020 and 0.8 Gt in 2025 and 2030 to be used in US ETS

Table 2: Assumptions for other scenarios based on 'Follow me'

	AAU	ETS	Policy
'Head in the sand'	▪ Only binding targets for EU	▪ Only EU ETS ▪ Offset limit 0.06 Gt in 2025 and 2030 (half of 2015 and 2020 limit)	▪ Mandates in non-EU developed countries at 25% of 'Follow me' ▪ No mandates in non-Annex I ▪ Market-driven policy score at 50% of 'Follow me' for non-EU developed countries and at 25% for non-Annex I
'High ambition'	▪ EU 30% and US 20% reduction compared to 1990 in 2020 ▪ Reduction target on average 20% of 1990 in 2020 and 75% in 2050 in Annex I ▪ No hot air	▪ Targets for ETS systems adjusted according to country targets ▪ Additional ETS in Japan and South Korea ▪ Offset limits increased by 100% of additional reduction in 2015 and 2020 and 50% in 2025 and 2030 in EU ETS	▪ 100% mandates in transport, buildings, agriculture, forestry and waste in Annex I ▪ 50% mandates for global air and sea transport ▪ Mandated policy score doubled (maximum of 100%) in non-Annex I ▪ Market-driven scores at 100% for Annex I and 50% for non-Annex I

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Chart 1: Market-driven policy effectiveness scores in 'Follow me' scenario

Market driven policy ambition by policy execution resulting in a policy effectiveness score , %

(Policy ambition score * Policy execution score = policy effectiveness score)

Groupings	U.S. and Canada (U.S., Canada)	OECD (France, Germany, Italy, Rest of EU27, Japan, Rest of OECD Pacific, Rest of OECD Europe, U.K.)	China (China)	Fiscally strong emerging (Mexico, Middle East, South Africa, Russia, Brazil)	India and other developing (India, Rest of Eastern Europe, Rest of Latin America, Rest of Africa, Rest of devel-oping Asia)
Power	100 * 100 = **100**	100 * 100 = **100**	80 * 90 = **72**	77 * 80 = **61**	73 * 70 = **51**
Buildings	100 * 90 = 90	85 * 90 = **77**	63 * 70 = **44**	30 * 60 = **18**	25 * 50 = **13**
Road Transport	90 * 90 = **81**	67 * 90 = **60**	40 * 70 = **28**	47 * 60 = **28**	40 * 50 = **20**
Agriculture	25 * 80 = **20**	60 * 80 = **48**	50 * 60 = **30**	40 * 60 = **24**	30 * 50 = **15**
5 Industry sectors	90 * 100 = **90**	90 * 100 = **90**	74 * 90 = **67**	72 * 80 = **58**	73 * 70 = **51**
Waste	35 * 90 = **32**	45 * 90 = **41**	100 * 80 = **80**	100 * 60 = **60**	100 * 70 = **70**

	All regions
Sea transport	30 * 60 = **18**
Air transport	50 * 80 = **40**

	U.S., Canada, OECD and Fiscally strong	Brazil	Other developing	Rest of Africa	Rest of devel-oping Asia (incl. Indonesia)
Forestry	85 * 100 = **85**	75 * 80 = **60**	50 * 50 = **25**	40 * 40 = **16**	65 * 60 = **39**

Forestry is grouped differently to reflect importance of Brazil, Indonesia and Rest of Africa

