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FOREWORD

This document was prepared by the OECD and IEA Secretariats in March-May 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.

The Annex I Parties or countries referred to in this document are those listed in Annex I of the UNFCCC (as amended at the 3rd Conference of the Parties in December 1997): Australia, Austria, Belarus, Belgium, Bulgaria, Canada, Croatia, Czech Republic, Denmark, the European Community, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Latvia, Liechtenstein, Lithuania, Luxembourg, Monaco, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russian Federation, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, United Kingdom of Great Britain and Northern Ireland, and United States of America. Korea and Mexico, as OECD member countries, also participate in the Annex I Expert Group. Where this document refers to "countries" or "governments", it is also intended to include "regional economic organisations", if appropriate.

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OECD and IEA information papers for the Annex I Expert Group on the UNFCCC can be downloaded from: http://www.oecd.org/env/cc/

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1. Introduction

This paper aims at providing, as much as possible, a comprehensive repertory of approaches for future international co-operation in climate change mitigation, based on the literature. It does not attempt to assess the validity, the merits or demerits, the technical or political feasibility of these various proposals. However, as this literature is currently mushrooming, this papers aims to gather under one headline proposals made by various authors that share the main basic features, explicitly mentioning some interesting variations of each main concept.

This paper also aims at offering an elementary classification of the various options. How do various approaches differ? A first group of approaches based on quantitative approaches would be somewhat compatible with international emissions trading. Section 2 presents options dealing with the nature of the quantified objectives. Section 3 presents approaches for the timing of emission objectives as well as for differentiation. Section 4 presents a family of approaches that would not easily be included in a broad emissions trading regime. Most, but not all, suggest various forms of agreements on policies and measure and technology-focussed approaches, and some are not entirely exclusive of linkages with quantitative approaches. The greater variety and more detailed examination of quantitative approaches reflect the fact that greater attention has been given to target-based approaches by economists and others. It does not express a value judgement of the merits or demerits of quantitative versus non-quantitative approaches.

Despite its brevity, this paper includes various options ignored in other surveys. It seeks to provide building blocks to enable the reader to consider a much broader set of options by combining them in various ways. For example, most timing/allocation schemes could work with the various qualitative options for targets, either independently or simultaneously. Moreover, one could combine features from quantitative approaches with other features from non-quantitative approaches options. The various options may coexist at various levels, either among different countries or within them.

Although some options introduce long-term perspectives, such as global emission paths or amounts, this paper does not offer an in-depth discussion of the ultimate objective of the UNFCCC and its possible interpretations in terms of concentration, temperature, rate of change and others. All approaches aim to provide substantial emission reductions to stabilise atmospheric concentrations of greenhouse gases.

For most analysts, equity considerations are inherently supposed to maximise participation in a climate mitigation approach – but no single equity principle is likely to find support from all countries. This paper offers no in-depth discussion of this issue.

For each option presented below, after synonyms found in the literature are given, the main descriptive features are provided. Possible suggested variations around the basic concept are then briefly described. Mostly drawing from the literature, the most significant aspects relating either to implementation or to likely results are then summarised under “remarks/issues to consider”. No attempt is made, however, to provide an assessment and a value judgement on the various options, their merits or demerits. Finally, we provide a list of references of the literature.

A brief conclusion summarises the findings of this survey and provides suggestions on how this work could be developed further within the context of the Annex I Expert Group (AIXG).

2. Quantitative Approaches: Nature of Objectives

A large body of literature elaborates on the concept of quantitative emission objectives for countries; it is divided into two parts. This section focuses on the nature of these options.

For some authors (e.g. Oppenheimer & Petsonk 2004), there is not much, if anything, to change in the current negotiated structure with fixed and binding targets, i.e. the Kyoto Protocol (section **2.1**). Its entry into force will create a strong momentum and ultimately, although perhaps progressively, all countries, industrialised and developing, will join in. Enough flexibility is provided by multi-year commitments, banking, the inclusion of several gases and of sinks and the flexibility mechanisms. For these authors, other options would introduce too much flexibility and therefore threaten the achievement of the ultimate objective of the Convention. Therefore, the main dimensions left to the negotiations should be that of timing and stringency of commitments – elements that are discussed in the next section on allocation schemes.

For many others, the option of fixed and binding targets does not fit best with the uncertain context of the global climate change problem. In particular, countries might be reluctant to commit ten or fifteen years in advance while they have limited certainty on their future development and mitigation costs. More flexible options, such as objectives indexed on actual economic growth (section **2.2**) or quantified objectives with a price cap (section **2.3**), could alleviate these concerns, albeit at the expense of near-term certainty on emission levels. They could trigger the adoption of more ambitious commitments by allowing countries to narrow the range of possible future costs.

Flexible options would seem necessary to expand the current mitigating regime to developing countries in particular. A broader regime would alleviate general concerns about competitiveness and leakage, and allow achieving greater abatements at lower costs by tapping low cost abatement opportunities wherever they can be found. Options considered in the literature include indexed targets or price caps possibly for all countries, but also "non-binding targets" for developing countries. These would allow trading (i.e. selling) if a country has emissions below its quantified objective, but would not request a country to cover a possible deficit by buying on the international emissions trading markets (section **2.4**). An intermediate step towards country-wide objectives of any type could be that of sector-wide targets or mechanisms (section **2.5**).

All these options (including fixed and binding targets) could presumably co-exist in one single international or global system. Similarly, it would seem possible to link together smaller systems based on a range of options.

A recently-developed option coined "Action Targets" (section **2.6)** proposes to define targets as emission reductions expressed as a percentage of actual emissions during the compliance period. This option may provide the highest level of certainty with respect to the level of efforts and costs, but may run into difficulties similar to those experienced with project-based mechanisms with respect to baseline definition and additionality.

Another proposal suggests harmonised domestic-only trading regimes with price caps and two types of commodities – annual and perpetual (section **2.7**). This is because it recognises the many uncertainties that make climate change a complex decision-making issue, and sees international emissions trading as a problem rather than a solution.

