Caps and fences in climate change policies
Trade-offs in shaping post-Kyoto

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Abstract

The Kyoto Protocol is a first, small step towards mitigating global warming. In the post-Kyoto era much larger greenhouse gas (GHG) emissions reductions will be necessary to keep atmospheric GHG-concentration levels at a ‘safe’ level. Due to the more ambitious reduction targets that need to be set and the desirability of getting more countries involved, establishing a follow-up treaty of the Kyoto Protocol is a challenging task.

This paper can be viewed as a sequel to a previous report assessing the impacts of a policy scenario in which industrialized countries in 2020 accept emission targets that are 30% below 1990 emission levels. Its aim is to provide an analysis of additional scenario’s over and above this case, thus providing policy makers with a wider spectrum of alternative post-Kyoto policy settings and their implications.

The paper analyses the macro-economic consequences of post-Kyoto policies in 2020. The costs of climate policy are largely determined by three factors: the reduction target, the economic development in the underlying scenario without new climate policies and the design of that policy. We analyse several policy options against the background of a benchmark case from an earlier study: a global cap and trade system with a cap in 2020 for the countries of Annex I that will be 30% below their 1990 emissions. Amongst the policy options studied are: coalitions with (much) less than global coverage, limited trading possibilities (e.g. because of the requirement that at least half of the reduction target should be met domestically), full versus limited use of the Clean Development Mechanism (CDM) in incomplete coalitions and reduced ambitions by lowering caps or imposing carbon taxes of limited height. Thus, alternative trade-offs between abatement costs and abatement efforts are established and discussed.

We show that the abatement costs in the benchmark case are relatively modest. These costs will rise considerably with shrinking coalition size and with limited opportunities for emissions trade or CDM. If coalition size shrinks migration of energy-intensive activities to non-participating countries tends to increase. Costs will increase if the opportunities of CDM cannot be fully used when coalitions are incomplete. Seizing CDM opportunities will reduce emissions only in part, due to domestic leakage in the developing countries. Though, carbon tax systems may be as effective in reducing emissions as cap-and-trade systems, burding sharing over countries will be quite different.

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Summary

In the post-Kyoto era much larger greenhouse gas (GHG) emissions reductions will be necessary to keep atmospheric GHG-concentration levels at a ‘safe’ level than the reductions that have been agreed upon under Kyoto. Due to the more ambitious reduction targets that need to be set and the desirability of getting more countries involved, establishing a follow-up treaty of the Kyoto Protocol is a challenging task.

Departing from the central case of a 30% emissions reduction by the countries of Annex I in 2020 compared to 1990 levels (see Bollen, Manders and Veenendaal, 2004), the modest aim of this study is to provide an analysis of additional scenario’s over and above this case, thus providing policy makers with a wider spectrum of alternative post-Kyoto policy settings and their implications.

In particular, the impacts are assessed of varying coalition size, of restrictions on imports of emission permits, of the utilization of the Clean Development Mechanism (CDM) and of other, often more limited emission reduction targets, as implied by raising emissions caps or imposing carbon taxes of limited height.

The assessments are in terms of policy-induced deviations in 2020 from a baseline that does not contain any post-Kyoto climate change policy. This baseline is a global scenario characterized by relatively high growth rates, called GLOBAL ECONOMY, which has been adapted for the Netherlands to reflect the most recent views of the so-called Reference Projection on Dutch developments within the context of this scenario. The consequences of choosing this baseline are twofold. On the one hand - because of its relatively high rates of growth - the costs of complying with the policy targets will also be relatively high. On the other hand the adaptation of Dutch baseline developments to the views contained in the Reference Projection has made the emissions profile for the Netherlands much more modest than it was before. Hence, our assessment of Dutch compliance costs for the central case becomes more modest too. Whereas Bollen, Manders and Veenendaal (2004) assessed Dutch compliance costs for the central case (0.8% of real national income) to be relatively high within an EU-context, this study points to macro-economic costs for the Netherlands that are more or less average (0.5% of real national income).

