Designing institutions for climate change:

Why rational design involves technology

Outline

Abstract

This paper aims to explore how to augment the institutional solutions offered by current political theory for addressing the unprecedented problem of climate change. Although steering directly at emission reductions in an international treaty has benefits in terms of cost-effectiveness, the paper arrives at the conclusion that considerations around technological development should be drawn into the treaty equation in order to generate sufficient reciprocity to have a politically feasible international regime. It then argues that the benefits of technology agreements for climate change mitigation may be larger than commonly assumed, as they - if properly designed - could lead to real emission reductions and provide more flexibility to reach agreement in post-2012 negotiations than proposals modelled exclusively on the Kyoto Protocol or other types of absolute emission targets. Based on rational design of international institutions for environmental governance, and attempting to take into account considerations of technological dynamics and the "sociotechnical system", contours of a possible environmentally effective and politically feasible international climate change agreements are sketched.

1. Introduction

This paper aims to explore how to augment the institutional solutions offered by current political theory for addressing the unprecedented problem of climate change. It arrives at the conclusion that benefits from technological development should be drawn into the equation in order to achieve a politically feasible international regime. It then argues that the benefits of technology agreements for climate change mitigation may be larger than commonly assumed, as they - if properly designed - could provide real emission reductions and give more flexibility to reach agreement in post-2012 negotiations than proposals modelled exclusively on the Kyoto Protocol or other types of absolute emission targets.

This paper works with a number of assumptions that require upfront mentioning but speak for themselves:

1. Addressing climate change means that greenhouse gas emissions need to be reduced drastically so as to stabilise greenhouse gas concentrations
2. Industrialised countries have to undertake action first (regardless whether it is domestically or through an international agreement on a different location)
3. It will be costly to reduce emissions to a level that sufficiently addresses climate change
4. Actors in the climate change negotiations act according to rational-choice theory.

Over the past decades, approaches founded on economically rational behaviour theory (Coase, 1988) and expanded with methods and insights from international relations have led to the recognition that the design of institutions in international governance matters much to the effectiveness of international governance (Keohane, 1984). Institutional design has developed as a subfield of international relations theory and is still under development, with recent additions in the field of international law (e.g. Raustiala, 2005), rational design of institutions (Koremenos et al., 2001) and networking theory (Powell, 1990; Slaughter, 2005). In terms of classical coordination games with a relatively symmetrical distribution of costs and benefits (Martin, 1992; Mitchell and Keilbach, 2001) or with obvious reciprocal elements or peer pressure (Simmons, 2000), the outcomes of international treaties seem predictable. For problems with asymmetrical interests and for issues that involve deep cooperation to be solved, it has been argued that in the case of "strong victims" and even "weak victims", positive exchange or negative coercion may be employed to reduce the externalities, i.e. rewarding compliance or sanctioning defection, respectively (Mitchell and Keilbach, 2001). However, no obvious answer from the international governance community has risen as of yet for the case of not only weak, but also poor victims, incapable of providing rewards to perpetrators or coercing them into agreement and compliance. This paper argues that climate change is exactly such a problem, that the current deadlock is indeed due to this very nature of the problem, and the inability to act is consequential of the institutional design of international governance in general. A potential solution, in the broadening of the scope of the issue to technology issues, is also offered.

Climate change has received increasing recognition as a global environmental problem since the early 1990s. In response, the international community set up a UN institution for climate change in the United Nations Framework Convention on Climate Change (UNFCCC), which aims at "stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system" (UNFCCC, 1992: Article 2). In the Kyoto Protocol, which was agreed three years after the UNFCCC entered into force, specific greenhouse gas reduction targets for industrialised countries were agreed (UNFCCC, 1997). On the basis of "common but differentiated responsibilities"(UNFCCC, 1992), developing countries were exempted from commitments but are able to participate voluntarily via the Clean Development Mechanism (UNFCCC, 1997).

After the Kyoto Protocol was agreed, numerous papers were published in the field of political science, subjecting the protocol to the general rules of institutional design (for a review, see Böhringer, 2003). The Kyoto Protocol was criticised for disobeying rules of participation, flexibility and compliance (see e.g. Barrett, 1998; Victor, 2001). Part of the criticism was proven right, as major players dropped out of the protocol and others will probably not comply. At the same time, however, in those countries where the protocol was seriously pursued, a carbon market now flourishes and the alleged design flaws have, at least partially, not come true. Subsequent assessments of post-2012 proposals have attempted to overcome some of the criticism (Aldy et al., 2003), but could never quite reach a workable treaty with a functional design.

The discussions on post-2012 regimes have recently gone beyond the political science arena and have entered the negotiations. Since the 11th Conference of Parties, the discussion of post-2012 regimes has an official place both under the UNFCCC and among the parties of the Kyoto Protocol. Naturally, many Annex I and non-Annex I countries which ratified the Kyoto Protocol would like to proceed with a targets and timetables approach, although there are unresolved issues regarding the geographical coverage and the extent of emission reduction targets. The literature on post-2012 regimes, understandably, also focuses on a second commitment period based approach (see e.g. Den Elzen, 2005). The current political reality, however, particularly the involvement of Parties that clearly put economic interests above the interest of preventing dangerous climate change, demands a different approach.

This paper argues that expanding the issue-scope of a climate regime to include technology may be such an approach. Until recently, agreements based on technology were either hardly mentioned in existing reviews of potential post-2012 climate regimes, or restricted to being only voluntary treaties without prospects for real reduction of greenhouse gas emissions. Technology agreements were usually dismissed as environmentally unfriendly, only R&D and excluding deployment, and not acceptable from the climate point of view (Berk et al., 2002; Höhne, 2005). At best, they were considered as additional action to a more core agreement on emission targets. There have been early proposals (Edmonds et al., 1998) and more recent assessments have also considered deployment of technology (Blok et al., 2005). Statements at the Seminar of Government Experts in May 2005 and, to some extent, the recent agreement in the context of the Asia-Pacific Partnership hint that technology-oriented agreements could to play a major role in post-2012 climate regime discussions. Recently, a review paper of different technology-oriented agreements has defined what such agreements comprise, how effective they have been in the past, and what their role may be in the climate change regime (Coninck et al., 2007).

Agreements based on technology bring up a number of different questions. Actually, technology dynamics are not yet taken into account in institutional design or even in domestic policymaking (Shove, 1998). For climate change, given the timescales (decades to centuries), the geographical level (global) and the challenges in terms of emission reductions (daunting), it may be helpful to incorporate insights from scholars in the field of technological change. In addition to arguing an IR-theoretic basis for technology-oriented agreements, this paper attempts to give a starting point for making international institutions compatible with the socio-technical regime changes.

After this introduction, the issue of climate change is introduced from the perspective of a redistribution issue in section 2, along with a description of the institutional menu of choices and tradeoffs to address the issue. Section 3 will reflect on technological innovation, technology dynamics and socio-technical change, while section 4 will discuss the implications for institutional design. Based on current positions, section 5 will conclude with a discussion of the practical implications of broadening the climate regime.

2. Climate change and design of international institutions

International relations and institutional design view problems the international community confronts with an eye of the distribution of interests in addressing the issue. It is therefore important to have a good understanding of what climate change is, what is may bring about, and what addressing the problem means for which parties in the world community. This section will first describe the climate change issues in terms relevant to the objective of this study, will subsequently and based on the observations in section 2.1, assess the outcomes of the international community response to the issue from the different theories that prevail in the international relations literature. Section 2.3 will zoom in further on the rational institutional design literature specifically for the case of climate change.

