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NEW COMMITMENT OPTIONS: COMPATIBILITY WITH EMISSIONS TRADING

Cédric Philibert, International Energy Agency

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FOREWORD

This document was prepared by the OECD and IEA Secretariats in November 2005 at the request of the Annex I Expert Group on the United Nations Framework Convention on Climate Change (UNFCCC). The Annex I Expert Group oversees development of analytical papers for the purpose of providing useful and timely input to the climate change negotiations. These papers may also be useful to national policy-makers and other decision-makers. In a collaborative effort, authors work with the Annex I Expert Group to develop these papers. However, the papers do not necessarily represent the views of the OECD or the IEA, nor are they intended to prejudge the views of countries participating in the Annex I Expert Group. Rather, they are Secretariat information papers intended to inform Member countries, as well as the UNFCCC audience.

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Questions and comments should be sent to:

Cédric Philibert
Energy Efficiency and Environment Division
International Energy Agency
9, rue de la Fédération
75015 Paris
France
Email: cédric.philibert@iea.org
Fax: +33 (0)1 40 57 67 39

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Executive Summary

This paper considers different options for quantitative greenhouse gas emission commitments from the standpoint of their technical compatibility with emissions trading. These are dynamic targets, binding targets with price caps, non-binding targets, sector-wide targets/mechanisms, action targets, allowances and endowments, and long-term permits. This paper considers these options from the standpoint of their compatibility with emissions trading. It does not discuss their other merits and demerits, for example, the effect on greenhouse gas emissions levels.

All options are shown to be technically compatible with domestic emissions trading. All but one – "allowances and endowments" or the so-called McKibbin-Wilcoxen approach – are also technically compatible with international emissions trading, and could allow domestic entities to trade directly on international markets.

Dynamic targets, non-binding targets, binding targets with price caps and sector-wide targets are fully technically compatible with each other and with fixed, binding targets. Not only assigned amounts, but nature of targets and price-capping mechanisms can be differentiated, though some options, such as dynamic targets and a price capping mechanism, at the possible expense of some trading restrictions such as gateways which may cause some economic efficiency losses.

Whether "action targets" could be part of this sub-group of mutually compatible commitment options remains to be seen, as the necessary ex-post international recognition of achievement may postpone any participation in international trading until much after the end of the commitment period. "Long term permits" and "allowances and endowments" could form the basis of alternative global schemes, but are hardly compatible with other options.

A modelling exercise sheds some light on how emissions and prices could evolve if countries were to adopt different options for their emission targets. In particular, it considers the effects of unexpectedly high growth in GDP. Scenarios developed in this paper show the following:

- The introduction of a "low" price cap in the emissions trading system would induce only slightly higher emission levels, as the bulk of the emission reductions are assumed to be obtained at relatively low costs.
- In case of unexpectedly high economic growth, non-binding targets or dynamic targets for developing regions will entail a deviation from the anticipated profile of emissions from these regions, and increase overall emissions over expectations, in a proportion connected with the surplus of economic growth.
- The region with higher than expected growth may then want to quit the emissions trading system – especially in case of non-binding, but fixed targets. This may however have only a limited impact on the CO_2 price – the increase in the carbon value, due to a lower permit supply, is restrained by higher overall energy demand and resulting higher energy prices. As a consequence, the carbon value may not meet the price cap that other regions may have instituted, assumed to be at a higher level in this scenario. In this sense, the regime appears relatively robust to unexpected developments.

These results depend on the model and initial hypotheses. Using another model, or changing the hypotheses for the scenarios considered, may yield different results. In any case, this analysis suggests that interactions with energy markets must be taken into account in assessing the possible impacts of flexible targets and economic shocks on global carbon prices.

1. Introduction

The present paper aims at delivering precise information on the technical compatibility of emission trading with various options for setting quantitative greenhouse gas emission objectives. The environmental consequences of different commitment options are not explicitly addressed in this paper. Consideration is given to the following:

- dynamic targets,
- binding targets with price caps,
- non-binding targets,
- sector-wide targets/mechanisms,
- action targets,
- allowances and endowments, and
- long-term permits.

The technical compatibility of the fixed and binding target option with emissions trading is not looked at in this paper, as this constitutes the usual and most-studied setting of targets for emissions trading. This entails no value judgement on this option for future international collaboration. More broadly, this paper only addresses technical issues relating to the compatibility of these options with emissions trading, and does not discuss the intrinsic merits and demerits of various options (e.g. the trade-off between reducing uncertainty on abatement costs and introducing or increasing uncertainty on emission levels).

The paper is in two parts. In the first part, each option is briefly described and then analysed from the standpoint of four issues:[1]

1. Is the option compatible with ***international*** emissions trading *per se*, i.e., if all countries were to adopt this option for their targets, would they be able to trade allowances among themselves, presumably in the framework of trading mechanisms offered by some international agreement?
2. Is the option compatible with emissions trading and with ***other types of targets*** adopted by other countries (or in a few cases in the same country), including fixed and binding targets? Further, how can these options be made compatible with each other?
3. Is the option compatible with ***domestic*** emissions trading, i.e. in the framework of some national or sub-national legislation?
4. For targets compatible with both international and domestic levels of trading, can trading take place directly between domestic entities in different countries – referred to as ***domestic to international*** emissions trading?

In the second part, we provide a set of illustrative scenarios that combine different options that appear to be compatible with international and domestic emissions trading. These are fixed binding targets, dynamic targets, targets with price caps and non-binding targets. For the sake of simplicity various forms of sector-wide targets, although they also appear fully compatible with all others, are not included in the analysis. This model-based analysis sheds light on how emissions and prices could evolve under combinations of various country targets when confronted to economic shocks.

One objective of this simulation is to reveal whether economic shocks may have a "domino" effect – for example, confronted with higher-than-projected growth, a large developing country cannot achieve its non-

[1] Fuller description and discussion of these options and references can be found in Philibert (2005).

binding target and thus renounces entering international emissions trading; as a result, the international permit price reaches the level of the price cap in some or all industrialised countries, allowing them to exceed their own emission limits. The analysis finally provides some hints on the likely deviation on emission trends, by comparison to targets, that more flexible options may drive.

2. Emissions Trading and the Various Options

This section examines seven options for quantitative emissions commitments. For each case, it attempts to address the four questions identified in the introduction.

2.1 Dynamic targets

Dynamic targets in their general form would define assigned amounts on the basis of projected projection of economic development. These assigned amounts would then be adjusted depending on actual economic growth, i.e. in case of deviation from projection.

Some analysts suggest that ***international*** emissions trading with indexed targets would be more complex due to the adjustments of assigned amounts. Others see trading facilitated by dynamic targets, on the assumption that they reduce the uncertainty on the likely "gap" between emissions and assigned amounts.

This assumption, and the validity of dynamic targets, has itself been challenged. Recent IEA work on this issue shows that dynamic targets, indexed to gross domestic product, would reduce uncertainty to a small extent only (see Box 1 on page 8).

The capability of dynamic targets to partially reduce uncertainty on the amount of allowances that must be bought or can be sold does influence their compatibility with emissions trading. However, this compatibility does not fundamentally rest on this property. Let us figure out how dynamic targets would work, first at a country level.

An assigned amount is set, along with a formula for its revision. Trading can take place anytime. Either at the end of the commitment period, or yearly, or only at the beginning of the commitment period, the assigned amount is adjusted upward or downward. In most cases, this adjustment will match the trend of emissions.