Another option (section **2.8**) seeks to transform long-term goals into near-term incentives via the creation of "Long-Term Permits" that could be used at any time in the future and represent an emissions total coherent with an agreed long-term stabilisation goal.

2.1 Fixed and binding targets

Other names

- Kyoto-style targets (if at country level)
- Absolute targets

Main features

- Fixed and binding targets can be defined from a percentage reduction (or increase) from emissions in a given reference year, allowing calculation of "assigned amounts" (as done in the Kyoto Protocol).

Variations

- Fixed and binding targets with a price cap (see section **2.5** below)

Remarks / Issues to consider

- Fixed targets allow relatively simple emissions trading and are hence conducive to least-cost compliance.
- Fixed targets give certainty on emission levels (if countries comply) but no certainty on compliance costs.
- Environmental stringency depends on difference with a business-as-usual or reference emission projection. Fixed targets are therefore not necessarily more environmentally ambitious than other target types.
- As for targets under the Kyoto Protocol, "absolute targets" do not imply absolute reductions, i.e., reductions with respect to some earlier reference year. A fixed, "absolute" target can be above the reference year, and even above projections.
- While fixed targets make emissions trading possible, they do not automatically create an access for entities to the international market, which requires domestic trading arrangements.
- Some authors suggest fixed and binding targets represent the only sound option even for developing countries (e.g. Oppenheimer & Petsonk 2004; Ott et al. 2004).
- Fixed and binding targets for developing countries might be set at sufficiently high levels to provide them with "headroom" (Stewart & Wiener, 2003); they might be sector-wide only.
- More broadly, most allocation schemes (see section **3** below) have been conceived on the basis of fixed and binding targets.
- Many other authors consider it unrealistic for developing countries to take on economy-wide absolute targets.

Relevant literature

IEA 2001; Toth & Mwandosya 2001; Depledge 2002; Baumert, Perkaus & Kete 2003; Kallbekken & Westkog 2003; Stewart & Wiener 2003; Willems & Baumert 2003; Oppenheimer & Petsonk 2004; Ott et al. 2004.

2.2 Dynamic targets

Other names

- Indexed targets
- Growth targets (also used for fixed targets with emissions above reference year).
- Relative targets

Main features

- With dynamic targets, assigned amounts are based on some assumption on economic growth (or other variable) then adjusted according to actual economic growth.
- Dynamic targets can take a wide variety of forms. In particular, they could include combinations of a fixed assigned amount plus a variable assigned amount fully proportional to the GDP. Fixed targets and intensity targets (see below) are thus the two mathematical extremes of a more general formulation (Ellerman & Wing 2003).
- Other, more complex formulation for indexation, are also possible, as illustrated by the Argentinean proposal in 1998, of a target expressed as a function of the square root of GDP, which empirically adjusted to the evolution of past Argentinean emissions (see Bouille & Girardin 2002).
- Dynamic or "relative" targets do not mean "relative" reductions (implicitly from a baseline) as opposed to "absolute" reductions (implicitly from a reference year) – but relative to the evolution of some agreed variable.

Variations

- "Intensity targets" represent one form of dynamic targets where the assigned amount is calculated as entirely proportional to GDP. Therefore, the target can be expressed in "intensity" terms, i.e., as a ratio of emissions over GDP.
- "Dual intensity targets" would associate two intensity targets of different stringencies, one binding and the other non-binding (Kim and Baumert 2002).
- The adjustment of assigned amounts with respect to actual economic growth could take place either during the commitment period, or only once at its beginning.
- "Performance targets" derive national indexed targets from sectoral indexed targets (Höhne et al. 2003).

Remarks / Issues to consider

- Dynamic targets are intended to reduce uncertainties in emissions associated with variable rates of economic performance.
- Dynamic targets require an agreed measure of the GDP and its variations. For some , the way GDP is measured (e.g. "exchange rates" or "purchasing power parities" or "local currency") does not matter, as the intent is not to fix targets by international comparisons of carbon intensities; for others it does matter as variations of GDP over time may differ depending on measure units (Müller & Müller-Fürstenberger 2003).
- Some authors see trading with indexed targets as more complex due to the uncertainty on assigned amounts. Others see trading facilitated from reduced uncertainty on the likely "gap" between emissions and assigned amounts.
- Dynamic targets only reduce cost uncertainty to the extent it arises from uncertainty on emission trends (Philibert 2004a). However, they do not deliver certainty on emission levels.
- It has been suggested that indexed targets could be made more stringent than fixed targets for equal or lower expected costs (see, e.g., Jotzo & Pezzey 2005).

Relevant literature

Hargrave 1998 ; Baumert, Bhandari & Kete 1999; Frankel 1999; Lutter 2000; Bouille & Girardin 2002; Lisowski 2002; IEA 2002; Kim & Baumert 2002; Müller, Michaelowa & Vroljik 2002; Dudek & Golub 2003; Ellerman & Wing 2003; Höhne et al. 2003; Müller & Müller-Fürstenberger 2003; Grubb 2004; Philibert 2004a; Jotzo & Pezzey 2005.

2.3 Binding targets with price cap

Other names

- Safety valve
- Price ceiling
- Hybrid instruments

Main features

- 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.
- Implementation can be domestic (national) or international (see below "Remarks").
- The price cap reduces uncertainty on abatement costs, but also reduces certainty on abatement levels (assuming countries would otherwise fully comply, at any cost).

Variations

- While "mainstream" price cap concept suggests setting the price cap at a level corresponding to the upper range of cost estimates, other proposals favour a "low level" price cap with a view to limit international finance transfers resulting from emissions trading (see **2.7** below).