2.1 Climate change: a redistribution issue

The climate change problem has a number of characteristics that qualify it as a "redistribution issue". For the sake of this article defined as "an issue that requires a more proportional distribution of commodities in order to be solved in a just manner"[1]. In the context of climate change, the perception of what is "just" pertains both to who bears the burden of preserving the collective good of a stable climate (i.e. who reduces greenhouse gas emissions), and who would suffer the most from impacts of climate change. The issue of development is closely intertwined with climate change as a redistribution issue, as more developed states generally emit more greenhouse gases and also suffer less from the impacts of climate change. For designing international institutions for climate change, it is important to understand the diversity in players in the culprits for the problem, the ones who will bear the cost of solving it, and those who will bear the costs of collective inaction.

The terms "enhanced greenhouse effect", "global warming" and "climate change" are used to describe the change in the Earth's radiative balance by the elevated concentrations of gases and aerosols to the atmosphere that absorb in the infrared and therefore capture the energy contained in the solar radiation reflected by the Earth's surface. The main greenhouse gas is carbon dioxide (CO_2), which originates largely from the combustion of fossil fuels - oil, gas and coal - in industry, electricity production and transport. Other important gases are methane and nitrous oxide as well as the aerosol soot. In this paper the focus will be on CO_2, as this gas is both the greatest cause of the problem, and poses the most fundamental challenges for the solution. In order to prevent climate changes from happening, the concentration of CO_2 in the atmosphere would need to stabilise at a certain level.

Greenhouse gas concentrations before the industrial revolution (around 1850) were about 280 parts per million (ppm). Current concentrations are around 380 ppm. It is uncertain exactly what concentration would prevent dangerous climate change, as climate sensitivities (i.e. how the climate exactly responds to a shifted radiative balance) are not known exactly. However, working with a range of likely climate sensitivities derived from paleoclimatic data, it has been argued that an increase in global mean temperature of 2°C would not lead to extreme climate risks or very costly impacts. Early models indicate that a concentration of 550 ppm (or double the pre-industrial level) would be low enough to stay below the 2°C (IPCC, 2001), but others have argued that the risk of "overshooting" that temperature increase is around 80% at a stabilisation level of 550 ppm, and argue that stabilisation at 450 ppm or even lower would be necessary (Meinshausen and Hare, 2005). The emission reductions associated with those stabilisation levels are achievable with current technologies, but will have profound impacts on the way energy is used and produced.

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[1] This definition is based on the Wikipedia definition of "redistribution", which is: "Redistribution is a term often applied to finite commodities within a society. Redistributive efforts often strive for a more proportionate distribution of these commodities in order to make the society more just." See http://en.wikipedia.org/wiki/Redistribution.

The availability of reliable and cheap energy is an important precondition for virtually all economic activities. In 2003, 80% of all primary energy used in the world originated from fossil fuels. This share is lower than the 85% of fossil energy in 1973, but the use of energy has also increased by about 75%, so the absolute use of fossil fuels is still on the rise (IEA, 2005). Most energy scenarios project doubling of CO_2 emissions by 2050, due to increasing energy use and persistent share of fossil fuels in the energy mix. Emissions will need to at least be at the current level, and preferably lower, than current emissions. It has been argued that it is technically feasible to achieve such goals with the current portfolio of technologies (IPCC, 2001). Global options to reach such levels are outlined by Pacala and Socolow (2004) in a comprehensive approach. They identify a number of "wedges" that each can reduce global carbon emissions by 1 GtC in 2050. Seven of such global wedges would be sufficient to generate the same emissions in 2050 as now, and would annul the baseline emission rise. Examples of wedges include very large-scale application of wind energy, thousands of CO_2 capture and geological storage facilities at power or synfuels plants, reduction of car use by half, double car mileage, or greatly improved land use and forestation practices. All energy supply wedges are currently more costly than the economically optimal unbridled fossil fuel energy supply. Energy efficiency options can be cost-effective, but face other barriers that inhibit their implementation (IPCC, 2001).

Given the economic development in particularly Asia over the coming decades, expected to be fuelled by notably coal (IEA, 2005), and given the required stabilisation of CO_2 concentrations, the emissions in the developed world would have to decrease significantly, by several tens of percents compared to current emissions. Currently, CO_2 emissions in the industrialised countries are about half of the global emissions, while these countries constitute only about 20% of the world's population. The lion's share of the greenhouse gases that have cumulatively been emitted over the past 150 years originate from the industrialised countries. These countries are also in the best position, both having the required economic means and level of technological development, to invest in addressing climate change. These factors have led to the political consensus that the actions to reduce CO_2 emissions would be taken (or at least paid for) in industrialised countries first, as reflected in the earlier mentioned UNFCCC (1992).

On the other hand, however, it can be argued as well that the industrialised countries have been conditioned more than developing countries towards a fossil-fuel-based, high energy-using society. This is especially the case in the United States, where per capita energy use is double of that in Europe, and even 15 times as high as that of India. This is due to a number of factors that cannot be changed overnight, such as the vehicle fleet and car dependence, the size and type of buildings, and the constellation of the power sector. It makes deep emission reductions for those countries that have chosen an energy-intensive path in the past, unknowing of the consequences in the future, more disruptive and costly, as well as more difficult to achieve as it involves a more profound breach with prevailing practices.

The main incentive to prevent climate change is the aversion of harmful impacts that result from the rise in global mean temperature. The rise of temperature has direct impacts on extreme weather events such as heat waves, and on the performance of sectors such as agriculture and tourism. Indirectly, the rise in temperatures appear to affect other meteorological phenomena, such as precipitation, flooding and droughts, hurricanes, and sea level, both through thermal expansion of the ocean water and through melting of land ice (IPCC, 2001; IPCC, 2007). Hypotheses backed by patchy empirical and modelling evidence have been floated that developing countries, and particularly the poor in those countries, will bear the greatest consequences of climate change (Schelling, 1992).

Recently, more evidence has been published that confirms this conclusion. Research focuses particularly on agriculture, as that is the most important sector in developing countries, and the most sensitive to climatic changes. Mendelsohn et al. (2006) assume a parabolic relation between temperature and market impacts and model the economic effects of climate change on various sectors. They conclude that the location at lower latitudes of most developing countries is unfavourable in the light of climate change. These countries find themselves on the declining part of the parabolic hill, as opposed to the industrialised countries, which are generally in more temperate climate zones at higher latitude and can potentially benefit from higher temperatures in sectors such as agriculture. Impacts of climate change on global food supply and hunger have also been evaluated, and show a higher risk of hunger, particularly on the already disadvantaged continent of Africa (Parry et al., 2005). Indeed, climate change seems to increase the gap between rich and poor countries (Mendelsohn et al., 2006). To make things worse, the models assume that effects of the higher CO_2 concentrations in the atmosphere lead to a fertilising effect for crops, which partly compensates for the negative climatic consequences (Mendelsohn et al., 2006; Parry et al., 2005, and references therein). Other recent results, however, indicate that the CO_2 fertilisation effect is probably overestimated in current assessments and is absent in several essential crops (Long et al., 2005).

None of these studies attempt to estimate the non-market impacts of climate change, as they are hard to convert into economic losses or gains. However, these impacts are by no means insignificant. They include more deaths through extreme climate events, as well as impacts on health and ecosystems. A large natural disaster has a considerable influence on the economic prosperity of a developing country, and a large hurricane, apart from the loss of life, can have detrimental economic consequences. All of these results fortify the hypothesis that most damage resulting from climate change will fall to developing countries, whereas some industrialised countries may even benefit from the consequences of climate change.