By comparison with fixed targets, the unforeseen incremental effort required to achieve the target (in case of higher-than-expected economic growth), or the unforeseen surplus of allowances (in case of lower-than-expected economic growth), will be lower – at least in most cases. The need to rely on trading over the "grace" period[2] would presumably be less with dynamic targets.

The scheme requires an acceptable estimate of the GDP in about the same timeframe as the GHG inventory. Although it has been shown that variations of GDP over time may differ depending on the measure units (Müller and Müller-Fürstenberger), what is ultimately required is an agreement on a single metric that can be assessed with precision over the years.

This scheme seems to hold even in the case of "pure" intensity targets, those dynamic targets that would be expressed in GHG emissions per GDP. An agreement on such targets would not require, as in the more

[2] In the case of the Kyoto Protocol, the grace period is the "additional period for fulfilling commitments" of one hundred days after the end of a commitment period defined by the Marrakech Accords, during which Parties can trade emissions to achieve compliance on the basis of the assigned amounts of the said period.

general case, an agreement on an assigned amount, an economic projection and an index formula. An intensity target would encompass all these elements in a single expression.

In any case, the government would then need to translate the intensity target into a fixed quantity of assigned amount units in their registries in order to allow international emissions trading. At first, the fixed quantity could be based on the basis of an economic forecast. This quantity could be revised at set dates to account for changes in GDP or else. To the extent that these changes are concomitant with changes in emissions, the effect on the trading potential or needs of the country ought to be small. In other cases, the international market may react as new numbers are issued. It is not clear that this would be any different from a market reaction to the publication of a country's inventory, showing an unexpected departure from its fixed target. The dynamic nature of the targets therefore does not imply that tradable units should be allocated at the end of the commitment period – doing so would create significant and unnecessary impediment to the country's participation in emissions trading.

Therefore, international trading with countries following other target types such as fixed and binding targets does not raise any technical problems.

For similar reasons, it would be easy for governments to allocate parts of their assigned amounts to domestic entities and allow domestic trading to take place. Objectives for domestic entities within a country with a dynamic target could itself be "absolute" or "relative", i.e., output-based. This is unlikely to make a difference as all targets must ultimately be converted in the same metric – tonnes of CO2-equivalent, with the corresponding units reflected in the country's registry.

As these tonnes may be traded on domestic markets, they could be traded on international markets, thus allowing direct domestic to international emissions trading. In all cases, governments will bear the ultimate responsibility for compliance, and they may have to adjust their own action on international markets during the grace period. This is however always the case, regardless of the target type.

In an ideal case, adjustments of the country's assigned amount at the end of the commitment period would go in the same direction as the average deviation of emissions for domestic sources included in the domestic emissions trading schemes – but this may not be always the case. An underestimation of the growth in services, including more transport, for example, can be coupled with an overestimation of the growth in heavy industry.

If targets for industry are themselves output-based, possible difficulties for governments are not substantially different. Governments with fixed targets having allocated a subset of emission allowances to industries will face the same type of problems as they will have less direct control on emissions from sources outside the domestic trading system.

There is of course the possibility for industrialised countries to establish comprehensive domestic emissions trading scheme[3] – either an upstream system with allocation to fossil fuel producers and importers or the combination of an upstream and downstream systems. If the whole assigned amount is allocated to domestic entities as fixed targets, but is then adjusted downward because economic growth is less than expected, the government will have to cover the difference from markets while entities, or at least some of them, will presumably have relatively easier targets and cheap or free reductions – as their activity had been slowed. A cautious approach may be in this case to only allocate a minimum allowances corresponding to the worse economic scenario (and downward adjustment of the country target), while the difference in allowances between this scenario and the unadjusted assigned amount is put aside in a reserve – a somewhat broader kind of "reserve for new entrants".

[3] See IEA, 2005, forthcoming.

Box 1. Dynamic Targets and Uncertainty: a Real but Limited Effect

To what extent would dynamic targets reduce the economic risks for developing countries in adopting targets – or the risk of introducing large amounts of hot air into the global regime? At best, they would only address the uncertainty arising from uncertain economic forecasting. Other sources of uncertainty regarding abatement costs arise in particular from the uncertain evolution of fuel costs, and of the availability of new technology, its rate of diffusion and costs.

Pizer (2003, 2005) compared annual emissions and annual CO_2/GDP levels for 6 industrialised countries in the years 1981 to 2001, showing that both fluctuated randomly by about 5%. For 5 countries the ratio of standard deviations in percent annual changes for emissions and intensities was close to 1 – only the United States exhibiting a ratio of about 2/3. On the basis of Pizer's results, Dudek & Golub (2003) claimed that "*setting an intensity target does not really reduce uncertainty about future costs".*

However, Pizer's analysis is based on annual emission and intensity fluctuations, likely to cancel out to some extent with whatever type of targets over several years. What matters is the predictability of both emission levels over a long period of time, such as the 10 to 15 years that spans between the adoption of targets and the end of the commitment period (1997 – 2012 in the Kyoto Protocol, possibly 2007 to 2017 for another period).

Recent work undertaken at the IEA sheds light on this issue from a kind of "reality test". We[4] have first constructed "past projections" of economic growth and emissions for a series of developing countries, simply by extrapolating trends of 1971 to 1991 to the years 1997 to 2001. We have then compared these projections with actual GDP growth and emissions, estimating the "errors" in these forecasts.

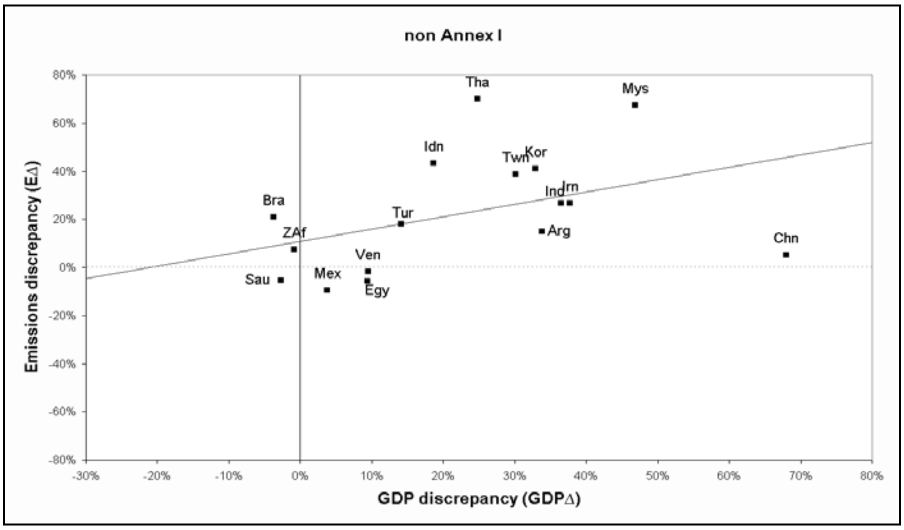


Figure 1: Variations in Emissions & GDP Forecasts

The results are plotted on Figure 1. The "errors" in forecasting GDP and emissions are represented on, respectively, the horizontal and vertical axes. Note that the origins (representing perfect forecasting) are in the middle of the figure for emissions but somewhat on the left for GDP. The regression line illustrates the dynamics between deviation in GDP forecasting and deviation in emissions forecasting. Its coefficient of determination is equal to 0.174, indicating that only 17.4% of the variability in emissions can be explained by the variability of economic development.