Remarks / Issues to consider

- Countries would negotiate two main elements: emission goals and the price cap level.
- International implementation of a price cap would imply the possibilities for countries (and possibly domestic entities with quantified objectives) to comply with their quantified objectives by buying additional allowances to some designated international entity at a fixed price.
- Domestic implementation would imply that sources can comply with their quantified objectives by buying allowances from the government at a fixed price. For entities without quantified objectives, the government would need to show that they are faced with a cost that is at least as high as the price cap, if the economic logic of the option is to be preserved. This would imply a more complicated international review mechanism. Another option would be that of a comprehensive trading regime covering all sources – presumably an "upstream" regime.
- A single price cap for all countries would facilitate international emissions trading. A single price cap does not imply equal compliance costs, as these depend on countries' quantitative targets.
- In case of different price cap levels one should ensure that only countries/agents in full compliance are net sellers on the markets (cf. non-binding targets); trading with several price cap levels would lower cost-effectiveness.
- Money raised through the price cap – if any – might be used in many manners. For example, funding more R, D&D would help reduce abatement costs in future commitment periods; funding more adaptation would alleviate impacts of relatively higher emissions.
- The price cap concept may facilitate participation and compliance by capping marginal abatement costs.

Relevant literature

Pizer 1998 ; Aldy, Orszag & Stiglitz 2001; Schlamadinger et al. 2001; IEA 2002; Pizer 2002; Newell & Pizer 2003; Jacoby & Ellerman 2004; Philibert & Reinaud 2004 ; NCEP 2004; SEPA 2004; Egenhofer & van Schaik 2005.

2.4 Non-binding targets

Other names

- Emission budgets (Philibert 2000)
- Non-binding target with trading
- No-lose targets (Bodansky 2004)
- One-way targets (Grubb 2004)
- "Positively binding" targets (Höhne et al. 2005)

Main features

- 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.
- A country with a non-binding target is a potential seller, not a potential buyer.

Variations

- Dual Intensity Targets: they would associate a dynamic but binding target with a dynamic non-binding target set at a lower level (Kim & Baumert 2002).
- Pan (2003) distinguishes "voluntary reductions" that should not be eligible for trading, "conditional reductions" that could be eligible for trading, and "luxurious/wasteful emissions" that might be subjected to progressive taxation.
- No Cap but Trade (see below 4.4) extends the concept to all countries: the buyer is an international institution.

Remarks / Issues to consider

- Non-binding targets have been suggested for developing countries only. The incentive provided by emissions trading requires the existence of a demand-side – presumably countries with binding targets.
- Non-binding targets for developing countries could be set close to business as usual emissions, taking into account technical progress and, possibly, some "win-win" options (Philibert 2000). Viguier (2004) suggests that countries with such non-binding commitment would only be allowed to sell a share of their reductions.
- One must ensure that only countries in compliance with their non-binding target are net sellers on the market. Several possibilities have been spelled out:
    - trading could be allowed only at the end of the commitment period;
    - once a country enters trading, its commitment becomes binding;
    - use of two targets: the country would be allowed to sell if its emissions are below the non-binding target (or "selling" target), and would need to buy if its emissions are above the binding (or "buying") target set at a higher level;
    - or, countries made responsible for tonnes sold: they must buy them back if emissions exceed the target (but do not need to cover actual emissions).
- It has been suggested that non-binding targets could be made more stringent than fixed targets for equal or lower expected costs (see, e.g., Jotzo & Pezzey 2004).
- Non-binding targets could help include developing countries in a global mitigation framework while avoiding the introduction of "tropical hot air" in the global carbon market as a consequence of uncertainties on energy futures and, even more, on deforestation rates (Persson & Azar 2004).

Relevant literature

Philibert 2000; Chan-Woo 2002; IEA 2002; SEPA 2002; Chen 2003; Dasgupta & Kelkar 2003; Kameyama 2003; Pan 2003; Willems & Baumert 2003; Bodansky 2004; Diringer 2004; Höhne et al. 2005; Grubb 2004; Jotzo & Pezzey 2004; Persson & Azar 2004; SEPA 2004; Torvanger, Twena & Vevatne 2004; Viguier 2004.

2.5 Sector-wide targets/mechanisms

Other names

- Sector-wide crediting mechanisms (including "allowances" as well as "credits")
- Sector crediting baselines

Main features

- Sector wide targets could be designed to cover various sectors.
- Sector wide targets could be binding or non-binding, fixed or indexed.
- Targets for industry sectors could be designed to link directly companies to international emissions trading.
- Targets for transport, household and small business sectors might be designed to reward and facilitate national or local government efforts through emissions trading, e.g. by providing a source of financing for mass-transit systems.

Variations

- Sector-wide crediting mechanisms could be designed as unilaterally-funded sector-wide CDM or other project-based mechanisms projects.
- Sector wide policies and measures could be made open to trading (see section **4.1**).

Remarks / Issues to consider:

- Compared to narrowly-defined project-based mechanisms (i.e. a project concerns a "plant", not a "sector"), sector-wide targets or crediting mechanisms may:
    - entail lower transaction costs per tonne;
    - alleviate concerns relating to competitiveness and potential leakage by providing an "opportunity cost" to all greenhouse gas emissions in covered sectors;
    - alleviate concerns relating to possible "perverse incentives" given to developing country governments (i.e. incentives to not implement sound sector-wide policies to maximise revenues from project-based mechanisms) - turning them into right incentives to act;
    - increase crediting of "anyway" tonnes through averaged baselines; it has been suggested to offset this risk by halving the amount of credits (Yamagata 2004).
- With respect to country-wide quantified targets, sector-wide targets may:
    - entail lesser institutional requirements in terms of monitoring and enforcement (although narrower field may require more detailed monitoring);
    - create more direct links between economic agents in the covered sectors and international investors;
    - remove part of the abatement cost uncertainty attached to uncertain economic growth;
    - provide for lesser opportunities to reduce emissions cost-effectively and raise concerns about leakage from one sector to another;
    - open up domestic sector issues to international negotiations and make them more complex.