The above shows that redistribution aspects of climate change have two components. Firstly, by reducing greenhouse gas emissions more, industrialised countries redistribute the right to use fossil-fuel-based, cheap energy to the developing countries, in order to provide them with the opportunity to develop. Secondly, the industrialised countries have to make profound changes in their energy system in order to prevent the negative consequences that primarily take place in developing countries.

2.2 Theories of international relations and climate change

What does the notion that climate change is a redistribution problem mean to its institutional design? Taking one step back and looking at the reasons behind agreeing on an international institution in the first place might give valuable insights in the primary drivers. The next step is to use this context for discussing the question what, subsequently and in that context, would be rational design characteristics of an institution for climate change.

There are different views to why states sacrifice sovereignty by agreeing to an international institution. The different views originate from different general theories of international relations. Most views argue that international institutions are the outcome for solving collective action problems (Olson, 1965) and use a game-theoretic-type of analysis with the aim of reaching Pareto optimum, analyse the interests and positions that are inhibit realising this optimum. Keohane (1982), for instance, explored "why self-interested actors in world politics should seek, under certain circumstances, to establish international regimes through mutual agreement". He arrives at three potential drivers for regime demand: the demand for a liability framework, improving information and reduction of transaction costs.

Keohane writes from a liberal tradition of international relations, where states are thought to think economically and see international institutes as instruments for furthering their own interests. Different views on the role of international institutions exist, however. Realists regard international institutions as a direct reflection of state power and, although they can be useful for solving cooperation games, there are hardly more than token institutions for the already existing (and static!) world order. Idealists, or constructivists, to the contrary, view institutions more as independent advocates of emerging global values (Snyder, 2004). In environmental governance, for instance, their existence enhances the development of global values that enable states to "take more progressive steps towards governance and sustainable development" (Haas, 2002). The three schools agree that the value of international institutions is bound to increase in a globalising world, as national issues become more related to global issues. Whether it is national norms that require continual and increasing alignment with global norms (constructivism) or whether national interests are increasingly linked to global interests (liberalism), the need for international institutions increases with issue density, and the relevance of international institutions will rise.

In terms of climate change, the demand for an international institution on climate change would indeed originate from the perception of climate change as a collective action problem. A stable climate can be viewed as global collective good, although section 2.1 highlights some features that distinguish climate change from classic cooperation game in the environmental field. The main diversion from classic cooperation game is that the costs and the benefits could barely be distributed more unevenly in the case of climate change. The countries bearing the greatest cost to undertake action to address climate change are the countries benefiting least, and those countries suffering most are not in a position to do much about it; their emissions are too low to reduce them much, and they are too poor to provide the perpetrating states with rewards for action.

An additional complicating factor is that the "depth of cooperation" (Downs et al., 1996; Raustiala, 2005) required to address climate change is unprecedented in environmental issues, and perhaps even in all international governance. Depth of cooperation is defined as that extent to which a treaty diverts behaviour from the baseline. Given the intrusiveness of measures to reduce greenhouse gases into every single aspect of our economic activities, the depth of cooperation for any environmentally effective climate treaty is great. Related to that, and adding to the complexity of the issue, is the breadth of actors that needs to be involved in, convinced to, stimulated or coerced into action. Reducing greenhouse gas emissions involves lifestyle, electrical appliances, industrial practices, energy production, mobility, buildings and agriculture. The actors are therefore multilayer: apart from governments, they include individual consumers, appliance users, vehicle drivers, businesses, manufacturers, real estate developers, urban planners, the metal and cement industry, the electricity sector, the fossil-fuel industry, airlines and farmers. Many have argued that the technologies that need to be implemented and the measures that need to be taken require more than just bringing down a number of barriers for making technologies ripe for the market; they require a change in the "sociotechnical system" (Shove, 1998; Hofman, 2005). There is a significant body of literature on sociological aspects of technology and technology system dynamics, which will be discussed in section 4.2. It would be a novelty to introduce such a multi-layer and multi-level system in an international regime. Although by no means impossible on the domestic level, it is likely to be challenging on the international level.

Although there are other grounds to pursue a more sustainable energy system, to increase energy efficiency and to use non-fossil sources of energy, reduction of CO_2 emissions is the only compelling reason to make those changes as immediately and profoundly as a 450-ppmv or even a 650-ppmv scenario would require. On top of all that, future scenarios are inherently uncertain, and the climate system is so complex that it can only be understood by approximation through complex computer simulations. Until recently, opponents of measures against climate change used the scientific uncertainty about the human influence on the climate as an argument against action. These criticisms of the scientific basis for climate change have by now all but disappeared (IPCC, 2007), but have delayed the general support for a climate regime by at least a number of years, perhaps even a decade.

Acknowledging the risk of oversimplifying, a preliminary simplified assessment of the position that advocates of the different theories of international relations may clarify some of the developments in the past 15 years around the institutional setting of climate change. Those states that assume a realist perspective will generate an institution that will agree on treaties reflecting the views of the states currently in control. Given the redistributional features of the climate change issue, the weak victim is unlikely to be heard, and it is unlikely that the climate change problem would be ultimately addressed. Similarly, assuming the international institution is based on consensus (as the UNFCCC is) and all states have equal votes and act rationally from the liberal view, the likelihood that states without an interest in reducing greenhouse gas emissions agree to a sufficiently effective treaty is small, as it will be a cost without a benefit for them.

Prospects for addressing climate change improve when constructivism is assumed. Climate change is narrowly associated with ethics - which is one of the reasons why the redistribution aspects are so relevant (Brown, 2003). Poor countries are confronted with the disadvantageous consequences of the exploitation of both natural resources and the atmosphere by rich countries. Climate change is both a consequence and a cause of the difference in income, implying a vicious circle of more climate change, more differences in income, and again more climate change. An international institution, able to decide on what is morally correct, would prevent climate change and promotes these values with the sovereign states. This could eventually lead to a treaty that acts on the redistribution required for addressing climate change.

None of the theories alluded to above exactly resemble the positions of the states most responsible for much of the global greenhouse gas emissions. Every country uses thoughts and ideas from every one of them. However, some broad and generalising conclusions can be drawn. The United States position shows influences of both realist and liberal schools in a variety of political processes (Snyder, 2004), and climate change is no exception. This would explain their current reluctance to agree on treaties not in their perceived interests. The European Community shows features of liberalism and constructivism, resulting in the adoption of the "precautionary principle" as a leading thought. In that light, several EU Member States have adopted domestic measures specifically aimed at climate change even before there was international agreement on the issue.

2.3 Foundation of a rational design of a climate change regime

Recent initiatives in the field of international relations and institutional design have focussed on a rational-choice-based approach of institution-making, culminating to a number of useful dependent and independent variables (Koremenos et al., 2001). Independent variables are exogenous to the variation in institution design and include the number of actors, distribution problems, and uncertainties; they are given for the issue the treaty tries to address. Dependent variables are dimensions or degrees of freedom for the states that negotiate the institutional design. Five dimensions are considered for dependent variables: membership, scope, centralisation, control and flexibility.

Based on dependent and independent variables, Koremenos et al. identify a number of "conjectures". Although the authors emphasise that there are other significant institutional conjectures, they argue that these particular ones are substantively important: both analysts and negotiators typically focus on them, and they are measurable. This also makes these conjectures, or degrees of freedom, relevant for the issue of climate change. Some of the conjectures identified by Koremenos et al. will be used later in this paper for an analysis of degrees of freedom for climate change regimes. First, however, I will focus on the consequences of the situation structure of climate change as described above for the institutional design.