For a majority of countries, intensity targets would have lightened the burden of compliance with a fixed target during a period of more rapid than expected economic growth. For one country, Saudi Arabia, intensity targets would have reduced the amount of hot air that is due to lower than expected economic growth. However, for a few countries, fixed targets would have done a better job, because deviations in economic and emissions forecasting are of opposite signs. For Egypt, Mexico and Venezuela, intensity targets would have increased the amount of hot air. For Brazil and South Africa, intensity targets would have exacerbated difficulties in target compliance.

All countries for which fixed targets would have done a better job are close to the centre of the picture. Only ex-post analysis can determine whether fixed targets would have been better for a particular country. Ex-ante, before uncertainties are resolved, intensity targets still appear more appropriate for these countries, as the analysis shows a general correlation between deviations from economic and emissions forecasts.

However, the low coefficient of determination (17.4%) suggests that intensity targets can alleviate concerns arising from uncertainties in emission forecasts but not eliminate them. It remains possible however that dynamic targets (of which intensity targets are only one possible form) shaped according to each country's circumstances could further reduce uncertainty on emission levels despite uncertain economic growth.

[4] The author is indebted to John Newman for conceiving the methodology, data gathering and computing.

In the above, we assumed that countries with fixed targets would not oppose unrestricted trading with countries that have adopted dynamic targets. This assumption may not hold true: the former may fear that their environmental goals risk being undermined by high sales from countries with dynamic targets. Under the UK emissions trading scheme, this perceived risk justified the establishment of a gateway between sources with absolute caps and sources with output-based emission goals. If a gateway were a prerequisite for the participation of countries with dynamic targets, markets may become segmented and price differences could emerge, implying a loss of economic efficiency. Depending on how countries with dynamic targets would be authorised to sell emission permits on the international market, the international trading system could incur greater uncertainty on the supply side.

2.2 Fixed targets with price caps

The price cap implies the possibility for countries (or domestic sources) of greenhouse gas emissions to emit more than their assigned amounts provided they buy additional allowances at a fixed price. There are indeed two distinct possibilities for implementing the price cap concept in international emissions trading system regimes. With the first option, the supplementary permits would be sold by some international body, to countries or to domestic entities; this could be called "international implementation". With the second option, domestic entities within countries would buy these permits from their government; this could be called "domestic implementation".

The design of a national price cap approach will affect its compatibility with ***international emissions trading*** systems. Things may differ significantly, for example, if implementation is international or domestic; if there is only one price cap (i.e. set at a unique value), or if there are several in an international regime. In any case, the price cap is a design feature for international trading regime. There would be no obligation for any country to make use of it and there is no issue of compatibility with ***other target types***.

In case of international implementation, trading would occur amongst countries up to the level of the price cap. With respect to ***domestic*** emissions trading, governments may also introduce a price cap for their firms, which could take the form of a compliance payment – unlike a penalty, sources would not have to make up for emissions above target once they have paid. Alternatively, firms could buy supplementary permits directly from the designated international body at a fixed price. These firms would simultaneously augment their assigned amount in the domestic regime and that of their country in the international regime.

Domestic implementation is more complex. As countries do not buy supplementary permits, they could be required to demonstrate that all emission sources are confronted with a marginal abatement cost that is at least as high as the price cap – other countries will then know for sure that this country has tried in its earnest to meet its target and exceeds it although some domestic sources are confronted with marginal abatement cost higher than the agreed price cap level. This could be checked easily if comprehensive (upstream) domestic tradable permit schemes were applied, in which case all sources would face the same price (Kopp et al. 1999; Philibert & Reinaud 2004). Alternatively, this could result from the association of a trading regime for some emitters with a carbon tax set at the price cap level (or higher) for all others, although this would entail some economic efficiency losses if the carbon price in the sectors covered by trading does not reach the price cap level. As noted by Willems & Baumert (2003) there is however in this case, a risk that governments "*recycle price cap revenues back to the very entities that paid for the supplementary permits, thereby circumventing the price cap's intended purpose.*" If this risk can be alleviated, and if, indeed, full price coverage can be achieved at domestic level, there would not be a difference between the two options with respect to their compatibility with emissions trading.

Differences in economic conditions and willingness-to-pay to mitigate climate change may make it necessary to consider several price cap levels. For example, one may envisage a structure with:

- A very low price cap for low income developing countries;[5]
- A low price cap for the advanced developing countries and most economies in transition;
- A higher price cap for other industrialised countries.[6]

The possibility of multiple domestic price cap levels across countries may cause difficulties that need to be examined. Trading between zones with different price caps would require restrictions to ensure that a country with a low price cap only sells real reductions below its assigned amount to countries with a higher price caps – and not "supplementary permits" generated by the price cap. Otherwise, sources in the country with a low price cap could simply acquire supplementary permits at that price, for the sole purpose of selling them, at a profit, to entities facing a higher carbon price. The lowest price cap would then dominate the entire trading system. To avoid such domination, countries that rely on their price cap may be prohibited from being net sellers. In this case, they would need to buy allowances on the market to cover any early sales. Only thereafter would they be allowed to buy supplementary permits at the fixed price.

Will the use of price caps set at different levels within a single international system, with restrictions on buying/selling to avoid the lowest price cap dominating the market, entail losses of efficiency? Let us consider a case of two countries with different price caps: the one with the low price cap, country A, cannot fulfil its obligation and uses its cap; there remains, however, abatement options in country A at a cost that is higher than its price cap, but lower than the price cap in country B. They will probably be neglected, while costlier options in country B will have to be used – a clear loss in economic efficiency. Thus, multiplying the number of levels of price cap may create efficiency losses. It may well be, however, that the overall efficiency losses depend more from the gap between the lowest and highest levels of the price caps than from the number of different levels.

Direct ***domestic to international*** emissions trading would be possible. However, the necessity that only countries in full compliance (i.e. without activating the price cap) could be net sellers would bear some risks for governments. They may find themselves in a situation where domestic entities are net sellers while the country exceeds its target. Arguably, governments would not be in position to require their selling companies to buy on markets, as these companies would be in compliance with their domestic obligations. Therefore, before buying supplementary permits at the said price, governments would have to buy permits on the markets to recover their initial assigned amount. This adds an incentive to avoid over allocation to companies covered by the scheme to the incentive to control emissions from sectors that are not covered by the emissions trading scheme.

2.3 Non-binding targets

Non-binding targets open to trading would allow a country to sell surplus allowances if its emissions are less than its assigned amount but not requesting it to buy if its emissions are more than its assigned amount.

Non-binding targets are compatible with ***international*** emissions trading but countries can only sell emission allowances in excess of their emissions. Options to meet this requirement include:

[5] Note that a price of zero would turn the commitment into a non-binding target.

[6] Such a grouping of countries in three categories would roughly follow the lines of country grouping suggested by Claussen & McNeilly (1998). They distinguish countries that "must act now", countries that "should act now but differently" and countries that "could act now". It would not be exclusive from an extended differentiation of individual countries' assigned amounts (and indexation formulas if targets are also dynamic).