Relevant literature

Philibert & Pershing 2001; Samaniego and Figueres 2002; Winkler & Spalding-Fecher 2002; Chung 2003; Dasgupta & Kelkar 2003; Stewart & Wiener 2003; Schmidt, Lawson & Lee 2004; Yamagata 2004; Bosi & Ellis 2005.

2.6 Action targets

Main features

- An action target is a commitment to reduce GHG emission levels by an agreed percentage which is applied to an observable baseline: actual emissions during the commitment period.
- In practice, 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 reductions could not be demonstrated, countries would buy the corresponding deficit from the market. If demonstrated reductions are higher than the agreed percentage, they can be sold to other countries.
- An action target could be adopted at any institutional level: firm, industry, municipal, state or national. They should aim at fostering sustainable development.
- Because committed reductions are a percentage of actual emissions, large fluctuations in economic and emission levels would have moderate effects on the level of abatement efforts required when compared with fixed or GDP-indexed targets.
- According to its inventors (Goldberg and Baumert 2004), action targets would eliminate the need to guess a future emissions baseline, as they use an "observable baseline", namely actual emissions.
- The said simplicity of this option and the guarantee it provides with respect to levels of efforts would make it especially relevant for framing future developing country commitments.

Remarks / Issues to consider

- While actual emissions would precisely determine the amount of abatement required, demonstrating actual reductions requires constructing a baseline, i.e. the emission trends that would have happened without the party's actions. This demonstration might be technically difficult (as baselines and additionality under project-based mechanisms) and politically controversial; the uncertainty on level of efforts inherent to other target options is traded off against uncertainty on actual compliance with the action target.
- If a demonstration of domestic reductions appeared too difficult, Action Targets could become mere obligations to buy permits covering an agreed percentage of actual emissions. This would not be particularly suitable for developing countries, and would suppose other target options for selling countries.
- Contrary to sector-wide CDM, Action Targets would be binding and require some efforts from developing countries before trading could occur. It would provide greater certainty on the level of efforts than other target options (even indexed targets), but at the expense of the complexities of agreeing on baselines and accounting, and greater uncertainty on overall emissions.

Relevant literature

Goldberg & Baumert 2004.

2.7 Allowances and endowments

Other names

- Domestic Hybrid Trading Schemes

Main features

- Each participating country (industrialised or developing) would:
    - Require that energy producers within their borders have an annual emission allowance for each ton of carbon embodied in their energy produced or sold domestically or imported;
    - Issue perpetual emission "endowments" that give the owner an emission allowance every year forever, equal to a specified fraction of a base period emissions;
    - Be allowed to sell additional annual allowances to firms within its borders at a stipulated price, such as 10 \$/tC (2.72 \$/tCO_2) (cf. price cap option);
    - Create domestic markets in the endowments (perpetual) and allowances (annual). There would be no international trade, but short run economic efficiency would be guaranteed by the common price for annual allowances.
- Developed countries would receive emissions endowments based on their Kyoto targets.
- Developing countries would receive emissions endowments equal to their current emissions plus an agreed percentage. Therefore, in the short run, the price of annual permits would be zero in developing countries. The permit price will equalise over time as developing countries' ability to pay rises.

Remarks / Issues to consider

- The distinction between annual allowances and long term endowment is aimed at giving long term price signals to the various agents while not entailing excessive short term costs; the use of a "low" price cap is intended to limit international revenue transfers arising from emissions trading.
- The long term endowments should be compatible with perpetual emission levels allowing greenhouse gases stabilisation i.e. corresponding to the long term capacity of natural sinks. Emissions above these levels will in practice be taxed.
- While new scientific information may make desirable to revise perpetual endowment allocation, their very nature may make this difficult. Current knowledge of CO_2 stabilisation dynamics suggests perpetual endowments close to zero and a correspondingly high price that would make them difficult to trade.

Relevant literature

McKibbin & Wilcoxen 2002; Haites 2005.

2.8 Long-term permits

Main Features

- Participating countries would establish national emission trading systems involving long term tradable permits that could be used to cover emissions at any time during a long commitment period, e.g., from 2010 to 2070.
- Permits would account for natural absorption, e.g. a carbon dioxide permit allowing 1 tonne in 2070 would allow 1.71 tonnes in 2010.

Variations

- Extended time flexibility through borrowing (Jacoby & Ellerman 2004). While the Long-Term Permits proposal fixes the global amount of emissions allowed for several decades, borrowing does not need the same decision. However, both aim to provide extended time flexibility to allow economic agents to identify the most economically efficient timing of emission abatements.

Remarks / Issues to consider

- Full time flexibility can help deal with abatement cost uncertainties and avoid price spikes – an objective also explicit in proposals such as the price cap (see above).
- Full time flexibility lowers countries / agents interest in participating in a trading regime, which could undermine the cost-effectiveness of actions taken to comply at any point in time.
- The risk with very long-term compliance period is that of non-compliance, especially in the international arena when participants are sovereign countries.
- If economic agents or countries indefinitely borrow from the future and postpone action, the increasing cost of complying will be a challenge for any national and international compliance regime.
- Negotiating long-term permits is likely to be more controversial than successive negotiations over reduction objectives.

Relevant literature

Peck & Teisberg 2003; Jacoby & Ellerman 2004; Philibert & Reinaud 2004.

3. Quantitative Approaches: Timing and Allocation Schemes

The literature on quantified objectives distinguishes options relative to the nature of targets, as seen above, and options with respect to timing, differentiation and possible allocation schemes; the latter are presented in this section.

The original "multi-stage" approach addresses the issue of timing as well as that of quantified commitments (section **3.1**). This approach allows the unique circumstances / development status of different countries to be taken into account, e.g., in accordance with their differentiated responsibilities under the Convention. The proponents of multi-stage identify various types of thresholds (emissions per capita, emission intensity, GDP per capita and others) to trigger mitigation commitments. This approach builds somewhat on the current differentiation of commitments under both the UNFCCC and its Kyoto Protocol, albeit going beyond the existing division in only two broad categories – Annex I and non-Annex I.