Chart 2: Abatement cost curve after investor perspective adjustments

Abatement cost 2030, € per tCO2e

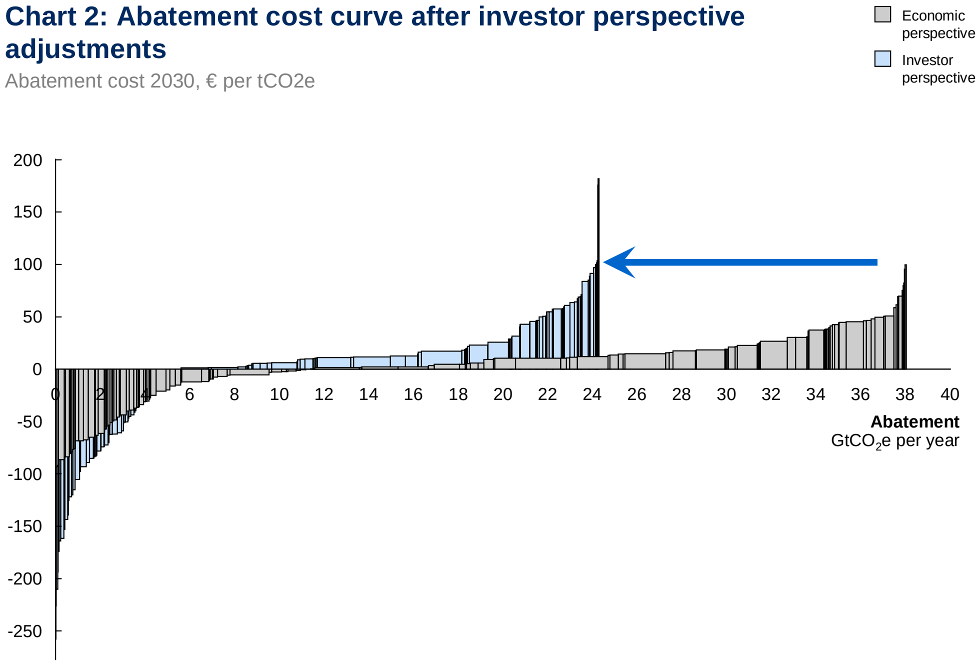


Chart 3: Calculation flow of carbon markets model

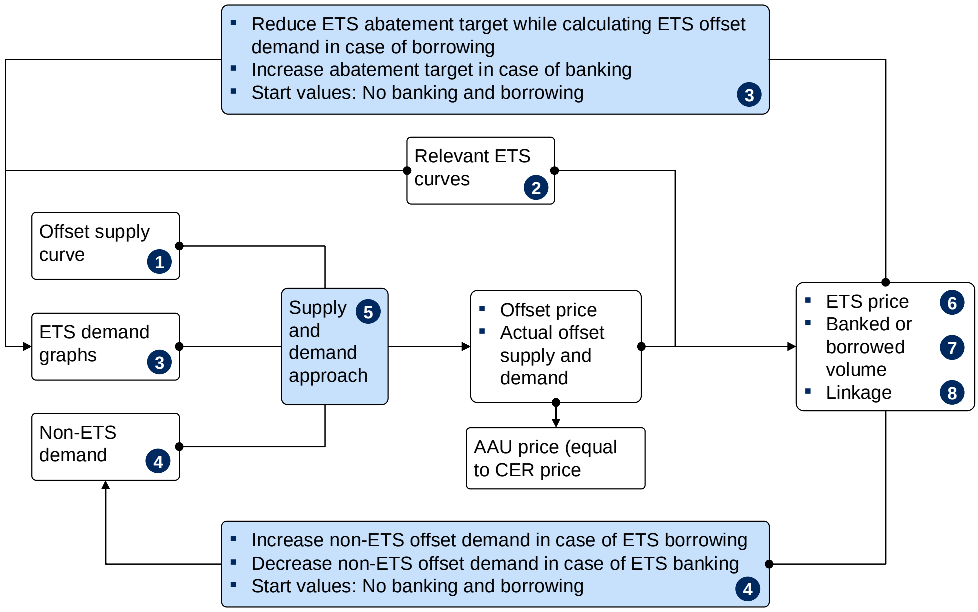
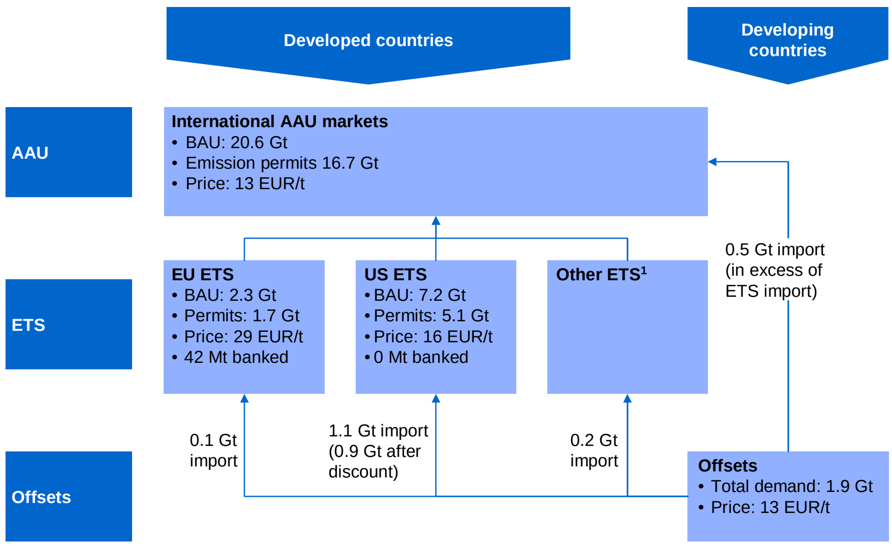