- Allowing trading only at the end of the commitment period, although this would very much reduce market liquidity;
- Converting non-binding targets into binding targets once trading occurs. This option may deter countries from engaging in trading until they are sure this would not put them at risk and may be the least acceptable to developing countries.
- Requiring a country exceeding its allowed emissions after having sold emission allowances to buy enough allowances to offset its excess sales. Once this is done, the country's emissions are still not capped. Such a provision that "limits responsibility to units sold" seems to better fit the non-binding nature of this approach while neither restraining unduly market liquidity nor discouraging up-front financing of emission reductions. A commitment period reserve similar to that instituted by the Marrakech Accords would also limit the extent of overselling.[7]

Not only could non-binding targets be linked with other target types – it is in fact an obligation, as trading requires buyers and countries with non-binding targets would be sellers only. However, it is not certain that developing countries with non-binding targets would trade and allow the international community to benefit from their low-cost abatement options.

Assigned amounts associated with non-binding targets could certainly be sub-allocated to domestic emission sources and trading allowed between them at domestic level. Presumably, however, this would have to take place on a binding basis for domestic sources, as there would not be many buyers if they were allocated objectives on a non-binding basis.

Allowing direct domestic to international trading in a country with non-binding targets could have significant consequences depending on the safeguards employed to ensure the integrity of the international regime.

- If international trading is only allowed at the end of the commitment period for countries with non-binding targets, there would be no difficulty, but companies with available allowances would not be able to raise up-front financing for their investments in emission reductions. Market instruments such as futures may, however, develop to get round this difficulty.
- If the target becomes binding when international trading starts, developing country governments would presumably forbid their domestic companies from trading internationally before some governmental decision or approval process. If not, the country may find itself committed by a single transfer of allowances by one of its entities. After such a decision, there is no specific issue to consider, as the target would be binding. Before this decision is taken, developing country companies could not take advantage of carbon markets, up-front financing would not take place and market liquidity would be reduced.
- Even with a provision limiting countries' responsibility to earlier sales, i.e. developing countries can be net sellers on international markets only if their domestic emissions remain below their non-binding targets, complicated situations may arise. For example, if, as is likely, the domestic trading system does not cover all of the country's emissions, sources under the system would be selling (or even buying) internationally on the basis of their binding domestic target. If the country's emissions exceed the target, then the government would have to cover, if not the entire deficit, at least the allowances needed to reconstitute the initial assigned amount.

In this last scenario, developing countries' governments could hardly ask domestic sellers to buy the allowances needed to cover their sales, as they would have complied with the domestic rules. Here again, allowing companies to trade internationally may have the unintended consequences to make governments

[7] Using two different targets, a high binding target and a lower non-binding one, as sometimes suggested, would not by itself prevent overselling over the non-binding target.

liable for the emissions from the uncovered sectors, at least to the exact extent of the companies' selling. And although the balance of trade would end up at zero for emissions, there may be a net cost as there is no guarantee that allowances can be bought at a price that is not higher than the transfer price.

Non-binding may thus not be entirely risk free for developing countries' governments. Alleviating this risk could be an incentive to undertake the necessary measures to limit the emissions of the sectors not covered by emissions trading; and to avoid over allocating allowances to companies – a kind of indirect subsidy. Comparable risks are borne by industrialised countries' governments form their own targets, and arguably the financial liability of developing countries remains limited as overall emissions in these countries would remain unconstrained.

This risk may also lead developing countries' governments to delay the entry on international markets up to the point they can be almost sure of finding the whole country in compliance. Although the incitation would be much less than in the case of a target becoming binding, it could still reduce market liquidity and up-front financing of cleaner investments.

Risks of the sort would be further alleviated if non-binding targets are sector-wide instead of being country-wide, as shown below.

2.4 Sector-wide targets/mechanisms

Two distinct sectoral targets or mechanisms are considered here:

- Targets for one or several sectors in one or more countries, determined for each country.

- Targets for one or several sector at a global, transnational sector level. This latter form is often called "transnational sectoral agreements" (TSA) to highlight the importance of negotiating the objective between industries and governments.

Both forms of sectoral targets could be open to ***international*** emissions trading. The first form has been considered notably for developing countries interested in stimulating investments in a particular sector without taking on nationwide emissions targets. They could be fixed or dynamic, binding or non-binding. In the latter case, there would be little difference between emissions trading and sector-wide crediting mechanisms, which can also be either fixed or dynamic (i.e., output-based), as further explored in Ellis and Baron, 2005.

The compatibility of sectoral targets with ***other target types***, presumably country-wide, does not raise specific problems. There may be, however, concerns about inter-sectoral leakage: if the production of a material (say, steel) were subject to an emissions constraint (dynamic or fixed), competing materials (e.g. aluminium), if not themselves subject to sectoral targets, would become more cost-competitive. As their production grow, so would their emissions, which would offset some of the efforts achieved by the sectoral target.

When compared with country-wide non-binding targets, sector-wide non-binding targets would move the uncertainty surrounding the activation of the target (i.e. the entry of the country or sector into trading allowed by complying) from the economy as a whole to the sectors concerned. This would give firms greater control of their capacity to take part in emissions trading. Contrary to what would happen with country-wide targets, governments could make the companies of the sector in question fully responsible for trading only if they end up in non-compliance, i.e. responsible for covering any deficit due to early sales.

Sectoral targets could easily evolve into ***domestic*** emissions trading, except if they were all non-binding and leaning towards the project-based mechanism type.

Transnational sectoral agreements raise a different set of issues. Conceptually, TSA could cover all emissions – provided all sources in all countries were covered by one or another sectoral target. However, this seems unlikely, as transnational targets seem more appropriate for global industries than for dispersed activities – a TSA may be easier to develop in an industry where production is highly concentrated, such as aluminium or even steel, than in more dispersed sectors such as the cement, heat and power, household or transport sectors (except, for the latter, for its vehicle technology dimension with fuel economy targets given to or negotiated with the car making industry)[8]. Therefore, TSA are likely to exist with other target types covering other sources in most industrialised economies. An interesting question is thus how transnational sectoral agreements can be made compatible with domestic emission trading under ***other target types***.

There would be a need for these agreements to be fully recognised and endorsed at international level. This would allow devolving accountability of the emissions to the industry globally. In countries covered by another target type sectors covered by a TSA may thus be exempted from domestic allocation while remaining open to trading with other sectors. Alternatively, if countries recognise not only the global objectives of the industry but also its allocation by countries, countries could remain accountable for these emissions under their target – in which case the TSA would essentially constitute a mere negotiating process and the so-called agreement would end up as a set of binding sectoral targets.

The likely "voluntary" nature of TSA also leaves open the possibility of agreements not fully recognised under international agreements. This would be the case if, for example, TSA were introduced in the implementation of the Kyoto Protocol. In this case, trading under a TSA implying two countries with country-wide assigned amounts could be merely recognised as trading between the two countries. It would be more difficult to take account of trading under TSA with countries having no country target. Allowances from such countries would have to be registered under some form of project-based mechanism (i.e. the Clean Development Mechanism in the Kyoto Protocol) – clearly a more complex situation.

In sum, country specific sectoral targets and to an even greater extent transnational sectoral agreements would by construction favour direct ***domestic to international*** trading over purely domestic trading.

2.5 Action targets

An action target is a commitment to reduce GHG emission levels by an agreed percentage which is applied to the actual emissions during the commitment period[9]. Countries would have to demonstrate domestic reductions, i.e. show that emissions would have been higher by the agreed percentage in the absence of actions taken to reach the target.

If the demonstrated reductions are higher than the agreed percentage, they could be sold to other countries. If the commitment is binding and could not be met, countries would need to buy credits from the market. Action targets are therefore compatible with ***international*** trading and with ***other target types*** in other countries.