Mitchell and Keilbach (2001) further explore some of Koremenos' conjectures by evaluating a number of environmental treaties that vary along the dimensions. They argue that in cases of symmetric externalities, where several states cause an externality and all of them also experience damage, the international institution can rely on narrow issue-specific reciprocity and is merely a coordination game. On the contrary, when asymmetric externalities are in play, the situation becomes more complex and other means than just coordination are necessary to form an international response to the problem. The victim state could refer to a "negative linkage" in the form of coercion or other kinds of sanctioning, or it could use a "positive linkage" and reward the state that complies with the international agreement. Apart from the question whether the situation structure is symmetric and asymmetric externalities, Mitchell and Keilbach consider the political strength of the victim. They arrive at the following scheme of choices as depicted in Table 2.1.

Table 2.1 Outcomes of institutional design as a consequence of situation structure (after table 2 in Mitchell and Keilbach (2001)).

Political strength:	Strong victim	Weak victim	Examples
Symmetric externality	Issue-specific reciprocity		• Whaling among whaling nations • Ozone depletion among ozone depleting nations
Asymmetric externality	Coercion (negative linkage) OR Exchange (positive linkage)	Exchange (positive linkage)	• Ozone depletion between industrialised (strong victims) and developing nations • Whaling between whaling and non-whaling states (strong victims) • Rhine river chloride between France/Germany/Switzerland and the Netherlands (weak victim)

Where Mitchell and Keilbach halt their analysis at the notion of weak versus strong victims, where they define "strong" victims in the way a realist would define them: able to exert coercion over the perpetrating states, one could take another step and consider the economic abilities of both the victim and the perpetrator. If, for the examples in Mitchell and Keilbach, one would classify the victims and beneficiaries as "rich" and "poor" besides being only strong or weak, additional insights arise.

Consider the case of a strong and rich victim, such as in the "whaling between whaling and non-whaling states" and a rich and weak perpetrator. Although the interest of the whaling states of re-introducing commercial whaling may be partially economic, partially also cultural and social issues are at stake. For instance, in Iceland, a rich country, whaling is a profession the country identifies itself with and leaving the whalers unemployed has a social cost beyond economic costs. If the victim would offer rewards for complying with the International Convention for the Regulation of Whaling (ICRW), it would unlikely be sufficient as the cost is not the only barrier to complying with the ICRW and other factors are difficult to compensate.

Also, in Mitchell and Keilbach's terms, the creation of the Financial Mechanism under the Montreal Protocol has exactly the same background of a strong victim. However, the analysis neglects that the perpetrators in the case of the Montreal Protocol are the developing countries, which often do not prioritise environmental issues, especially if they are costly to implement and if the problem is not harming them[2]. In the case where they lack the resources to address the environmental issue, positive exchange, in this case a reward for complying with the Montreal Protocol, works.

Next, what would be the case in the Rhine river chloride case had the Netherlands not been a rich country, able to devote significant resources to reward France and Germany for reducing chloride dumping in the Rhine river? The options would have been very limited, and it is likely that the Dutch would have had to cope with the environmental problem.

The above leads to the following expansion of Table 2.1:

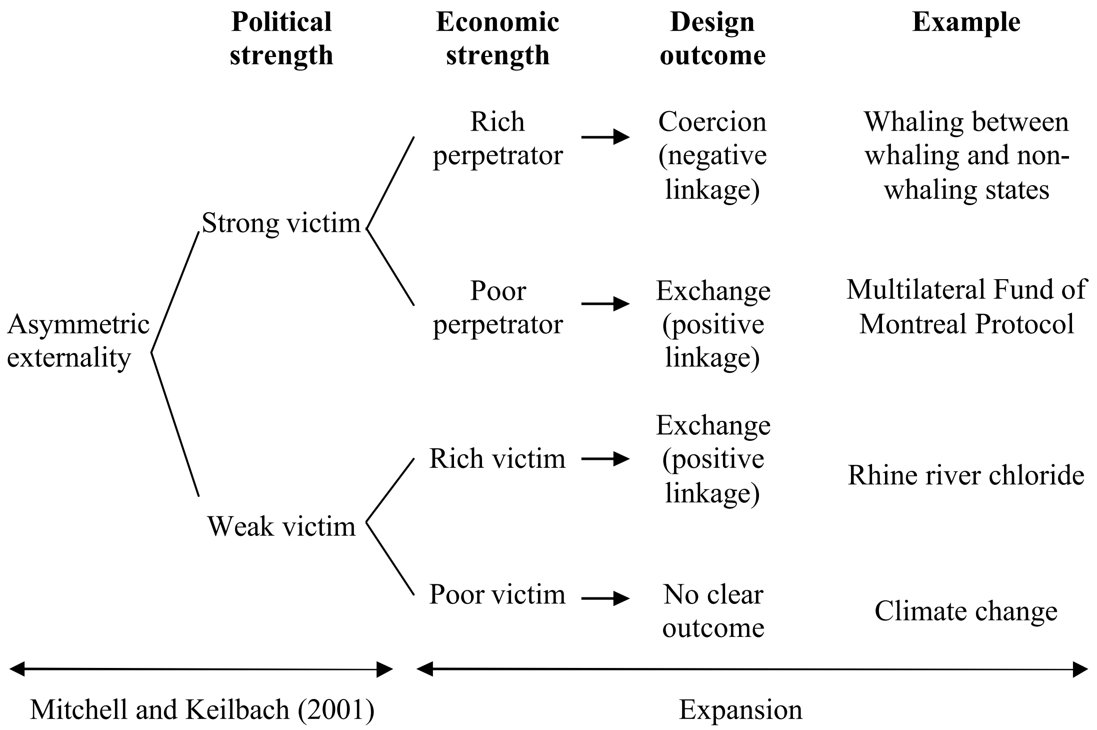

Figure 2.1 Expansion of Mitchell and Keilbach's (2001) analysis of design of international environmental institutions.

It may be apparent that climate change, as argued in section 2.1 on the global level, ranks in the category where the victims are both unable to sanction and unable to reward. This explains the current deadlock in the climate change negotiations. It can be suggested that the climate change problem can also be designed as stepwise graduation from an Annex-I-only cooperation to a cooperation involving developing countries too. However, as the victims of climate change are mostly located in developing countries, the demand for such a regime would be low.

In the light of the above, to what extent are the UNFCCC and its Kyoto Protocol designed rationally? Although an international regime on climate change to address the issue has been established in the UNFCCC, in that sense confirming the ability of the international community to respond to such a problem, the depth of cooperation in the UNFCCC is by no means sufficient to begin solving the problem. Acknowledging this, the Parties to the UNFCCC agreed on the more substantive Kyoto Protocol five years after the Framework

[2] The damage of stratospheric ozone depletion is mainly done in high latitude, where the ozone layer is already thin and low temperatures that are needed to generate the catalytic reaction surface needed for rapid ozone depletion. Most industrialised countries are situated at those high latitudes, whereas most developing countries are in lower latitudes.

Convention was agreed. In the Kyoto Protocol, the industrialised countries agreed to quantitative targets for greenhouse gas emissions of (for the major players the United States, Japan and the European Union) 6 to 8 % below their 1990 emissions. These emission reductions need to be achieved in the period 2008 to 2012. Trading in emission allowances is possible between industrialised countries. Developing countries have no obligation under the Kyoto Protocol to reduce emissions. However, there is a reward mechanism in the Kyoto Protocol for voluntary emission reductions in developing countries. The emissions reductions generated by projects in developing countries can be sold in the international greenhouse gas allowances market and can be used by industrialised countries to achieve their Kyoto emission reduction targets.