Chart 4: Carbon markets in 2020

Follow me Scenario



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1 Australia and Canada

Chart 5: Carbon prices

€ per tCO2e, Follow me Scenario

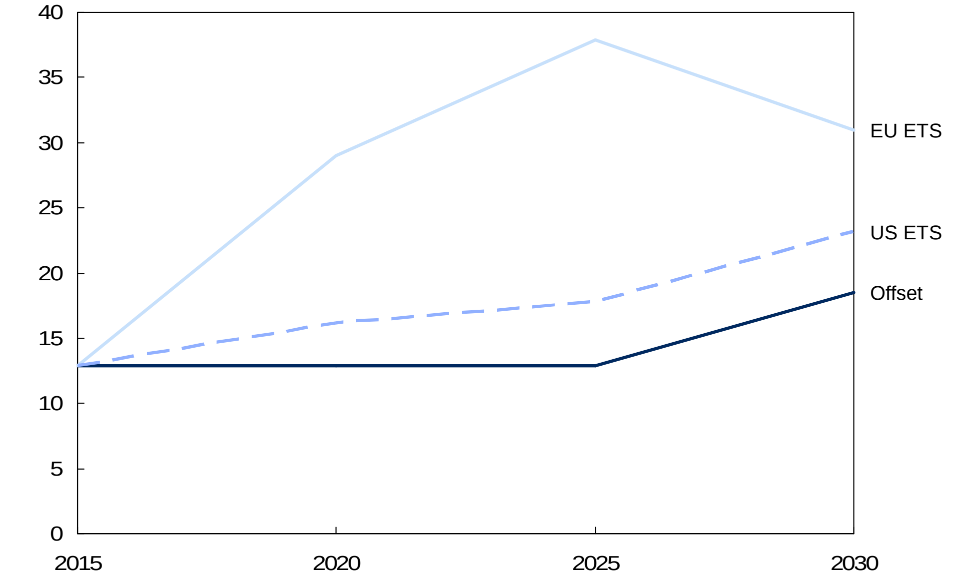


Chart 6: EU ETS cost curve 2020

€ per tCO2e compared to GtCO2e, Follow me Scenario

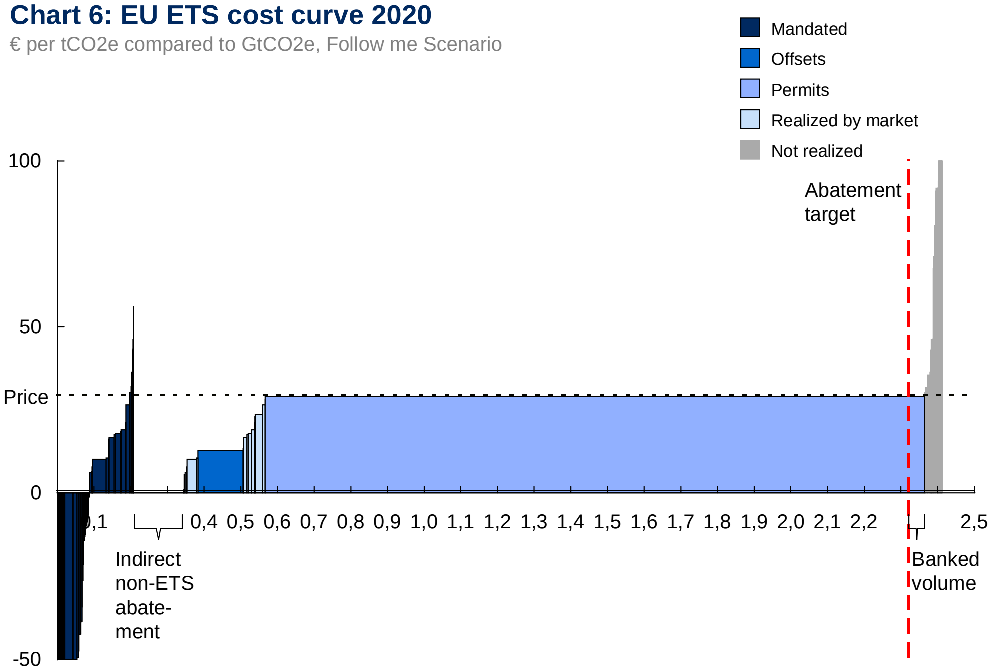
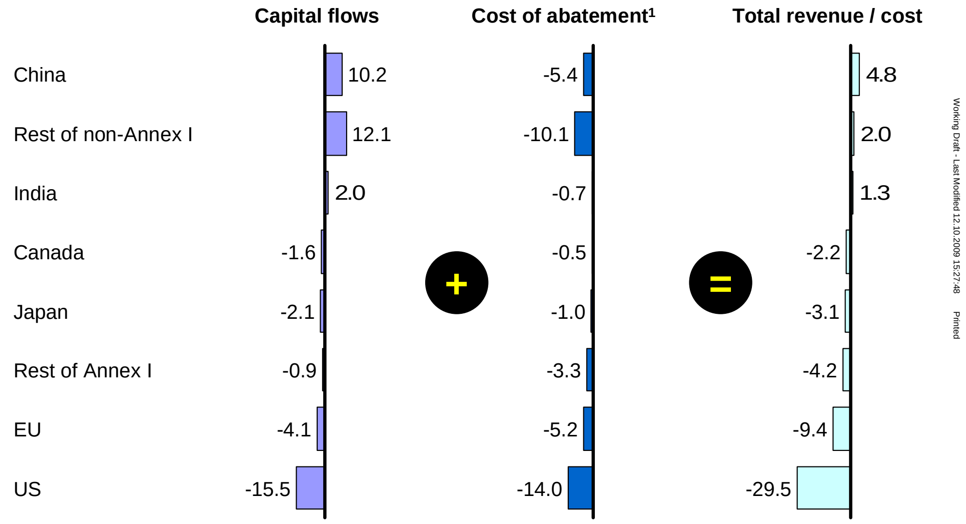