Unsurprisingly, the study shows that shrinking coalition size -while maintaining reduction targets for its members- raises abatement costs and may reduce environmental effectiveness. In particular, if EU-25 would travel the road of post-Kyoto alone, the macro-economic costs to the Netherlands would amount to 2.3% of national income in 2020 while global emissions would rise 20% above those of the central case.

If imports of emission permits would be restricted by requiring that half of the abatement should be achieved domestically, costs would rise in those regions where this restriction becomes binding and fall elsewhere due to depressed import demands. As the Netherlands rely heavily on foreign abatement to meet their climate change target, Dutch compliance costs will rise: the ceiling on permit imports would increase compliance costs by 0.4% of national income compared to the central case.

Opening CDM opportunities in non-member countries for a coalition of Annex I reduces compliance costs on the one hand but tends to raise global emissions on the other. This is caused by leakage in the host countries.
For example, if CDM is applied to power plants local electricity prices are likely to decrease. As project funding is at marginal costs, electricity producers will make infra-marginal profits. Because of competition these will in the end be passed-on to consumers in the form of lower prices. Hence, electricity demand will rise and emissions will pick-up again. Moreover, if the supply of primary energy carriers, such as coal, is inelastic, the price decrease due to the CDM-projects will trigger additional demands in other sectors of the economy. Taking these impacts together, local leakage may amount up to 40% of the direct reductions that were aimed at through CDM-project.
However, if CDM-projects are available throughout the host economy, leakage may diminish considerably with substantial cost savings to Annex I.

Less ambitious targets lead to lower costs and higher emissions. For example, compliance costs for a coalition of Annex I countries with a reduction target of 30% would amount to 2% of real national income. If this reduction target would be halved, global emissions would rise with 6% in 2020 and compliance costs for Annex I would fall with 0.8% of real national income. If the Kyoto targets were to be extended to 2020 and the United States and Australia would join with ceilings at a level of their 2010 baseline emissions, compliance costs for the current Kyoto partners would actually fall due to the arrival of new abatement opportunities within the United States. Global emissions in 2020 would rise substantially however, with more than 25% compared to a 30% reduction by a coalition of Annex I.

The impacts of substituting cap-and-trade schemes for uniform carbon taxation depend upon the divergence between the height of the emissions price and the level of the carbon tax. For identical coalitions a lower tax rate will reduce costs and increase emissions while the opposite is true if the tax rate exceeds the price of tradable permits. Neglecting income effects, both schemes would be equally efficient in abating global warming if the time profiles of permit prices and carbon taxes would coincide. The distributional impacts can be substantial though. If, for example, a global cap-and-trade scheme with a permit allocation approximating equal right per capita is replaced by a universal carbon tax, compliance costs will diminish for Annex I countries but become substantial for developing countries. Though the revenues from carbon taxation may be partly used for international income transfers that would make the burden sharing acceptable to negotiators, domestic pressure to recycle these revenues back into the own economy is likely to prevent the conclusion of such an arrangement. The grandfathering schemes under cap-and-trade seem to provide a more solid basis for international burden sharing. Hence, a cap-and-trade system might be the more promising scheme to bring consensus amongst negotiating parties.

1 Introduction

The Kyoto Protocol is a first, small step towards mitigating global warming. In the post-Kyoto era much larger greenhouse gas (GHG) emissions reductions will be necessary to keep atmospheric GHG-concentration levels at a ‘safe’ level. Point of departure in this report is the ambition to bring emissions of industrialized regions 30% below 1990 emission levels in 2020. This target can be shown to be compatible with the EU ambition to limit the rise of global mean temperature to 2°C above pre-industrial levels.

In Bollen, Manders and Veenendaal (2004) the macro-economic consequences were shown of emissions reductions in Annex I countries with 30% in 2020 compared to 1990 levels against alternative background scenarios of economic growth. This publication can be considered as a sequel, in which we depart again from a 30% emissions reduction in 2020 in Annex I countries and show the consequences of alternative post-Kyoto policy settings. In particular, we show the impacts of varying coalition size, of restrictions on imports of emission permits, of the utilization of the Clean Development Mechanism (CDM) and of other, often more limited emission reduction targets, either by raising emissions caps or by installing a carbon tax of limited height. We thus provide policy makers with a wider spectrum of alternative post-Kyoto policy settings and their implications.