As many authors elaborated various proposals following the same basic ideas, the concept has progressively evolved in various proposals to embrace a greater variety of targets. The incorporation of new target options might be seen as an attempt to fix the shortcomings of the original multi-stage approach – the fact that this slow process may lead to concentration levels that some may deem too high.

Contraction and Convergence (section **3.2**) offers a different perspective based on a moral argument according to which all human beings are entitled equal per capita emission allowances. Participation to global emissions trading is not "staged" – the timing only regards the rhythm of convergence towards equal per capita entitlements.

Other allocation approaches ("Global Triptych" but also "Multi-sector Convergence", section **3.3**) start also from the need to achieve convergence but distinguish among the various sectors of the economies; rather than per capital emissions, energy or emission intensities may be required to converge to common levels. Immediate equal per capita allocation has also been suggested in another framework (section **3.4**), with additional features intended to alleviate some undesirable but likely effects of the equal per capita entitlement.

Although the original "Brazilian proposal" formulated in 1997 was designed at framing quantified fixed, binding objectives for industrialised countries only, it has been further developed as a possible tool to frame targets for all countries (section **3.5**).

Finally, a number of proposals suggest to base allocation schemes on an assessment of costs. Cost considerations are one factor of primary importance for countries adopting greenhouse gas emission mitigation strategies, in light of implications for economic growth and competitiveness. This leads to much diverse methods of sharing them amongst countries (**3.6**). The technicalities of them may differ slightly, but all would more or less necessitate an agreement on how to compute the costs ex ante, which may not be trivial.

3.1 Multi-stage approaches

Main features

- The original multi-stage approach (Berk and den Elsen 2001) proposed a pathway towards a global regime in which developing countries participate in several stages involving progressively more stringent binding fixed and intensity targets.
- Increasing GDP per capita levels would trigger developing countries from no commitments to binding intensity targets and then to fixed targets, from stabilisation of emissions to absolute reductions – the latter applying automatically to industrialised countries.
- Allocation would be based on per capita GDP and historical responsibility.
- This concept has given birth to many variations (see below).

Variations

- Some precursors: Claussen & McNelly 1998; "Ability to pay" (Jacoby, Schmalensee & Wing 1999 - see section **3.6** below).
- Some proposals keep the original choice of target options and only differ by relatively minor changes in triggers and allocation methods, all generally based on a mixed between GDP per capita and emission per capita (CAN 2003, Criqui et al 2003, Höhne et al. 2003, or Michaelowa, Butzengeiger & Jung 2003).
- Other proposals use an expanded list of options for quantified objectives, including non-binding targets (SEPA 2002, , Torvanger, Twena & Vevatne 2004, or Höhne et al. 2005).
- Another proposal (Ott et al. 2004) substituted intensity targets by fixed and binding targets for 15 "newly-industrialised" and 37 "rapidly-industrialising" developing countries, under the condition that all major Annex I countries take on reduction targets and provide financial and technological resources.
- Another proposal (Tangen & Hasselknippe 2003) suggests progressively building a global regime through bilateral negotiations to link national or regional regimes.

Remarks / Issues to consider

- Proponents of the original multi-stage approach (Berk & den Elsen 2001) have recognised it might be too slow a process to achieve sufficiently low concentration levels as emissions of many developing countries would remain unabated for a long time. Moreover, tightening action by industrialised countries might be slowed by the lack of cheap abatement opportunities offered through emissions trading and by concerns about competitiveness and leakage.
- Broadening the list of options to non-binding targets may help alleviating these concerns by engaging developing countries sooner in global mitigation action.

Relevant literature

Claussen & McNelly 1998; Jacoby, Schmalensee & Wing 1999; Berk & den Elzen 2001; SEPA 2002; CAN 2003; Criqui et al. 2003; Höhne et al. 2003; Michaelowa, Butzengeiger & Jung 2003; Tangen & Hasselknippe 2003; den Elzen & Berk 2004; Ott et al. 2004; SEPA 2004; Torvanger, Twena & Vevatne 2004; Höhne et al. 2005.

3.2 Contraction and Convergence

Main features

- Fixed and binding targets only for all countries.
- A global emission pathway would be agreed upon, leading to a long term stabilisation of GHG concentrations at some agreed level (Contraction).
- The global emission budget for each year would be divided among countries so that per capita emission allowances converge by an agreed year (Convergence).
- As a result, per capita entitlements in developed countries would decrease continuously, while those in developing countries would first increase then decrease essentially after convergence has been reached.
- Emissions trading would be encouraged.

Variations:

- "Common but differentiated" (Gupta & Bhandari 1999) distinguishes a transition period through 2025, in which developed countries are given reduction objectives, and most developing countries adopt fixed growth targets. In a second period, global emissions are allocated to countries on a per capita basis, with some flexibility to account for variable national circumstances.
- "Common but differentiated" (Höhne et al. 2005): Annex I countries' per capita emissions converge within e.g. 40 years (2010 to 2050) to a low level. Individual non-Annex I countries converge to the same level also within e.g. 40 years, but starting when their per capita emissions are a certain percentage above global average. Until then they may take on non binding targets.
- Equal per capita over time (Bode 2004): developed countries per capital emission allowances would be reduced below that of developing countries and eventually rise back and converge at a common level;
- "Global Tryptich Approach" and "Multi-sector Convergence" combine various forms of convergence (see details in "Global Tryptich Approach" above).
- A completely different form of convergence would be the convergence of emission intensities.

Remarks / Issues to consider

- Depending on the pace of convergence, some or many developing countries may initially receive large amounts of surplus allowances. Industrialised countries would need to buy this "tropical hot air" before being in position to finance additional emission reductions through emissions trading (IEA, 2002).
- Depending on the pace of convergence, there is a possibility that after some time some or many developing countries start being bound by quantified emissions objectives at much lower levels than those previously enjoyed by industrialised countries (Chen & Pan 2003).
- National circumstances, such as varying energy endowments, may justify disparities in per capita emissions even if global emissions were compatible with stabilisation of concentrations.
- Contraction of global emissions, required by GHG stabilisation, would inevitably lead to some degree of convergence. This does not necessarily make convergence towards equal per capita emissions the only legitimate principle for allocation.