Chart 7: Capital flows and abatement cost

Revenue in 2020, € billion, Follow me Scenario



1 Negative cost set to zero

Chart 8: Carbon prices under different climate scenarios

€ per tCO2

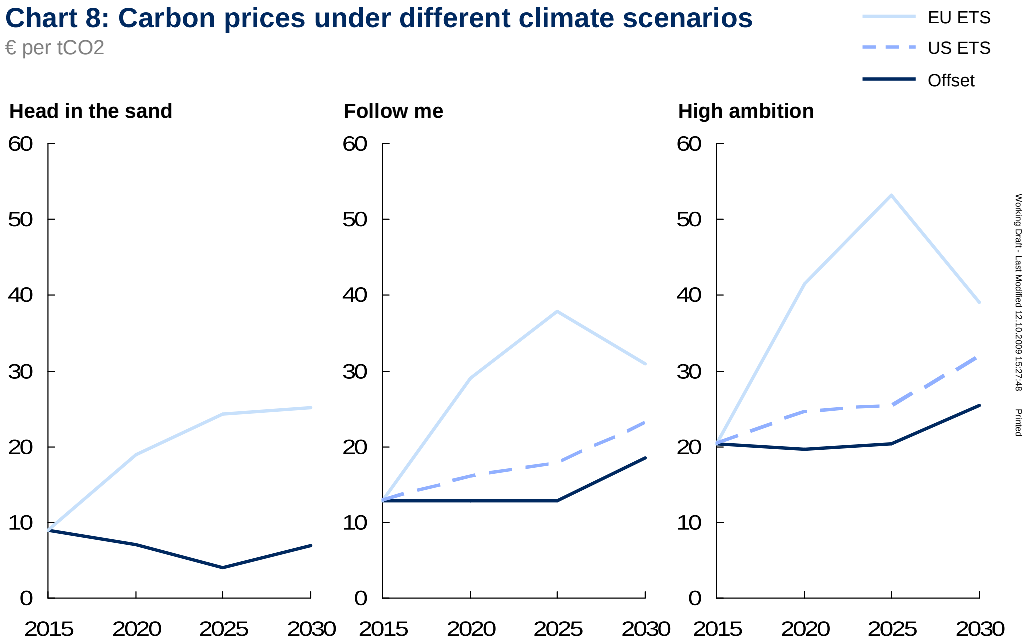


Chart 9: Abatement under different climate scenarios