2.4 Increasing scope for climate change

The scope-related conjectures of Koremenos et al. (2001) indicate increasing scope with severer distribution and enforcement problems, and number of actors. In addition, the implication of Mitchell and Keilbach's analysis is that the situation structure of climate change defies the purpose of issue-specific reciprocity, issue-specific coercion and issue-specific rewarding. Broadening the scope of an international institution might be the only solution for the deadlock that has arisen by focussing on the narrow climate-change-aimed treaty that has been agreed in the Kyoto Protocol. If the issue can be broadened in such a way that the perpetrator's interests are hurt less by the measures needed, or that a clear benefit can arise from the measures addressing climate change, there might be a way out.

Broadening climate change to other issues has been suggested before, albeit without the analysis of political science done in this section. The issues suggested are plenty (Kok and de Coninck, 2004): energy security of supply, air pollution, stratospheric ozone depletion, agriculture, biodiversity and finance and subsidies. Analyses of the institutional linkages between the UNFCCC and other conventions and treaties have also been done (Asselt et al., 2005), leading to candidate institutions for issue linkages, such as the Global Environment Facility, International Civil Aviation Organisation, the Conventions on Biodiversity and Desertification. The type of measures to widen the agenda differs per issue, and includes measures both inside and outside the UNFCCC regime.

Although in theory mergers of two subject areas are possible, it is by no means a practical or legal sinecure. International institutions often have a secretariat, protocols, and an institutional history. They regularly have developed a culture of their own. Merging them with another international institution might also involve the complete renegotiation of a carefully balanced convention. It might not be in the interest of perpetrating states to sacrifice a working convention in a field that is dear to them to an uncertain outcome in a field that is perceived to hurt its interests. To avoid this phenomenon, which may be called "institutional lock-in", it would be more feasible to find an area to link with climate change that has not yet been institutionalised in an international agreement.

This paper argues that such an area could be found if climate change treaty could be institutionalised in a technology-oriented agreement. There is no international agreement yet on technological innovation, as countries compete on this terrain and technological innovation is therefore primarily a domestic issue. There is no institutional lock-in. In addition, deployment of climate-friendly technologies (technologies that reduce greenhouse gas emissions relative to a baseline) is a condition for addressing climate change. Agreeing on a treaty as part of the UNFCCC that would take the form of serving the interest of the rich, perpetrating states in the field of climate change would benefit the industrialised countries in maintaining or improving their global position as technological leaders, and makes use of the concern in those states around current developments in shifting competitiveness within the global economy.

3. Considerations of a technology-based institutional design for climate change

It has been argued that the scope of a climate change agreement should be broadened to accommodate the significant interests around climate change and greenhouse gas emission reductions. This paper suggests broadening it with issues related to technological development, given the relevance for climate change and the current institutional gap this issue still enjoys. It focuses on a climate change treaty that might be agreed after the end of the Kyoto Protocol's first commitment period, in 2012. Most of the literature on post-2012 climate regimes assesses different policy proposals for climate change treaties for their utility for different purposes.

The proposals considered are normally quite specific and detailed. Not only the general form of the agreement is defined, also the policy instruments, the monitoring regime and the potential distribution of obligations or efforts among participating countries are fixed in such assessments (see e.g. Aldy et al., 2003; Höhne, 2005). Using the generic political science literature on institutional design, one could start from a higher level than the treaty itself and distinguish the various degrees of freedom or dimensions that are available for both technology-oriented agreements (such as the expanded scope suggests) and target-based agreements (like the Kyoto Protocol and the follow-ups anticipated by its signatories).

The most fundamental dichotomy in the discussion on climate regimes is the trade-off between effect and effort-based regimes. The first discussion will therefore focus on that. Section 3.2 provides a discussion what effect or effort-based regimes would mean for compliance. Subsequently, other degrees of freedom are discussed in 3.3. Section 3.4, based on the arguments earlier in the chapter, summarises the arguments for technology-oriented agreements.

3.1 Effect-based or effort-based regimes

Ever since the Kyoto Protocol was agreed, it has been evaluated, leading to both lessons learned and a large variety for alternative proposals. The entry into force of the Kyoto Protocol in 2005 enabled the official tabling of the post-2012 debate in both the UNFCCC and among the Parties to the Kyoto. Proposals vary widely, both in their aims and in their architecture. All of them aim to address one or more of the main perceived problems of the Kyoto Protocol: the rejection by the US, the low involvement of developing countries, the costs of mitigation, the limited emission reduction, lack of incentives for long-term technological innovation, and the compliance arrangements (Aldy et al., 2003). The extent to which the post-2012 proposals address the design of institutions varies much as well. Indeed, the design of the institution is intimately linked to the policy instrument used in the regime.

Although this paper focuses on institutional design rather than on policy instrumentation, the one cannot be evaluated without a general sense of the other. We therefore define two dimensions of policy directions that link to ongoing discussions institutional design and that can accommodate to the different proposals. These policy directions can then be discussed based on what is published on institutional design in a more abstract way. All proposals can be characterised as either "effort-based" or "effect-based" treaties, while at the same time, they can be weaker or stronger in the commitment they ask (see Figure 3.1).

"Effort-based" treaties fix a maximum effort of the signatories to the treaty and therefore incur an uncertainty on the effect of the treaty. There are degrees in efforts and consequential degrees in effect-uncertainty. For example, if a tax on CO_2 emissions is installed, it is clear how much the cost per tonne of CO_2 is, and therefore how much measures to avoid emissions of CO_2 are going to cost at most. It is however uncertain in the case of a carbon tax what will be the effect as a result in terms of the actual reductions of CO_2, as this depends on price elasticities of a number of relevant sectors and products. An even bigger uncertainty about the environmental outcome is in another example of a treaty, as advocated in the current international climate mitigation policy of the United States[3]: an agreement on the effort put into research, development and some deployment of carbon-neutral technologies. Where the emission effects of a significant carbon tax can be estimated with help of economic models, even large investments in research and development of technologies are not a guarantee for their structural deployment, and the effectiveness of such investments is highly uncertain (Sagar and Van der Zwaan, 2006).

"Effect-based" treaties work exactly the other way around; they fix an outcome of the treaty but allow uncertainty on the effort required to achieve that outcome. In the climate change world, the best-known effect-based treaty is the Kyoto Protocol, where the environmental outcome in terms of emission reductions is central. One of the criticisms on that treaty however is that the parties signing up for emission reductions have only limited insight in what it will cost them, and on whether they are not committing themselves to what will turn out to be an enormous financial burden. But apart from emission targets, other environmental outcomes can be taken as a treaty goal: a maximum temperature rise or a measure for the speed of climate change[4], or a greenhouse gas stabilisation concentration by the end of the century. These examples are intimately linked to the ultimate objective of the UNFCCC, and the concept of "dangerous human interference with the climate system". However, the more uncertain the links between impacts of climate change, temperature change, emissions, and economics of mitigation become, the less certainty there will be about the costs incurred. Another effect-based approach, which leads to a more uncertain environmental outcome, is to reduce CO_2 emissions per unit, for instance per GDP or per capita[5]. This would not punish countries for higher population growth than expected, or countries with economic development priorities.