Relevant literature

Agarwal & Narain 1991, 1998; Gupta & Bandhari 1999; Meyer 2000; Berk & den Elsen 2001; Aslam 2002; IEA 2002; Chen & Pan 2003; Bode 2004; den Elzen & Berk 2004; Höhne et al. 2005.

3.3 Global Triptych approach

Main features

- A method of allocation for fixed and binding targets for all countries by 2020 and 2050.
- Different principles for defining allowances are suggested for three broad sectors: power generation, energy-intensive industries, and the domestic sector that includes transportation and the residential/small business sector. Some form of convergence is proposed for each:
    - Convergence of energy efficiency in the energy-intensive industry;
    - Convergence of greenhouse gas intensity of electricity production;
    - Convergence of per capita emissions in the domestic sectors.
- National allocations would be the sum of allocation to these various sectors in each country. They would be computed to be compatible with stabilisation of GHG concentrations.
- Simulation exercises suggest that the Triptych approach would lead to objectives in 2020 of between -10% and -20% of 1990/1995 reference years for OECD countries, between -30% and -50% for economies in transition. Developing countries would be allowed increases varying from +40% to +200%.

Variations

- The "Multi-sector Convergence" offers a more complex allocation process on the basis of seven sectors: power, households, transportation, industry, services, agriculture and waste (Sijm, Jansen & Torvanger 2001).
- The "Extended Global Triptych" extends the original Triptych approach to non CO_2 gases and various sources that were not included in the original approach (Höhne et al. 2003).
- A simplified possibility for allocation would be the convergence of emission intensities.

Remarks / Issues to consider

- Reflecting sectoral realities and national circumstances in an international negotiation could help convince negotiating Parties that similar efforts are being undertaken by other Parties and could promote more ambitious objectives through coordination.
- Differentiating the various paces of progress in various sectors might be useful also to help determine allocation in other schemes with a broader set of target options.
- The Triptych approach has proven effective in the context of helping to frame the EU burden-sharing agreement. It can be applied on any subgroup of countries or at a global level. Countries around the world are more diverse, however, than EU countries, and less accustomed to share burdens.

Relevant literature:

Groenenberg, Phylipsen & Blok 2001; Sijm, Jansen & Torvanger 2001; Höhne et al. 2003; den Elzen & Berk 2004; Höhne et al. 2005.

3.4 Immediate Equal Per Capita

Other names

- Global Climate Certificate System (Wicke 2004)

Main features

- A global amount of allowed emissions would be set equal to global emissions as forecasted in 2015 (around 30 billion tonnes) and would be kept constant over the fifty years at least, therefore being progressively biting only after 2015.
- Global allocation of emission allowances would be made immediately on a strict equal per capita basis, free of charge.
- In all countries allowances to introduce carbon into the economy would be given to fossil fuel producers or importers, creating an "upstream" trading regime, as opposed to a "downstream" regime in which sources receive direct emission allowances.
- To prevent large financial transfers to arise as a result of an allowance shortage in industrialised countries and considerable surplus allowances in developing countries, two markets would be distinguished:
    - a transfer market between states for trading surplus allowances at a fixed price of US$2/t CO_2, after enough allowances have been supplied to fossil fuel providers on the basis of their "proven demand";
    - a free market for trading emission reductions between fossil fuels providers.
- A World Climate Certificate Bank would deliver these allowances and also an unlimited amount of supplementary allowances at US$30 – a price cap.
- Countries receiving surplus allowances would have to spend the money according to a "Sustainable Development and Elimination of Poverty" plan developed at a national level and approved internationally.

Variations

- Contraction and convergence (see above)
- Equal per capita over time (Bode 2004 – see Contraction and Convergence above)
- Equal per capita (Agarwal and Narain 1991)

Remarks / Issues to consider

- Stabilisation of global emissions at current levels for the next fifty years, then followed by a decrease, has been suggested as leading to relatively low level of atmospheric concentrations (Pacala & Sokolow 2004).
- The money transfers arising from immediate equal per capita emissions – even limited by a fixed price – would not contribute to mitigate climate change.
- It is not clear that the inter-governmental market and the fossil fuel providers market could be separated in practice, as they eventually trade the same commodity.
- Allocation of emissions rights on a per capita basis is unlikely to be accepted by all countries.

Relevant literature:
Agarwal & Narain 1991; Aslam 2002; Bode 2004; Wicke 2004.

3.5 Brazilian proposal

Other names

- Historical responsibility

Main features

- Fixed and binding targets for all countries.
- Emissions targets based on historical responsibility for existing temperature change.
- The original Brazilian Proposal during the negotiations within the "Ad Hoc Group on Berlin Mandate" (1995-1997) proposed a methodology for allocating emission reduction burdens among industrialised countries based on their relative historical responsibility for global temperature increase. The methodology could be applied to all countries.
- The original Brazilian Proposal included a financial penalty for non-complying countries which would be used to finance clean development projects – this formed the basis of the Kyoto negotiations on the Clean Development Mechanism.

Variations

- The extension of the allocation method of the Brazilian Proposal to set objectives for developing countries is a variation of the original proposal.
- Cumulative GHG emissions could be used as a reasonable proxy for historical responsibility of the various countries, avoiding the much deeper complexity of identifying their responsibility in temperature changes (La Rovere, Valente de Macedo & Baumert 2002).

Remarks / Issues to consider

- Although relying on historical responsibility to compute country emission objectives may seem to favour developing countries, it does not in reality as it only allows for absolute reduction objectives.
- The Brazilian Proposal presents serious data challenges since it relies on past emissions data, including from land-use changes, potentially going back several decades.
- The Brazilian Proposal in its original form relating to historical responsibilities in temperature changes raises a number of complex methodological issues. Several expert meetings have been organised to research this matter at the request of the UNFCCC. Other options including cumulative emissions and sea-level rise are also discussed as a potential metric in that context.
- Historical but inadvertent responsibility is not likely to be easily accepted by all countries.