GtCO2e

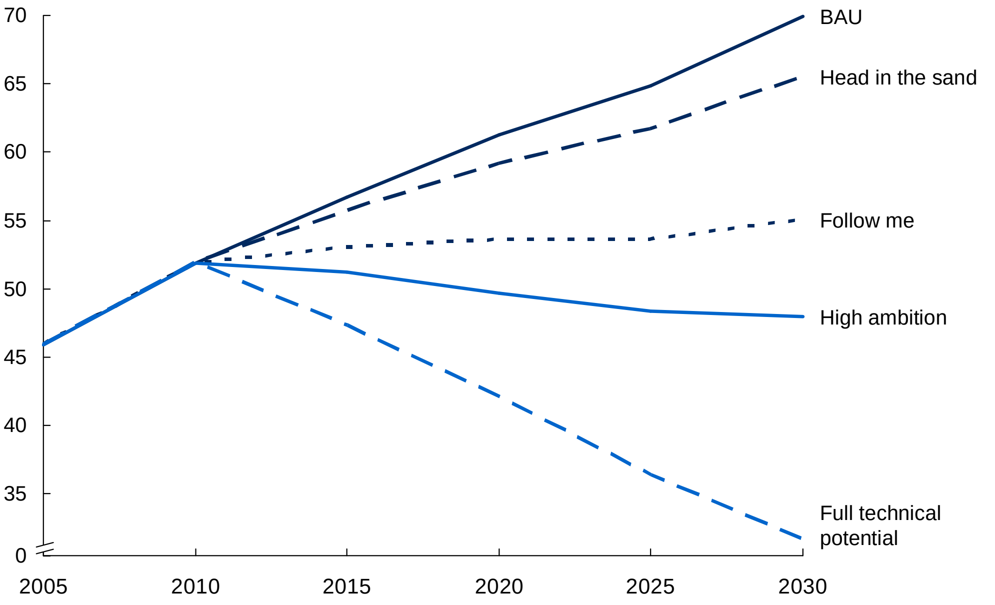


Chart 10: Carbon prices before and after linkage

€ per tCO2e, Follow me Scenario

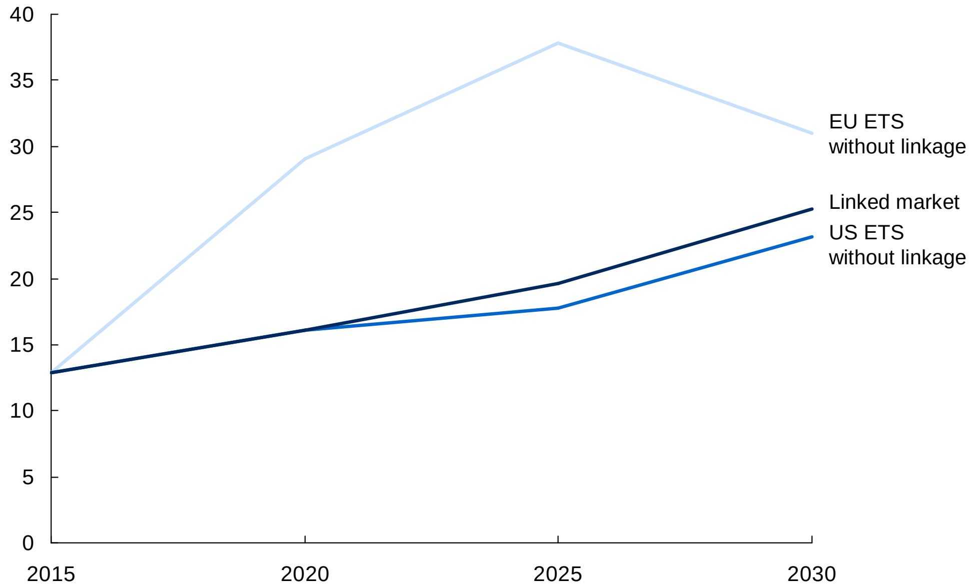


Chart 11: Carbon prices with and without banking

€ per tCO2e, Follow me Scenario