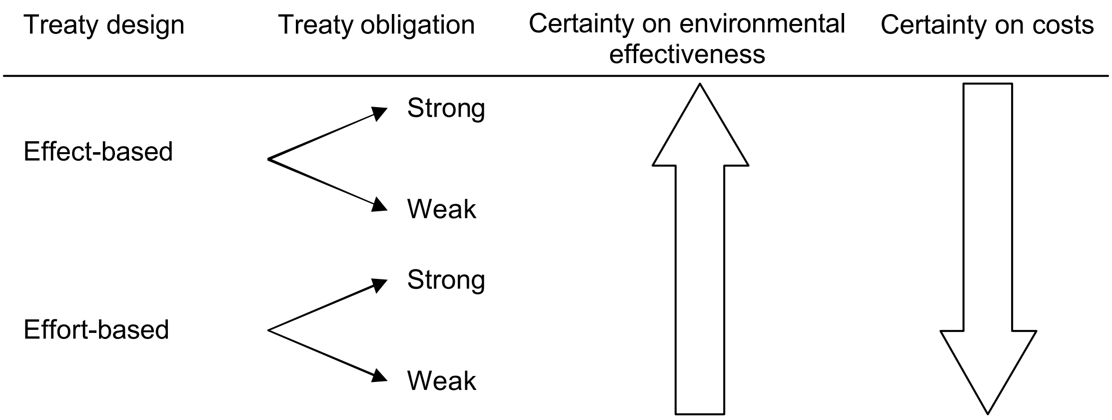

Figure 3.1 Effect and effort-based treaties and their relation to certainty on environmental outcome and costs.

There are also hybrid proposals, which combine elements of effect-based and effort-based treaties. However, the treaty will have to prioritise between the two, and when a treaty features deeper cooperation, one of the two elements will eventually be the bottleneck. An example is the "safety valve" approach (Victor, 2001), where an effect-based cap-and-trade

[3] The United States, with Japan, China, India, Australia and South Korea have initiated the Asia-Pacific Partnership on Clean Development and Climate, which plans to facilitate investments in climate-friendly technologies. Also, the US has initiated two technology cooperation partnerships: the Carbon Sequestration Leadership Forum, and the International Partnership on the Hydrogen Economy.
[4] For example, the European Union has expressed the aim to keep warming within 2 degrees Celsius and the pace of warming within 0.1 degrees per decade.
[5] In the literature, this is commonly called "relative", "intensity" or "indexed" targets.

system puts a maximum on the price paid for the credits, and is therefore in essence an effort-based system, as the costs in this case are capped, and not the emissions. Another form of hybrid systems would be a staged approach, where one group of countries adopts an effect-based and another an effort-based approach and the basic treaty design differs for different countries.

One of the aims of this paper is to argue that technology-oriented agreements can be effect-based and strong. They are not necessarily weak effort-based (and therefore for climate change ineffective) agreements as they are so often pictured in the post-2012 literature. But how do some of the different proposals for post-2012 treaties relate to the effect-based and effort-based general designs? An assessment is given in Table XX.

Table 3.1 Attribution of existing proposals to effect or effort-based, and target or technology based agreements.

General design	Cooperation depth	Target-based agreements	Technology-oriented agreements
Effect-based	Strong	Multi-stage approach[6], Brazilian proposal[7], Kyoto+	Strong technology deployment agreements[8] or technology standards[9]
	Weak	Intensity targets, sector-based emission targets	Moderate technology deployment agreements, moderate technology standards[10]
Effort-based	Strong	Carbon tax[11], emissions trading with safety valve[12]	Strong technology R&D commitments[13]
	Weak	Voluntary intensity targets	Moderate to weak technology R&D commitments[14]

Table 3.1 has two main messages. First of all, in both categories of target-based and technology-oriented agreements, there is a genuine breadth of options for treaties that all address climate change in one or the other way. This means that at the climate change negotiation table, there is an actual choice of directions, or they may even be potential for parallel agreement for groups of countries that favour the one or the other policy. Secondly, technology-oriented agreements can be drafted in such a way that they have environmental effectiveness as their prime goal, and can show a significant depth of cooperation.

3.2 Compliance issues

Before the other dimensions for climate change regimes in the framework of effect/effort-based, and target/technology-based treaties are explored, there is a continuing literature discussion on the issue of depth of cooperation on the one hand, and compliance on the other (see e.g. Chayes and Chayes, 1993; Downs et al., 1996; Simmonds, 2000; Raustiala, 2005). Without going deeply into this, the particular case of Canada in the Kyoto Protocol illustrates the discussion and provided lessons for further elaboration.

[6] Berk et al., (2005)
[7] See http://unfccc.int/resource/docs/1997/agbm/misc01a03.pdf.
[8] See RFF, 2006 (forthcoming)
[9] Edmonds et al., (1998)
[10] Barrett (2001, 2003)
[11] Cooper (1998, 2001)
[12] Victor (2001)
[13] Bradford (2004)
[14] Jacoby (1998), Buchner et al. (2002)

The case of Canada in the climate negotiations is a recent case in point for compliance problems, and the point made above on dynamic mental commitment. Showing its commitment to taking on a costly and stringent target for greenhouse gas emissions, Canada ratified the Kyoto Protocol in December 2002, after the United States and Australia had rejected it, lending support to the European Union, Japan and New Zeeland and putting more pressure on Russia to ratify. Russia was of importance as its ratification was necessary to reach the threshold support for the entry into force of the Kyoto Protocol. It eventually ratified Kyoto in 2005 and the protocol became legally binding, also for Canada.

Internally, however, not much had happened in terms of domestic climate policy in Canada. Although several programmes aimed at energy efficiency and renewable energy had been started, no consistent countrywide policy that would lead to the required emission reduction had been agreed. Part of the problem is the decentralised structure of Canada. The decision power on international agreements lies with the central government in Ottawa, but the implementation of the policies is largely with the provinces. Those provinces that rely heavily on fossil fuels for their economic prosperity, notably Alberta, did not agree to measures, and Canada's greenhouse gas emissions rose by nearly 27% between 1990 and 2004, which left Canada almost 35% above their Kyoto target of -6% below 1990 levels in the first commitment period (Environment Canada, 2006). Rises were mainly due to the emissions associated with the additional gas and oil production in the country, mainly for the US market. Notably the exploitation of the tar sands, which contain enormous reserves of oil but require energy-intensive extraction methods, has contributed to the rise, but has also created a flourishing sector in Canada. When the Canadian government changed towards a less environment-minded conservative government in the beginning of 2006, the government recalled all domestic policies that were in place and announced that it would not be able to reduce its emissions to the level required under the Kyoto Protocol. Indeed, reducing emissions by 35% over a period of only three years is generally regarded an impossible goal, even with a very environmentally minded government. Canada was therefore already widely regarded as a country that would be a buyer of emissions allowances on the global CO_2 market that the Kyoto Protocol had created. The government of Canada is legally obviously in a nasty position: it has committed to the Kyoto Protocol, but domestic issues and changing economic circumstances have caused the threat of non-compliance. The question now is whether the Canadian government remains a Party to the Kyoto Protocol and accepts the international embarrassment of non-compliance, or whether it will withdraw from the Kyoto Protocol altogether. The latest signals, partly because Canada is chairing the UNFCCC until Kenya takes over at the 12th Conference of Parties in November 2006, are that it will not withdraw. In addition, recent changes in government policies have shown that Canada is making more effort to reduce emissions, although it is still uncertain whether there is a chance that it will comply with the Kyoto Protocol.

In Canada's case, the initially lukewarm domestic commitment to the Kyoto Protocol turned into defection by shifting economic interests, more pollution and a less committed government. As argued in sections 2.3 and 2.4, broadening the issue towards technological development might increase support for a climate change agreement. One could for instance hypothesise that Alberta's oil and gas sector could use its favourable position to develop cleaner technologies that can later be exported to the United States and other fossil-fuel-producing countries, which would increase their support for an international agreement. If such situations could be foreseen and anticipated by states, technology-oriented agreements could increase chances of general compliance.