While actual emissions would determine the amount of abatement required, demonstrating actual reductions requires constructing a baseline, i.e. the emission trends that would have happened without the

[8] See Watson et al., 2005, Ellis and Baron, 2005, and IEA, 2005, forthcoming.

[9] See Goldberg and Baumert, 2005.

party's actions. This demonstration might be technically difficult (as baselines and additionality under project-based mechanisms) and politically controversial, especially as international acceptance would only take place after the end of the commitment period – as would presumably trading itself.

This may seem a deceptive conclusion, as action target are likely to offset most of the risks arising from uncertain economic projections, even better than dynamic targets could do. Even very large variations in emissions would only entail little changes in the size of the "action" needed to comply. Suppose, for example, a developing country forecasting emissions at 100 $MtCO_2$ per year during the commitment period and opting for an action target of 10%. Let us assume its yearly emissions during the commitment period are 150 $MtCO_2$. The size of the emission reduction to be demonstrated is thus 15 $MtCO_2$ instead of the 10 $MtCO_2$ originally planned – it should thus demonstrate that the unabated trend would have led to emissions of 165 $MtCO_2$. If the country had opted for an equivalent fixed target at 90 $MtCO_2$, the reductions required to comply would have jumped to 75 $MtCO_2$. If it had chosen a dynamic target, emission reductions required would have depended on the respective increases in emissions and GDP and on the indexation formula.

However, as this numerical example illustrates, it may not be easy for this country with emissions of 150 $MtCO_2$ to demonstrate convincingly that its action has still prevented an even greater increase in emissions to 165 $MtCO_2$ to justify having achieved its 10% action target.

Not only action targets face the same difficulties than project-based mechanisms in establishing credible baselines and demonstrating additionality, but they do so afterwards, for no agreement on the baseline is requested prior the start of action precisely to offset the various sources of uncertainties affecting unabated emission trends. This shifts the entire uncertainty on the political side – will there be an agreement afterwards? Will other countries accept that the emissions they can see are lower than those they would have seen if no action had been taken? Even if the effectiveness of some policies can been recognised by all, and their emission reductions determined with reasonable certainty, another country could still argue that other governmental actions had the opposite effect of increasing the emissions that would have resulted from the policies in place when the agreement was settled.

Technically, it will always be possible for a government under an action target to allocate assigned amounts to its ***domestic*** sources. Direct ***domestic to international*** trading may be less easy – it is somewhat difficult to conceive how domestic entities in an "action target country" could freely and directly trade internationally, unless the government accepts to take all the risks that result from the uncertainty on the recognition that the action target has been achieved. In fact, the risk for governments to allow direct domestic to international trading during the commitment period may be – somewhat paradoxically – greater in case of action target than under any other target type, even if the action target was non-binding, as in this case the government would remain committed to buy an amount of allowances equal to the sales.

2.6 Allowances and endowments

Under the so-called "McKibbin – Wilcoxen" proposal, countries would be given perpetual endowments that would generate yearly allowances – in a total quantity corresponding to the GHG stabilisation level chosen[10]. On top of these free allowances, countries could sell their domestic fossil fuel producers or importers an unlimited quantity of supplementary allowances at a price set deliberately at a "low" level – this price would work as the above-mentioned price cap. There would thus be two ***domestic*** markets in each country, one for perpetual endowments and another for annual allowances.

[10] See, e.g., McKibbin and Wilcoxen, 2002.

There would be, however, very little ***international*** emissions trading in such scheme, if any. This is not an inadvertent result of this construction, but on the contrary an intended result. The McKibbin – Wilcoxen" proposal, aims for cost-effectiveness, recognizes the uncertainties affecting climate change on both cost and benefit side of mitigation policies, and views international emissions trading as a problem, not a solution, as it would entail international money transfers felt to be politically unacceptable. These threes aspects are embodied in the design features of the price cap: its mere existence provides for alleviating cost uncertainties, its unique level for all domestic systems provides for cost-effectiveness (along with the comprehensive nature of the upstream trading regimes), and its low level prevents international emissions trading.

Therefore, this option does not seem compatible with ***other target types;*** and whether it provides for ***domestic to international*** emissions trading seems an irrelevant question. In particular, the rules established above to allow international trading with various price cap levels stipulate that only countries in full compliance with their objective could be net sellers. No country would be in that position in the McKibbin–Wilcoxen's "allowances and endowments" scheme, as endowments would presumably generate relatively few free allowances, and it is unlikely that any country could comply with these implicit objectives with marginal abatement costs lower than this "low" price cap.

Allowances and endowments could form the basis for a system of somewhat harmonised domestic trading regimes, but this option is by construction not really compatible with international emissions trading and the various options for commitment types that international emissions trading may accommodate.

2.7 Long-term permits

Long term tradable permits could be used to cover emissions at any time during a long commitment period, e.g., from 2010 to 2070.[11] Under this proposal, long term permits would account for carbon dioxide natural absorption, e.g. a carbon dioxide permit allowing 1 tonne in 2070 would allow 1.71 tonnes in 2010. Apart from this, long term permits would not be substantially different from allowances under other options.

Technically, long term permits would be compatible with emissions trading at both ***international*** and ***domestic*** levels. However, the incentive to trade may be rather low as compliance would be perceived as a very long term issue. Interim targets that could be set to provide an incentive to trade offer no solution, as they would suppress the flexibility of long term permit and bring the concept back to that of most of the other commitment options.

Similarly, there is nothing technically to prevent linking countries under long term permits with countries under ***other target types.*** The latter, however, may be reluctant to do so as they will fear that their systems can be inundated by cheap permits flowing from the countries with long term permits. This would introduce into the short term permit countries all the uncertainties about long term compliance of the long term permit countries. Similarly, allowing direct ***domestic to international*** trading seems straightforward among countries with similarly long permits and rather problematic between these countries and others.

Dynamic targets, price caps, non-binding targets and various types of sector-wide targets despite the uncertainties they create on emission levels, incorporate a requirement to 'check-and-balance' accounts periodically and to correct the trajectory of individual countries or even to fix the possible shortcomings of the international architecture on a decadal timescale. Long term permits may be a workable option, and may even be compatible with others, but if it proves otherwise, it might be too late from a climate perspective.

[11] See Peck and Teisberg, 2003.

2.8 Summary

Fixed and binding targets, dynamic targets, targets with price caps, non-binding targets and sector-wide targets of different types appear to be mutually compatible – and compatible with domestic emission trading and direct international trading between entities. All would make governments accountable for emissions, though this responsibility would be usually lesser with the more flexible options, and limited to preserving or reconstituting initial assigned amounts with non-binding targets.

Action targets remain an interesting option but may not be easily conducive to trading. Endowments and allowances would constitute an entirely different system, compatible with domestic emissions trading but not, by construction, with international emissions trading systems and other commitment approaches. Long term permits would be technically compatible with all other options but establishing linkages would raise harsh political issues with countries making different choices for themselves. They should thus be seen as constituting an alternative system by their own, compatibles with both domestic and international emissions trading but bearing limited compatibility with other options.

3. Interactions between Compatible Options

This section focuses on the short list of options that appear mutually compatible. A general presumption is that more flexible targets could help countries adopting relatively more ambitious goals i.e. help simultaneously deepening and broadening the participation to international emissions trading[12]. But how would these options combine in practice, especially if abatement costs turn higher than expected? What would be the deviation from intended emission paths? How will the various target options interplay? This section addresses these important questions on the basis of a modelling exercise.