We first explain the set-up of the scenarios in more detail and the approach followed in the next section. In section 3 we present the benchmark case of 30% emissions reduction by Annex I in 2020. Detailed tables of simulation outcomes for each of the scenarios are to be found in the Annex. Rather than commenting exhaustively on the impacts of each policy scenario in sequence, we will focus on certain impacts. In section 4 we discuss the trade-offs between costs, coalition size and emissions. We focus on the macro-economic consequences in terms of changes in real national income in section 5. The impacts on Dutch energy consumption and its composition are discussed in section 6. Opportunities to earn credits through CDM will lower compliance costs for the countries of Annex I. However, CDM may be rather ineffective from the environmental point because of local leakage in non-Annex I. We analyse this issue to some extent in section 7. The final section concludes.

2 Post-Kyoto policy scenarios

In this study we assess a large number of policy variants. Table 2.1 gives an overview of all simulations considered.

Table 2.1 Scenario properties

Coalition	*Emissions cap industrialized regions*				*Uniform carbon tax*	
	-30%	-15%	Kyoto forever	-30%, Imports =< 50%	20 euro per ton CO_2	10 euro per ton CO_2
Global	UG30			RG30	TG20	TG10
Annex I	UA30	UA15	UAKO		TA20	TA10
Annex I and CDM	UA30-C			RA30-C		
EU25	UE30					

In a first group of policies we assume a cap-and trade system. The size of the abatement coalition ranges from a global coalition to the group of EU-countries. The emissions reduction target for industrialized countries in 2020 ranges from 30% to the Kyoto targets. It should be noted that the policies with a global coalition (UG30 and UA30) also appeared in Bollen, Manders an Veenedaal (2004). We also consider a CDM-case (UA30-C). The Clean Development mechanism (CDM) allows industrialized countries in a non-global coalition to exploit the cheap abatement options in developing countries. Hence, this case can be considered a non-perfect global coalition.

The assumption of unrestricted international trade in emissions permits is common for the scenarios in this group. However, in negotiations on burden sharing the issue may be raised to require a minimum effort from the coalition members to reduce emissions domestically rather than abroad. We consider two examples of such an arrangement: the case of a global coalition in which free trade is restricted by the requirement that at least half of the emissions should be reduced at home (RA30) and the case of an Annex I coalition with access to CDM-projects in the electricity sector with the same restriction on permit trade (RA30-C).

In contrast to the cases with a cap-and-trade system, we also consider some cases with a uniform carbon tax. Parties might also disagree on installing a scheme of permit trade and instead negotiate a uniform carbon tax. Again, we vary coalition size and strictness of the abatement policy. We show the consequences of imposing taxes of 10 and 20 euro per ton CO_2 for global coalitions and for a coalition of Annex I only (TG10, TG20, TA10 and TA20).

The approach followed is very similar to the one in Bollen, Manders and Veenendaal (2004). First, the macroeconomic consequences of climate policy scenarios are assessed using the applied general equilibrium model WorldScan. This model has global coverage and in particular details regions within Europe (see Lejour, 2003, and Bollen, Manders and Mulder, 2004). The model distinguishes various sectors and is sufficiently detailed to monitor the development of energy-related CO_2 emissions[1]. The emissions ceiling defined generates an endogenous shadow price known as 'carbon tax' or 'emissions price'. A global ceiling with free emissions trade would result in a single worldwide emission price.