There have been proposals for increasing compliance for post-2012 regimes, for instance by making the cost of the treaty more predictable by installing a "safety valve" price (Victor, 2001) or by making a technology-oriented R&D agreement self-enforceable via an encouraging signing-up scheme (Barrett, 2003). The latter has been evaluated on environmental outcome by Buchner and Carraro (2005), who use applied game theory analysis to demonstrate that the greenhouse gas emission reduction based on technological cooperation rather than cooperation to achieve emission targets will not have comparable substance. However, in their analysis, they do not take into account the potential self-enforceability of technology-oriented agreements that further the technological interests of countries, nor the favourable attitude of business for certain technologies, which are indeed hard to approximate in a model. Although acknowledging the results of this study, the exploration of technology-oriented agreements may still be worthwhile.

3.3 Technology systems: bringing a different dynamic into play

Including the concept of technology in the agreement raises a host of questions. How do technologies and policy interact? What is effective and efficient technology policy? How is technology perceived and implemented in society?

The deep reductions in emissions required for addressing climate change support the conclusion that technological change is needed. Although we know in which direction this technological change should go (more energy-efficiency and low-carbon energy sources), it is not always acknowledged in the institutional design of international treaties, or even in domestic legislation, that technological change is more than the mere change of technologies. Technologies are introduced at a certain pace, which is not only determined by economic factors such as incentives, but also by user preferences and habits, and turnover factors that are specific to the technology. Indeed, different social actors adopt technologies in different ways. Social actors can be as diverse as large private companies, governments and individuals: consumers, end-users and citizens. The considerations for technological change can vary significantly across these actors.

This section will briefly explain the insights of technology dynamics literature, and will outline ways how those can be used in the design of international institutions for climate change. Central to the argument is the "co-evolutionary, multi-level perspective" that has been introduced by Frank Geels (2005), based on a decades-long debate in the sociology of technology. The starting point is the present socio-technological system, which is stable due to a multiple-dimensional lock-in. Although the system is stable and firmly locked in through a number of social, cultural factors, it is still dynamic. Innovation takes place, but it is strictly "incremental" - it will not spontaneously lead to the overturning of the whole system, but establishes the system even more firmly, and enhances the stability of the system through the "path dependency lock-in".

System innovations will hence not come about unless modifications in the multiple dimensions are introduced simultaneously. To picture the dynamics of how this works, the dynamic "Multi-Level Perspective" (MLP) is used, which describes the co-evolution of technology and society. The working of the dynamic MLP is pictured in figure 4.1. "Technological niches" are applications of technologies on a small-scale level. "Socio-technical regimes" are dynamically stable configurations of society and technologies. Landscape developments are external factors that cannot be influenced by actors or be changed at will.

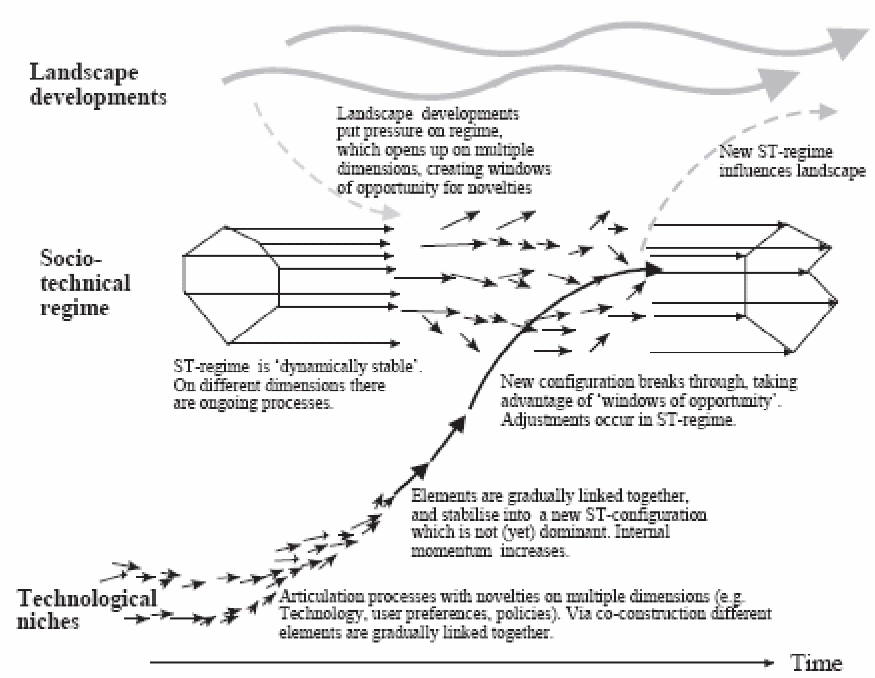

Figure 4.1. A dynamic multi-level perspective on system innovation (Geels, 2005)

In the case of climate change, the socio-technical regime could be for instance the hydrocarbon regime, responsible for much of the emission of CO_2 to the atmosphere. In order to provoke technological change in that regime, the landscape should create favourable windows of opportunity so that novelties are given the chance to step in, but this will not happen unless the novelties have been given the chance to develop and give themselves a place in the multi-dimensional reality. The change of a sociotechnical regime, therefore, requires alignment of landscape developments, and the maturing of the new technologies in a socio-technological context.

Geels (2005) goes on to describe how these processes work on the different levels. He uses development of different socio-technical system cases to support his theory. He distinguishes several patterns in the breakthrough from niche to regime level: a) niche accumulation, where diffusion of the novelty "occurs as radical innovations are used in subsequent application domains or market niches"; b) co-evolution of technologies, where a new technology is introduced with the help of another new technology, and both need to co-evolve in an intimately linked way in order to survive; and c) actor-related patterns. The latter are the perceptions, moods, or strategies of actors such as firms, policymakers, technology users and cultures, which need to be favourably configured towards the new technologies.

Empirical data to confirm or improve Geels' theoretical descriptions, especially structured studies on the exact role of actors, are still sparse, although work is underway and appears to confirm the co-evolutionary and multi-level perspective (e.g. Godoe and Nygaard, 2006, and references therein). Others have suggested domestic policies to address the failures due to the lack of consistency with the sociotechnical system (Sanden and Azar, 2005; Foxon et al., 2005). Hisschemöller et al. (2006), in addition, highlight the complexities of the different "paradigms of governance" - the various starting points and institutional biases of actors inhibit the implementation of new sociotechnical regimes in a given landscape. They recommend ex-ante use of the methodological device of "unfolding and exploring different paradigms of governance (..) to classify the (often hidden) assumptions that underlie policymakers' views with respect to the feasibility of options". Although the notions of technological dynamics appear to slowly trickle through at the national level, international governance still appears largely deprived of these insights. The next section attempts to make a start for combining the fields, taking climate change as a perhaps the most challenging case.

4. Initial thoughts on technology in a climate change treaty

The design of any future international environmental governance regime is inherently uncertain. However, we are certain that technologies will play a major role if greenhouse gas emissions are to be reduced. From past experiences in technological development, theories on rational design of international institutions, and the specific characteristics of the climate change challenge, some leads can be given on how to design an international regime for climate change in such a way that it is both instrumental in bringing about the required technological change, and aligned with the sociotechnical system at multiple levels.

Treaties that are designed to strictly pursue a single policy goal, such as greenhouse gas emission reduction, have many benefits: they are effect-based, and, in the case of a worldwide, multi-gas, cap-and-trade system, they allow for much flexibility in achieving the targets in different countries, sectors, and by reducing different kinds of greenhouse gases. The economic effectiveness, in theory, is therefore optimal if the climate problem would be regarded as only a problem of reducing greenhouse gases.