3.1 Methodology

A Baseline Projection for the world energy system was established using the POLES model up to 2050. This model is a partial equilibrium model – with a year-by-year recursive simulation process from 2004 to 2050. The model represents 46 key countries and regions. It provides for endogenous supply, demand and price dynamics on the international energy markets, and also for an endogenous development of new and low emission energy technologies. The Baseline Projection (BP) supposes no major change in current environment and energy policies in the various countries; it is in that respect a "technical change as usual plus policy-fix" scenario.

A Carbon Constrained Case (CCC) is then developed. It mixes different approaches to the definition of mitigation targets with technology-based approaches for the United States and quantified objectives with emissions trading – a cap and trade system – for the rest of the world.

With respect to the United States, it is supposed that technology approaches, notably a technology-push for the nuclear option combined with a full-scale phase-in of carbon dioxide capture and storage in power generation, would combine with pre-existing international fossil fuel prices increases and energy efficiency improvements to allow the United States economy to achieve a "de-carbonisation" rate of 2% per year over the entire period, only slightly more than its current chosen objective.

For the rest of the world, it is assumed that the other Annex 1 countries (hereafter denominated Annex 1*) would opt for a 50% emission reduction targets from 1990 levels by 2050. It is also assumed that

[12] See, e.g., IEA, 2002, and IEA, 2005, forthcoming.

developing countries would adopt "non-binding targets" set at 90% and 80% of their business-as-usual trends by 2030 and 2050 respectively. Emissions trading is allowed between industrialised countries, except the United States, and developing countries.

In a 'high growth' case, the hypothesis is made that a large developing country experiences a higher-than-expected growth and as a result renounces its non-binding target. It therefore cannot access trading and sell allowance surpluses. The resulting deviation on global emissions is computed, as well as the resulting change in the carbon value in the zone covered by a single emissions trading scheme.

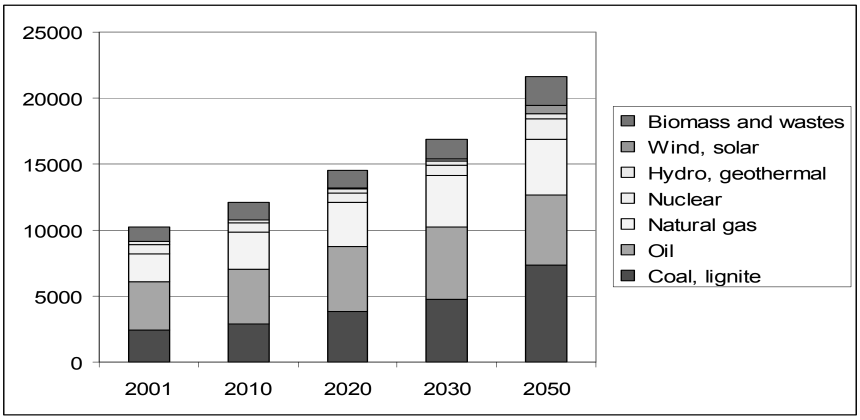
Simultaneously, it is assumed that a price cap is introduced for industrialised countries at a level set higher than the forecasted carbon value resulting from the chosen targets. Then the same assumption made above is introduced, i.e., a key developing country renounces its non-binding target and the possibility of trading – so as to test the possibility of "domino" effects, i.e. the likeliness that developing countries opting out trading would drive industrialised countries to deviate from their targets as higher carbon costs would possibly reach the price cap level.

Finally, a "strengthened carbon constrained" case is conceived on the assumption that the presence of a price cap could facilitate the adoption of more ambitious targets by industrialised countries by alleviating concerns related to the uncertainty affecting future abatement costs. The resulting carbon value is calculated and the potential effects of a price cap (with the same level as previous cases) are tested.

3.2 The Baseline Projection

The Baseline Projection, while very close to the results published by the International Energy Agency (IEA, 2004) in its World Energy Outlook (WEO) with respect to total energy demand in 2030, is based on different assumptions with respect to global oil and gas resources. As a consequence, international oil and gas prices are higher and the share of coal in the total primary energy supply is more important. The POLES Baseline Projection includes a more rapid growth of coal production and consumption. (Figure 2).

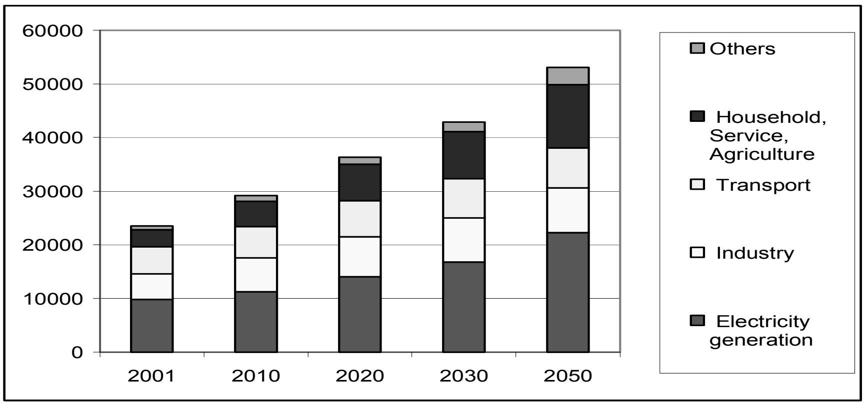
Figure 2: Primary Energy Consumption, Baseline Projection (Mtoe)



Source: POLES model

Energy-related CO_2 emissions are thus higher, at 43 $GtCO_2$ in 2030 against 38 $GtCO_2$ in the WEO. In 2050 global CO_2 emissions are higher than 50 $GtCO_2$, i.e. more than twice current levels (Figure 3). This corresponds to IPCC scenarios leading to CO_2 atmospheric concentrations of 1000 parts per million in Volume (ppmV) or higher. While this represents a case on the upper end of the IPCC range, it is particularly helpful as a means of illustrating the impacts of the various shocks identified above.

Figure 3: Energy-related CO_2 Emissions, Baseline Projection ($GtCO_2$)



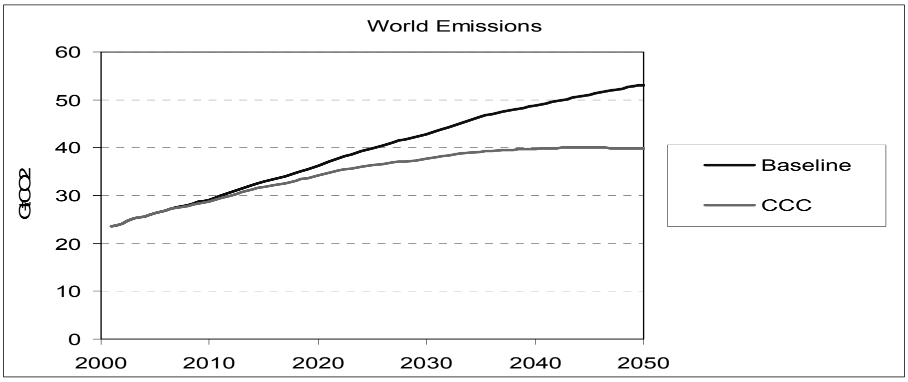
Source: POLES model

The increase in emissions is strongly differentiated across sectors. Surprisingly enough, the transport sector shows only a very limited 50% increase, which can be explained by the strong surge in oil price to 2050 as a consequence of scarcer resources. Conversely, emissions are expected to increase more than the average in the household/tertiary sector, with rapidly growing consumptions in developing countries, and in the electricity production sector.