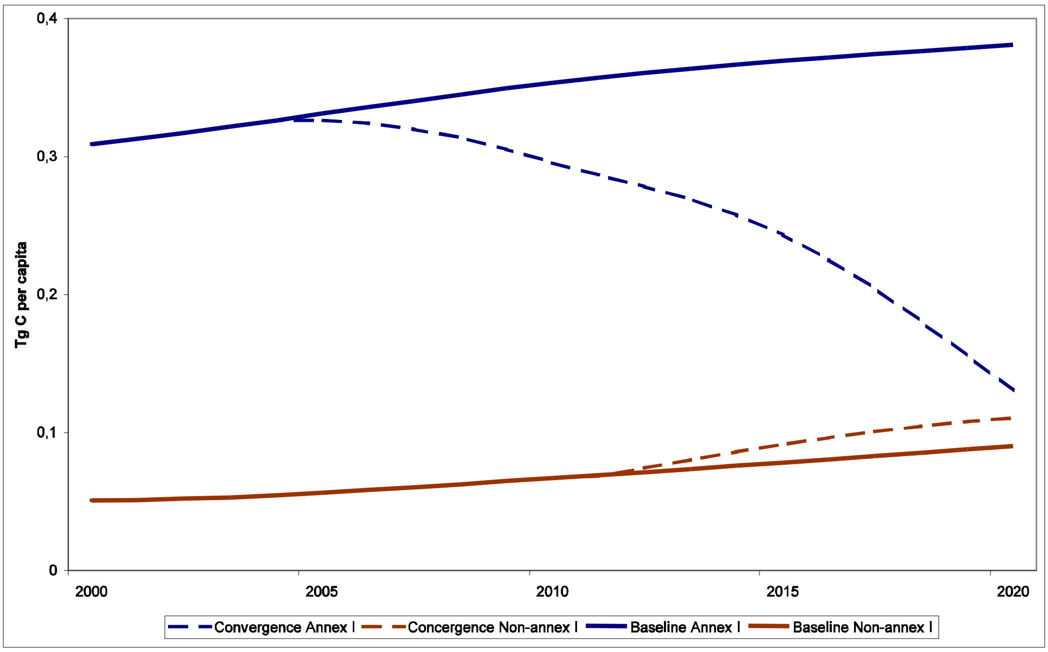
Second, the impacts of post-Kyoto policy settings are assessed in a particular year, 2020, against the background of a long-term scenario without any climate policy. In this document we use the GLOBAL ECONOMY scenario as a baseline (see De Mooij and Tang, 2003, and Bollen, Manders and Mulder, 2004). This scenario is characterized by high economic growth. Accordingly, the policy effort and associated costs to meet a given emissions reduction target compared to 1990 levels are relatively high. In contrast to Bollen, Manders and Veenendaal (2004), Dutch developments in the baseline could now be fully adapted to the projections up to 2020 of the so-called Reference Projection (van Dril and Elzinga, 2005). Hence, the assessed policy impacts for the Dutch economy deviate to some extent from those in Bollen, Manders and Veenendaal (2004). As a consequence of this adaptation Dutch emissions develop more favourably in the baseline than in Bollen, Manders and Veenendaal (2004) (see box). Hence, Dutch compliance costs are assessed more favourably than before. Unfortunately, both baselines carry the same name.

Third, the time profile for global GHG-emissions that is thought to be compatible with the EU-temperature target is the same as in Bollen, Manders, and Veenendaal (2004). In the benchmark case UA30, we apply a stylized burden sharing rule consistent with this stabilization profile. Starting from baseline emissions in 2010, regional emissions permits are gradually converging to an equal-per-capita allocation: a so-called contraction and convergence scheme (Berk and den Elzen, 2001 and Boehringer and Welsch, 2004). The year of convergence is chosen in such a way that the allocation is compatible with a 30% reduction for industrialized regions in 2020. Figure 2.1 shows the baseline emissions and the emission permits per capita for Annex I and non-Annex I in UA30. This contraction and convergence scheme implies that industrialized countries grant developing countries emissions permits above their baseline emissions (hot air). It should be noted that in policy cases where the reduction target is relaxed or the abatement

[1] We do not explicitly address emissions reductions of non-CO_2 greenhouse gases and the emissions ceilings imposed pertain to CO_2 only. Implicitly, it is assumed that non-CO_2 emission reduction targets are met as well.

coalition is smaller, eg. UA15 an UE15, global emissions will be higher. This means giving up on the EU temperature target[2].