For achieving the ultimate policy goal or stabilising greenhouse gas concentrations (or, for that matter, reducing their emissions), however, measures, such as the actual building and functioning of wind turbines, need to be implemented. It has been convincingly argued that market failures and technological externalities reduce the effectiveness of cap-and-trade policies (Jaffe et al., 2005). Modelling has subsequently suggested that a combination of technology-oriented R&D and sector-based emission targets, taking into account the imperfect market incentives for technological development and the differences between sectors, leads to a more economically efficient outcome (Otto et al., 2006). But even this nuanced economic view fails to account for the specifics of technologies, such as the different stages of development of technologies, the processes underlying adoption of technologies by users, infrastructure needs, desired or undesired lock-ins and the different turnover times for various technologies, resulting in varying natural moments of technology replacement. In addition, another weak point of the narrow emission-reduction approach it that it does not take co-benefits of the policy into account, which leaves the invisible for the negotiating parties, and consequently does not allow for specific reciprocity.

The question then arises how take into account the specifics of climate change mitigating technologies. Firstly, the level of technological development determines the most effective way of designing a technology-specific international or domestic policy (Sanden and Azar, 2005; Ueno and Sugiyama, 2006). Near-commercial technologies, i.e. technologies that are advanced but that still face cost barriers inhibiting market entry, will most likely benefit from market-based instruments to enhance diffusion, such as subsidies or tax benefits; instruments that contribute to the "learning by doing" factor of the learning curve. Such efforts, however, are misplaced for technologies in the research or demonstration phase. Those technologies should be supported by targeted research and development support, or specific support for demonstration projects; on the "learning by searching" part of the learning curve (Smekens, 2005). Notably the demonstration step, which is the essential bridge between the research and the mature-market phase, is often neglected in policymaking.

A word of caution should be added to this. Recently, there has been a tendency to rely more on networks to solve cooperation problems (Powell, 1990; Slaughter, 2004). International networks have many benefits: they allow for the involvement of non-state actors such as the private sector and NGOs, they are flexible, they can function well against low cost, greatly helped by the currently low communication costs. Networks can indeed be both effective and efficient where there is an information problem, where there are low incentives to free-ride and where there are symmetric benefits of the problem. There is a danger, however, in the presentation of networks as a panacea for problems that require other solutions. By applying the network instrument to problems that are not mere cooperation problems, that have incentives for free-riding and involve redistribution of resources, the lack of a mandatory (contract) commitment will be detrimental to the effectiveness of the agreement to address the problem. Networks, a useful instrument in principle, can in such cases be used an excuse for doing nothing, and could be used as a taken agreement to cover up the lack of progress or action by nations. In climate change, the United States has loaded upon itself such accusations by focussing their climate change efforts on networking organisations such as the Carbon Sequestration Leadership Forum[15].

Agreements oriented on technology can be both effect-based and effort-based. However, more than with emission reductions, per specific technology agreement, it is much clearer what the outcome will be in terms of costs if only one sector or one technology is addressed in the treaty, because the treaty is so specific about which measure should be implemented. Because of this better predictability, flexibility on compliance with the treaty, often in practice incorporated through a deliberate ambiguity in the treaty text, can be low, thus allowing for a more reliable compliance and enforcement mechanism. The notion that international agreements should take into account specific technology considerations, such as level of maturity, but also technology dynamics, as argued in the section above, adds to the arguments that technology-oriented agreements are worth considering.

5. Discussion and conclusion

In addition the discussion in section 2.1, which outlines that agreeing on deep emission reductions is not in line with rational interests of important actors in the climate change arena, two additional arguments can be made for technology-oriented agreements. First, both target and technology-based agreements can be designed in such a way that a good environmental outcome or a predictable cost can be achieved. It depends more on the principle choice of an effort or effect-based treaty which of the two important certainties is preferred. Secondly, the compliance literature in the field of international law shows a twisted image of the relevance of compliance - those treaties with clear compliance rules and strong enforcement are not necessarily most effective as the participants in those regimes agree to such legality only if the risk that they will not comply is low. If the interest in the treaty itself is not high, compliance will also be less.

Section 3.2 suggests that technology-oriented agreements have better prospects for compliance with the treaty. There are two additional arguments why technology-oriented agreements may be preferred over emission target-oriented agreements can be discerned. Firstly, the complexity and ease of implementation of the policy instrument: although emissions trading, according to economic theory, is the economically optimal way of providing incentives for greenhouse gas reductions, it is institutionally quite challenging in the sense that it is complex, it needs a fundamentally functioning legal system both in the states and on the international level, and it may not work optimally due to "friction" factors in markets, hedging behaviour of countries and firms, and because of imperfect or asymmetric information (Akerlof, 1970; Coase, 1986). When already a relatively developed governance system as the European Union has difficulties implementing a domestic emissions trading scheme (see e.g. Egenhofer et al., 2006), it can be expected that the difficulties in developing countries will be even larger (Greenspan Bell, 2006). Early environmental law, which is largely based on straightforward command and control measures, may originate from unfamiliarity with the more sophisticated market-based instruments, but might also be a consequence of insufficient institutional capacity to facilitate such complicated policy structures. Technology-oriented agreements can be made less complex, may provide more of

[15] For a more in-depth discussion on this, earlier work may be consulted (Coninck et al., 2007).

a basis to include developing countries and may increase the likelihood that they actually comply.

Secondly, the current positions of negotiating states in the UNFCCC give little hope for an agreement on emission reductions (in the process of agreeing on the Kyoto Protocol, the positions were not so far apart). The United States, at this point, is unlikely to agree on mandatory emission reductions, and the large developing countries are likely to resist obligations for non-Annex I Parties. Although there are complications with any international mandatory environmental agreement, the potential for a meaningful agreement in technology-oriented agreements appears to be larger than for emission targets.

Actually, in the last form, technology agreements would bear resemblance to the policies and measures (or actions) approach advocated by the European Union in the pre-Kyoto climate negotiations (Ott, 1998). Whether it is old wine in new bottles remains to be seen, and might also depend on the scope for technologies present now. Especially the awareness that CO_2 capture and storage might generate cheap CO_2 reductions against reasonably predictable costs increases the faith of the business sector as well as technology-oriented as well as coal-reliant countries (notably the United States and Australia) that pursuing the deployment of such technologies generates the momentum needed for deep reductions in emissions, without major economical disruptions.

It should be noted that the estimates of the interpretations of interests of states reflect what is their current position, i.e. in the most recently climate negotiations, as well as their intentions in national documentation, for instance in Senate decisions and other political statements. In the United States, notably, the efforts on the non-federal level should not be discarded. In some states, the first steps towards weak but real (and effort-based) emissions trading schemes are made, and on the municipal level, more than 150 cities have declared their intention to comply with the Kyoto Protocol provisions included for the United States if it had ratified the treaty. In large developing countries, such as China and India, renewable energy targets are law, and policies are designed to make them happen. In the European Union, although committed to reducing greenhouse gas emissions, concerns of security of supply or competitiveness of the economy on the global market might develop into a barrier to further emission reduction targets, notably if other large countries do not take on targets. Only focussing on the official position in international treaties might give a skewed picture of what is actually happening on the ground, and also ignores the problem of decision-making at multiple levels.

This paper has argued that a possible way forward for an international agreement on climate change mitigation is to increase its scope: to connect the issue with other policy areas in order to create leverage for those countries otherwise unwilling to address the problem. The positions in the actual ongoing negotiations under the UNFCCC are reflecting the perceived self-interests of the players as indicated in section 2.1. If a climate change regime can be broadened to include technological development, interests could shift and the regime as a whole may become more feasible.

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