3.3 The Carbon Constrained Case

In the Carbon Constrained Case, emissions peak at 40 Gt CO_2 in 2040 (Figure 4). This represents a reduction of 25% from the reference case in 2050. These emissions levels, which involve a stabilisation in emissions before 2050, are compatible with IPCC scenarios leading to CO_2 atmospheric concentrations stabilised at 750 ppmV.

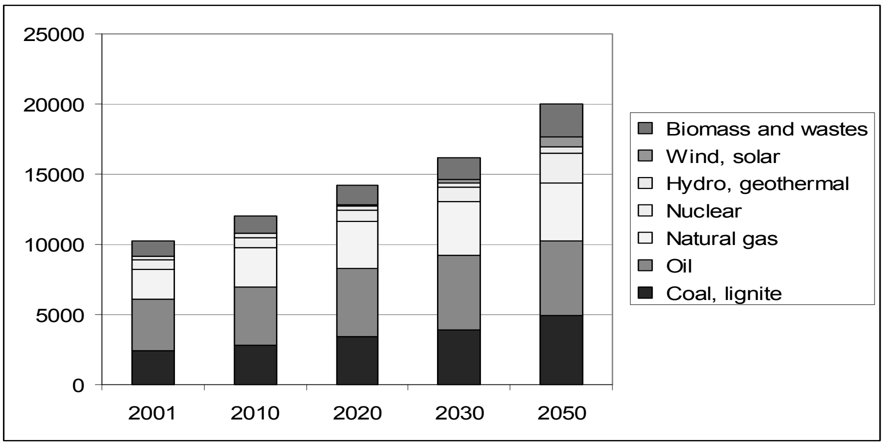
Figure 4: Energy-related CO_2 Emissions, Baseline Projection and Carbon Constrained Case



Source: POLES model

The reduction in world emissions results from the combination of a lower total world energy demand consumption and of changes in the primary energy mix towards less carbon intensive energy sources. In particular, the Carbon Constraint Case is characterised by a lower consumption of coal and to a lesser extent oil. Conversely the contributions of renewable and nuclear energy increase significantly (Figure 5).

Figure 5: Primary Energy Consumption, Carbon Constrained Case (Gtoe)

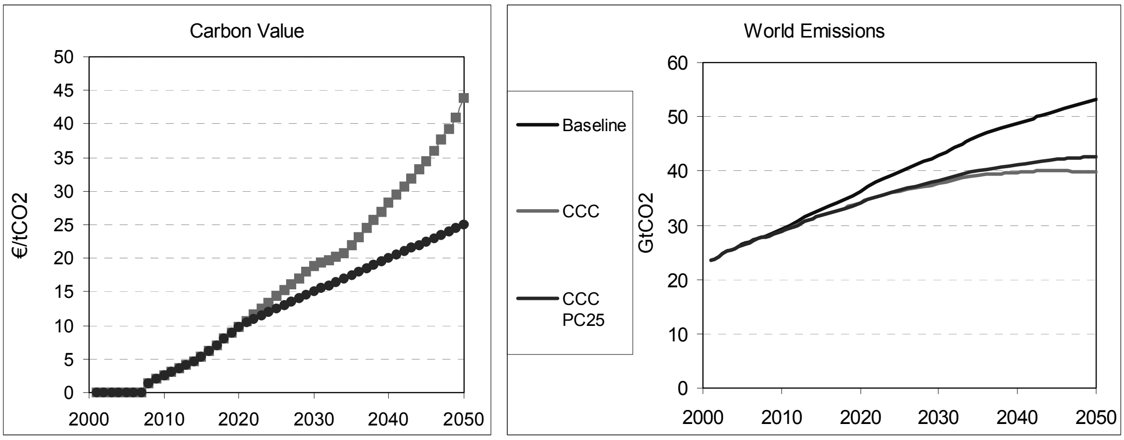


Source: POLES model

In the integrated emissions trading zone, the emission constraint results in a carbon price of 19 €/t CO_2 in 2030, progressively increasing up to 44 €/t CO_2 in 2050. Benefits from emissions trading largely compensate the abatement costs for developing countries resulting from their "below business as usual" targets.

The introduction of a price cap at a relatively low level – i.e. 10 €/tCO_2 in 2020, linearly increasing to 25 €/tCO_2 in 2050 – does not change dramatically the world emission profile: the reduction of about 40 % in the carbon value for the regions in the emissions trading system, translates into an increase in total emissions of only 7 % (Figure 7). This is explained by the fact that the bulk of emission reductions can be obtained at relatively low costs, while only the last units involve high marginal abatement costs.

Figure 6: Impact of a "low" price cap (left) on total emissions (right)



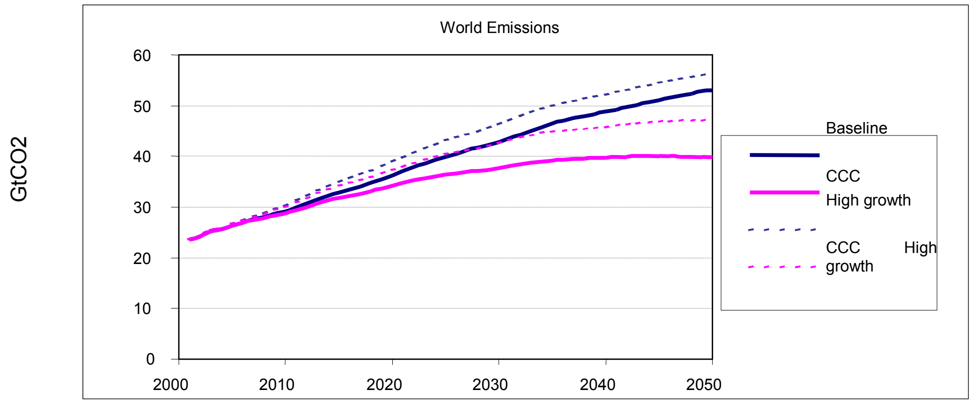
Source: POLES model

3.4 Impacts of a "high-growth shock" on emissions and carbon value

Taking into account the possibility that a large developing country might experience higher-than-expected growth (in the model China is used for the exercise), global emissions would increase in the Baseline

Projection by 7%. If China renounces its non-binding target, global emissions could go up by 18% over the carbon constrained case – this number in case this country abandons all action for achieving its target (Figure 7).

Figure 7. Energy-related global CO_2 emissions, impacts of a "high-growth shock" on emissions



Source: POLES model

The withdrawal of a large developing country from the integrated emissions trading zone deprives others from the corresponding emission reduction options, and this leads to an increase in the carbon value in this zone; however, the simulation shows that this increase is limited because higher energy demand from this country leads to higher global international energy prices (especially coal prices), which ultimately lead to relatively lower emission abatement costs. The combination of these two effects produces a limited increase in the carbon price from 44 to 46 €/t CO_2.