Relevant literature:
Ministry of Science and Technology 1997; Ministry of Science and Technology 2000; La Rovere, Valente de Macedo & Baumert 2002; Expert Meeting reports
(available at http://unfccc.int/methods_and_science/other_methodological_issues/items/1038.php).

3.6 Cost-based allocations

Main features

- The various proposals gathered here have all in common to focus on costs to drive timing and allocation of efforts. Beyond this common feature, they are inspired by very different considerations, and therefore very diverse.

Variations

- Ability to pay (Jacoby, Schmalensee & Wing 1999): a threshold of per capita welfare would trigger the adhesion of a country to the global scheme. The rate of emission reduction would be a function of three other parameters open to negotiations: the "near term reduction rate" would have its strongest effect on nations just above the welfare threshold, the "long term reduction rate" would essentially affect reduction rate of nations far above the welfare thresholds, while the "initial grace period" would mitigate the effects of the two previous and determine the maximum rate at which regions should slow the rate of growth of their emissions prior to beginning absolute reductions. "Ability to pay" is also a "multi-stage" approaches (see above).
- Equal mitigation costs (Babiker & Eckaus 2000): allocation would be set to equalise per capita welfare costs. The authors consider and dismiss other options (i.e. "equal per capita reductions" and "equal country shares in reductions), except the next one:
- UN budget contributions (Babiker & Eckaus 2000): allocation would be set to entail costs on a per capita basis that follow the rule used to apportion countries' contributions to the United Nations' budget (see also section **4.4**).
- No harm rule (for developing countries) (Edmonds, Wise & Barns 1995): business-as-usual emissions (possibly reduced by win-win actions) would form emission objectives. Such targets would therefore be perceived as entailing "no harm". The essence of the proposal is to allow industrialised countries to access cheap reduction opportunities in developing countries through international emissions trading.

Remarks / Issues to consider

- Cost considerations are of primary importance for countries adopting greenhouse gas emission mitigation strategies, and especially quantitative commitments.
- An advantage of quantified objectives is that emissions trading may favour a cost-effective repartition of efforts regardless of the initial allocation of allowances; this may allow negotiators to focus on other criteria for initial allocation.
- Most proposals suggested here would require an agreement on how to model and assess policy costs, an issue over which the IPCC has not reached consensus. This would be a major barrier to the implementation of these methods to determine country commitments. The no harm rule, however, would only require an agreement on business as usual emission trends.

Relevant literature

Edmonds, Wise and Barns 1995; Jacoby, Schmalensee & Wing 1999; Babiker & Eckaus 2000; Philibert et al. 2003.

4. Non Quantitative Approaches

While it does not set any objective to any country, the "No cap but trade" (section **4.1**) approach still requires elaborating business as usual emission patterns which will form the basis of "non-binding targets" for all countries. It thus offers a transition from quantitative approaches to non-quantitative approaches.

All other non-quantitative options presented here represent one or another form of agreement on policies and measures. These might be left unspecified (section **4.2**). They can also be directed towards technology improvements using mainly standards and commitments to facilitate technology transfers, and perhaps complementary agreements on R&D (section **4.3**). Another, quite different, possibility is to aim at harmonising domestic carbon taxes (section **4.4**).

4.1 No cap but trade

Other names

- Purchase of a Global Public Good

Main features

- No country would be assigned a quantified objective.
- All countries would be given emissions allowances based on business-as-usual emissions paths, plus possibly headroom.
- All countries would contribute to fund a new international institution, the International Bank for Emissions Allowance Acquisition.
- The International Bank would buy emission reductions everywhere starting with the least-cost options, thus ensuring cost-effectiveness.

Remarks / Issues to consider

- The "No Cap but Trade" proposal only rests on governments' money and does not seem able to mobilise private financing; it finances a global public good – namely climate – through taxation, but does little tot implement the polluters pay principle.

Relevant literature

Bradford 2004.

4.2 Policies and measures

Main features

- Recognising that GHG mitigation will require introducing policies and measures, some proposals substitute PAMs to quantitative emission objectives.
- Voluntary commitments to policies and measures could be taken by all countries (pledge and review). Similarly, PAMs include voluntary agreements between governments and various stakeholders.
- More developed countries would fund an institution that would help finance energy-efficient and decarbonised technologies in the developing world. The recipient will benefit and should be required to assume commitments to emissions-reducing actions.

Variations

- Sustainable Development Policies and Measures (SD-PAMs – Winkler et al., 2002): industrialised countries would take quantified objectives; developing countries would commit to policies and measures with a focus on their sustainable development objectives.
- Technology agreements (section **4.2**) or carbon taxes (section **4.3**) could be viewed as broad policies fitting under P&M commitments.

Remarks / Issues to consider

- Policies and measures based on "command-and-control" approaches are likely to be costlier than those based on market mechanisms.
- The concept of "mandatory" policies and measures discussed under the Berlin Mandate has received little attention in the literature.
- However, although of a voluntary nature, policies and measures may be subject to commitments, with the advantage that each government will know precisely what it commits to (Schelling 2002) – which may be less the case with quantitative approaches.
- Individual governments may find it difficult to commit to ambitious domestic policies and measures unless some international coordination prevents free-riding by other countries, and related competitiveness concerns.
- However, a voluntary PAMs approach may enhance cooperation if considered a sufficiently attractive approach by a broad group of countries.
- According to Schelling, countries would only agree to their own action once they have seen what others have committed to do. This "procedural equity" implicitly addresses competitiveness concerns.
- The SD-PAMs proposal offers a mid-way between non-quantitative and quantitative approaches in suggesting that policies and measures undertaken in developing countries could be open to trading through sector-crediting mechanisms (section **2.5** above).