Figure 2.1 **Baseline emissions and emission permits of Annex I and non-Annex I, in TgC per capita, 2000-2020**



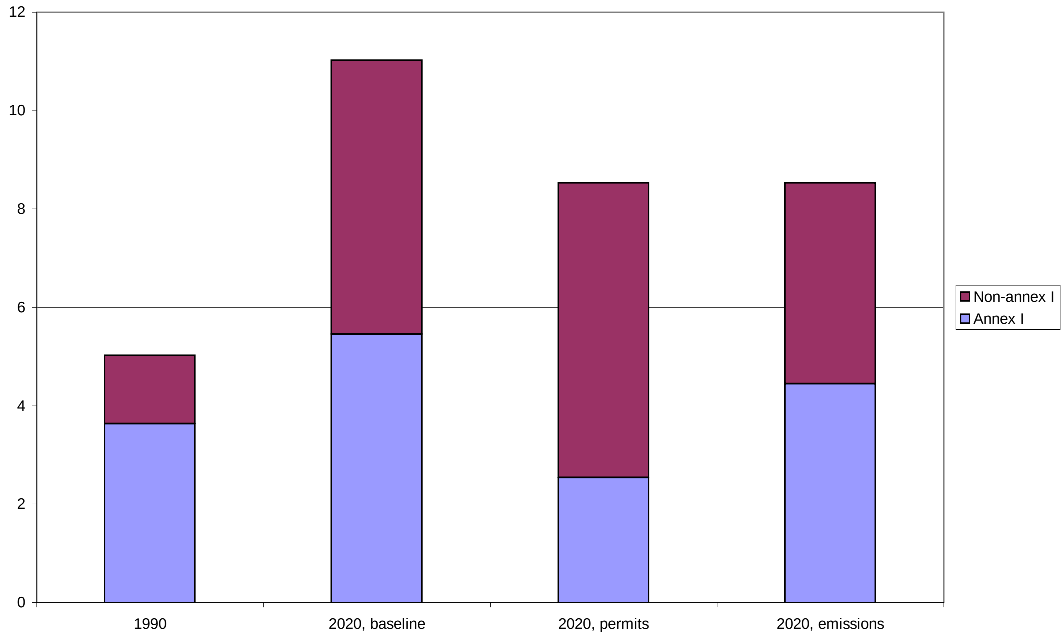
Finally, one should be aware of the fact that our model-based assessments have a stylized character. Quite a few factors that could substantially increase or decrease macro-economic costs have not been taken into account. For example, the costs of restructuring the economy, local distributional impacts and set-up costs of the climate policy as well as the costs of monitoring, transactions and enforcement are not assessed. On the other hand, potentially cost-reducing factors such as carbon capture and storage are not covered either.

[2] In the UA30 case global emissions will be somewhat *lower* than what is needed to reach the temperature target. In this case developing countries are not part of the coalition and will not receive any hot air.

3 30% reduction by Annex I within a global coalition (UG30) as a benchmark case

The policy variant UG30 has been discussed extensively in Bollen, Manders and Veenendaal (2004). We briefly repeat this discussion here for later reference. Emissions and emission permits for industrialized (Annex I) and developing countries (non-Annex I) are shown in figure 3.1. The figure shows that global emissions will increase up to 2020, regardless of whether or not there is a climate policy. However, without a climate policy, in 2020 global emissions will just exceed 11 TgC. With the climate policy this will be reduced to 8.5 TgC. Clearly, this is still far more than the global emissions of 5 TgC of the year 1990. The climate policy implies that Annex I countries receive permits that are 30% below 1990 emission levels. The 'contraction and convergence' rule implies, that non-Annex I countries receive permits that somewhat exceed their 2020 baseline emissions (see also figure 2.1). Due to the free trading opportunities in emission permits the Annex I countries will largely achieve their emission reduction targets by importing permits, amounting to 1.9 TgC.