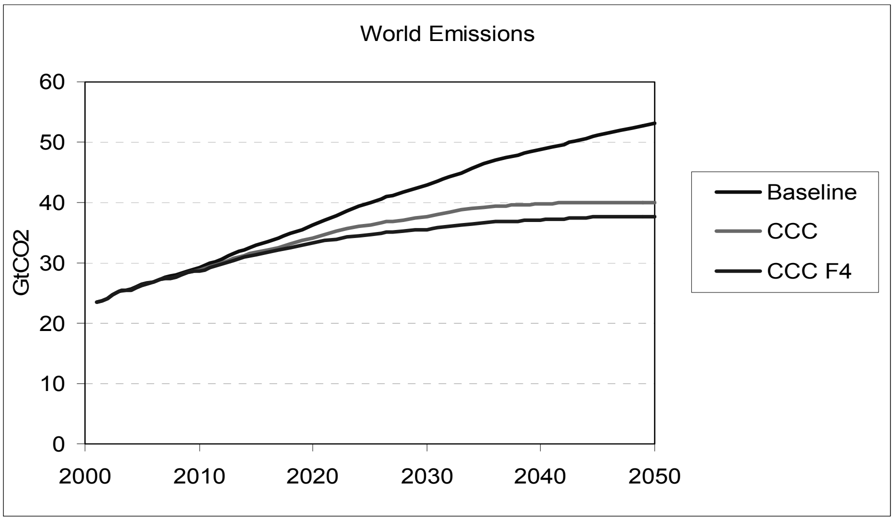
Assuming that a price cap had been introduced for industrialised countries in Annex 1* and set in the upper range of the cost expectations at 50 €/t CO_2, the model reveals no "domino effect": the renunciation by a large developing country of achieving its non-binding target does not, in this framework of hypotheses, drive industrialised countries to activate the price cap and deviate from their own emission targets.

The risk of this happening would probably be even lower in case of indexed targets, for they would allow the developing country experiencing higher-than-expected growth to remain in the trading system. In that case, the increase in its own emissions and therefore in the global emission level may be the same as with non-binding targets or lower – depending on how exactly assigned amounts are indexed on actual economic growth.

3.5 Strengthening the carbon constraint in industrialised countries

The strengthened carbon constrained case ("CCC F4") supposes that all industrialised countries, except the United States, voluntarily choose strong targets, corresponding to the Factor 4 reduction in 2050 against 1990 levels that is contemplated by several European countries. In that case the Annex 1* countries indeed strengthen their targets to 25% of 1990 emission levels. This further reduces global emissions to 37.5 Gt CO_2 (Figure 7). This is compatible with emission profiles leading to atmospheric concentrations of about 700 ppmV.

Figure 7: Energy-related CO_2 emissions, CCC F4 in Annex I*



N.B. Annex I here stands for Annex I countries without the United States*

Source: POLES model

This may be perceived as a relatively small improvement over the carbon constrained case, reflecting the limited and continuously decreasing share in global emissions of this group of countries: in 2050 the Annex 1* countries only represent 19% of total emissions in the Baseline. In the model, the carbon value increases in the emission trading zone to 58 €/t CO_2.

Assuming that the adoption of these more ambitious commitments has been initially facilitated by the existence of a price cap set at 50 €/t CO_2, the simulation reveals that although the carbon value reaches the level of the price cap, global emissions are almost unaffected at 38 Gt CO_2 against 37,5 Gt CO_2. This reflects the same type of phenomenon as in the first test with a price cap (Figure 6): as marginal abatement costs increase rapidly, the introduction of a price cap has a relatively small impact on total emissions. Despite the price cap, global emissions remain notably lower in this case than in the original carbon constrained case.

3.6 Key outcomes of the combined options scenarios

The outcomes of these modelling exercises can be summarised as follows:

- In the Baseline Projection, world energy-related CO_2 emissions are expected to double in 2050. This doubling in total emissions is due to sustained population and economic growth until the mid of the century, in a context of growing scarcity for oil and gas and of consequently intensified use of coal as a primary energy source.
- The "Carbon Constrained Case" scenario associates differentiated commitments and flexible mechanisms. It combines technological policies and dynamic targets for the United States, fixed emission targets for the rest of Annex I countries, and dynamic or non-binding targets for the developing regions.
- In this framework of hypotheses, world emissions would stabilise shortly before 2050 at a level representing a 60 % increase from current level. This corresponds to a significant 25% reduction

from Baseline Projections in 2050. However, the emissions profile would probably not result in a long term concentration levels under 750 ppmV (CO_2).

- In case of unexpectedly high economic growth, non-binding targets or dynamic targets for developing regions will entail a deviation from the anticipated profile of emissions from these regions, and increase overall emissions over expectations, in a proportion connected with the surplus of economic growth.
- The region with higher than expected growth may then want to quit the emissions trading system – especially in case of non-binding, but fixed targets. This may however have only a limited impact on the CO_2 price – the increase in the carbon value, due to a lower permit supply, is restrained by higher overall energy demand and resulting higher energy prices. As a consequence, the carbon value may not meet the price cap that other regions may have instituted, assumed to be at a higher level in this scenario. In this sense, the regime appears relatively robust to unexpected developments.
- The introduction of a "low" price cap for the countries in the emissions trading system would induce higher emission levels, but in a limited proportion as the bulk of the emission reductions are assumed to be obtained with relatively low costs.
- Price caps may also be of some help, as counterpart to the adoption of stronger emission reduction objectives. Logically the price cap should in that case be set at a level higher than the expected carbon value. Strong abatement targets have a limited impact, if the regions that are willing to accept them represent a too small fraction of the world total.

Uncertainties in models and assumptions relating to the world energy and greenhouse gas emissions scenarios over long time horizons should in no way be underestimated. However, simulations with detailed models that can take into account the key drivers and constraints to the development of the world energy system may help analyse the consequences for the climate system. They can therefore enhance the common understanding of the different issues at stake in the international climate negotiation.

In particular, the modelling exercises performed in this study have helped identify some key features of climate regimes that would develop, possibly on a "bottom-up" basis, with differentiated commitments and flexible mechanisms. One key insight is that such regimes may bring significant mitigation results and be relatively robust to unexpected developments. These results depend on the model and initial hypotheses. Using another model, or changing the hypotheses for the scenarios considered, may yield different results. In any case, this analysis suggests that interactions with energy markets must be taken into account in assessing the possible impacts of flexible targets and economic shocks on global carbon prices.

4. Conclusions

Fixed and binding targets, dynamic targets, price caps, non-binding targets and sector-wide targets or crediting mechanisms seem to represent a number of options that are fully technically compatible between themselves and with international emissions trading. They all permit, under certain conditions, different efficiency levels and at some risks, to allocate allowances to domestic emission sources and allow them to trade on international carbon markets. It remains to be seen if action targets can really join this group.

Long term permits or allowances and endowments offer more radical alternatives to fixed and binding targets. The former allows for full international and domestic trading and the latter for domestic trading and limited international trading; however, none of these options could be easily combined with other options for commitments.

The dynamic target, price cap, non-binding target and sector-wide target options can be used to provide additional flexibility in future climate agreements and can allow further differentiation between countries. Not only assigned amounts, but nature of targets and price-capping mechanisms can be differentiated, though for some options, such as dynamic targets and a price capping mechanism, at the possible expense of some trading restrictions such as gateways which may result in some economic efficiency losses.

The dynamic target, price cap, non-binding target and sector-wide target options have all been suggested as means to alleviate concerns that ultimately arise from uncertain abatement costs, either with a focus on developing countries or with a view to simultaneously facilitate broadening and deepening mitigation action. The modelling exercise reported in this paper suggests that this added flexibility is unlikely to entail important deviations from the emission trajectories they may help set. This conclusion, however, depends on the model and assumptions retained.

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