Relevant literature

Schelling 2002 ; Winkler et al. 2002; Reinstein 2004.

4.3 Technology agreements

Main features

- Technology agreements can take a variety of forms, from stationary source standards commitments to standards-based approaches that relate to energy efficiency investments to cooperative research and development agreements.
- For example, an agreement on a few broad technology standards would force the dissemination of zero emitting technologies; they would focus, for example, on zero emitting power plants and zero carbon content fuels.
- Such standards will be set years in advance. The obligations would first be made for all new plants in industrialised countries in 2020, then for all plants in 2050 in the same countries.
- Developing countries would have to satisfy the same obligations when their per capita welfare (measured in purchasing power parities) would equal those reached by industrialised countries in 2020 and 2050 (Edmonds & Wise 1999).

Variations

- Agreements on standards can be more diverse, and do not need be global: a critical mass of countries adopting a common standard may be enough to ensure global diffusion.
- Agreements could also cover R&D and funding for technology diffusion to developing countries (Barrett 2003).
- Technology agreements could also create new, or strengthen existing, bilateral and multilateral cooperation channels on technology development.
- Technology agreements could recognise domestic voluntary approaches, private-public partnerships and other useful elements of domestic technology policies.
- Technology agreements could also deal with international sectoral cooperation including both industry and official cooperation.

Remarks / Issues to consider

- Under perfect market conditions and for an identical emission goal, technology standards would be more expensive than a market-based approach (+30% according to Edmonds &Wise, 1999).
- Stringent standards set years in advance may not deliver the intended technology development, which is notably difficult to predict. Companies may anticipate that political authorities will waive the target if technological improvements are insufficient, particularly if the consequences of a full enforcement were very costly and/or politically difficult.
- Technology approaches may not be able to foster behavioural changes, while policies resulting in pricing the climate change externality could arguably drive simultaneously technology and behavioural changes.
- The bulk of potential for emission reductions in the coming decades may lie in energy efficiency improvements at end-use levels, based on numerous existing technologies. It is not clear to what extent such technologies would be amenable to broad international agreements.

Relevant literature:
Edmonds & Wise 1999; Barrett 2001; Benedick 2001; Barrett 2003; Philibert 2003; Philibert 2004b.

4.4 Carbon taxes

Main features

- Domestic taxes would be perceived on all GHG emissions, starting with carbon dioxide emissions.
- The level of these taxes, presumably set equal to the postulated marginal cost of climate change, would be harmonised internationally.

Variations

- Emission trading schemes with a "low" price cap (i.e. a price cap set in the lower range of projected abatement costs) would be close to carbon taxes. See, e.g., "Endowments and allowances" above.

Remarks / Issues to consider

- Carbon taxes spontaneously adjust the level of emission reductions according to their actual costs. It allows greater control on the abatement costs, buy leaves uncertain the amount of emissions reached at each time. This feature might fit well the "stock" nature of the climate problem.
- Cost-effectiveness would require same tax levels, i.e. same marginal abatement costs, in all countries, regardless of their development stage. This would result in vastly different social cost across countries and be perceived as inequitable. Internationally harmonised taxes face strong opposition by numerous stakeholders and governments.
- It could be difficult to measure the net level, and actual effectiveness, of carbon taxes in the broader context of other fiscal policies (such as fuel taxes and coal subsidies).
- Taxes are perceived on all emissions, while emissions trading allow government to fine tune allocation and auctioning in order to minimise the potential disadvantages of both – in particular at a time when not all countries are integrated in a single regime with comparable marginal abatement costs.

Relevant literature:

Cooper 1998; Pizer 2002; Nordhaus 2002; Newell & Pizer 2003.

5. Conclusion and Future Work

This survey outlines the characteristics of several approaches suggested for the climate regime post-2012. These include frameworks of a fundamentally different nature: from qualitative to quantitative measures, binding or non-binding targets, all-encompassing (i.e. multi-stage) to more discrete proposals (non-binding targets applying only to developing countries).

For the sake of clarity, the paper presents these options as alternatives, while it is already clear from current climate policy practice that these different approaches can be mixed. Countries that have agreed to quantified emission limitation objectives also take coordinated measures to foster renewables, engage in bilateral agreements on technology development towards climate mitigation, including with countries without quantified objectives. Further, supporters of a global trading regime consider that this could evolve from linking separate trading regimes as well as from top-down global negotiations (Tangen & Hasselknippe 2003). Other proposals elaborate further combinations of options. Sugiyama and Sinton (2003) suggest mixing emissions trading for some countries, and a zero emissions technology treaty and a "climate-wide development treaty" to promote development, technology transfer and adaptation. Others propose to apply voting rules to the choice of options (Müller 2001). Countries involved in emissions trading may be less sensitive than others to the need of having a comprehensive set of technology agreements. Various options can coexist within the same countries – assuming, for example, that some options better deal with short term reductions while others better deal with long term issues. Another possibility is that various options coexist in diverse gathering of countries. Separate elements can be agreed to altogether or in "single-issue" agreements (SEPA 2004).

Further work will be needed to provide more in-depth analysis of the options described in this paper. Numerous implementation issues remain to be addressed in more detail. And – future work will look into the feasibility and need for broader international policy packages, of which quantified objectives is only one element. Questions to be covered include the following:

- How can international policy-based and technology approaches complement existing and other quantitative approaches for international commitments?

- What would be the value of other policy coordination, in addition to coordination based on market approaches?

- What international options can be envisioned to build capacity in developing countries to facilitate commitments, in light of future mitigation costs?

- Beyond existing mechanisms (UNFCCC funds, Clean Development Mechanism), what vehicles can be used to encourage developing countries towards technology and infrastructure choices that would carry low mitigation cost, lower GHG emissions? How can bilateral agreements, international financial institutions, and multi-national companies be harnessed to deliver a lower GHG emission path in the near term?

- How can domestic development goals help overcome hurdles to international climate action? Are there domestic priorities that run against climate mitigation? Can these be addressed internationally?

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