Figure 3.1 Emissions and emissions permits, in TgC, Annex I and non-Annex I, in 1990 and 2020



Due to free permit trading within a global coalition the costs of abating global warming will be relatively limited. The reason for this is that free permit trade enables to make use of the cheapest abatement opportunities and these are mainly to be found in the countries of non-Annex I. Hence, the 2020 permit price will be rather modest, at 16 € per tonne CO_2. Due to free permit trade this price depends on the global emissions ceiling only, and is independent from the allocation rule for grandfathering the permits to countries.

For Annex I countries the reduction target is 30% vis-à-vis 1990-levels. Compared to baseline emissions levels in 2020 without a climate policy this target implies a reduction with 53%. As Annex I imports emission permits to a large extent from countries in non-Annex I the percentage change of Annex I emissions in 2020 after emissions trading amounts to 18% of baseline emissions. Hence, only a limited part of 34% (=18/53) of the reduction target for Annex I countries is achieved within their own borders.
The loss of income for industrialised nations mainly stems from payments to non-Annex I countries for permit imports. Real national income for Annex I countries in 2020 is assessed to be 0.5% less compared to the baseline.

Due to the adapted baseline Dutch emissions and, hence, compliance costs develop more favourably than as reported in Bollen, Manders and Veenendaal (2004). In comparison to the Annex I group of countries, the Netherlands has an average reduction target of 30% compared to 1990 levels. Compared to 2020 baseline emission levels, this means a reduction target of 47%. Only a relatively small percentage of this, 25% (=12/47), is achieved domestically, as the emission price at the global emission market remains rather modest. The macroeconomic costs for the Netherlands amount to 0.5% of real national income in 2020, compared to the baseline without a climate policy.

Two baselines: same label, diverging Dutch emission profiles

Compliance costs of climate change policies depend to a large extent upon baseline developments. The higher the emissions growth in the background scenario, the higher the efforts needed to limit emissions to a given absolute ceiling. The baseline used in this study for the Netherlands deviates considerably from the scenario used previously in Bollen, Manders and Veenendaal (2004). Hence, the results are not comparable. Because emissions growth is much lower, compliance costs in the Netherlands are considerably smaller. Unfortunately, both baselines carry the same name.

Costs in Bollen, Manders and Veenendaal (2004) are assessed against the background of the scenarios GLOBAL ECONOMY and STRONG EUROPE. These alternative baselines were prepared to explore long-term developments in the field of energy markets and climate change (Bollen, Manders and Mulder, 2004). In the current analysis we used the GLOBAL ECONOMY scenario as well, but with adjustments for the Netherlands to fit in with the so-called Reference Projection 2005-2020, recently developed jointly by the Netherlands Environmental Assessment Agency (MNP) and the Energy research Centre of the Netherlands (ECN).

Though the label used to indicate the baseline is unchanged, Dutch emissions develop more favourably in this study than in Bollen, Manders and Veenendaal (2004). The latter study also tried to adjust for the insights of the Reference Projection which by then was just underway and still of a preliminary nature. Apparently, in finalizing the Reference Scenario, emissions data have been downwardly adjusted. The table indicates the diverging developments in the Netherlands for national income, energy usage and CO_2 emissions.

Income, energy use and emissions in the Netherlands, 2000-2020

	Real national Income	Primary energy demand	CO_2 emissions
		Annual growth (%)	
Original baselines			
GLOBAL ECONOMY	3.0	2.4	2.4
STRONG EUROPE	1.9	0.9	0.7
Reference Projections			
GLOBAL ECONOMY	2.9	1.6	1.4
STRONG EUROPE	1.8	0.9	0.7

Though economic growth is almost the same in both groups of scenarios the Reference Projections indicate much larger decreases in energy and emissions intensities in GLOBAL ECONOMY, emissions growth in the original baseline of 2.4% per year being lowered to 1.4% per year in the Reference Projection.

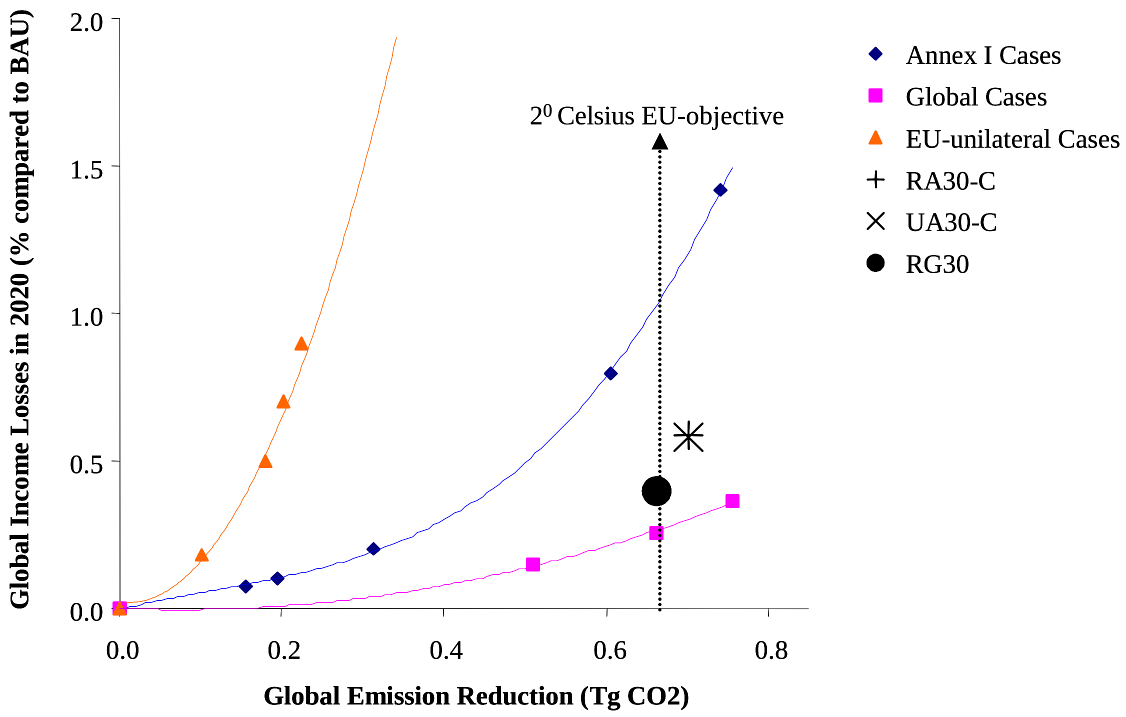
One of the reasons of this deviation is an assumed increase of the share of carbon-free energy carriers in the Reference Projection of the GLOBAL ECONOMY scenario. The low projected growth of Dutch emissions compares favourably with the pace at which baseline emissions are assessed to rise in a number of other European countries.

4 Trade-offs: costs, coalitions and the environment

The countries of Annex I can still increase their emissions compared to 2000, and through a global system with unrestricted permit trade they can effectively meet the requirements of a post-Kyoto policy that remains in line with the 2^0 Celsius EU-objective. But the abatement costs will rise substantially when the coalition size is shrinking while targets are maintained. On the other hand, relaxing targets will yield higher emissions, and lower the costs of abatement. This section discusses the trade-off between macro-economic costs, emissions reductions and the coalition size.

Figure 4.1 plots the global income losses of different policy variants related to the global emission reduction effort[3]. The variants are grouped in different sizes of the coalition: a global one, Annex I, and the restricted EU-25 coalition. Also point estimates are given for the other more hybrid cases (Annex I + CDM, and import restricted cases).

Figure 4.1 Global Income losses and emission reductions, 2020



[3] Global income losses are measured as the % difference between the income levels with and without the climate policy, and the global emission reduction effort is measured in terms of absolute differences of the CO_2 emissions.

What are the most important conclusions from Figure 4.1?

1. More willingness by coalitions to incur costs of abatement will increase the global emission reduction.
2. Reducing the coalition size lowers the options to meet the requirements of the 2^0 Celsius EU-objective, and hence increases the costs of abatement, and thus lowers the efficiency of the climate policy
    - Switching from a global coalition to a smaller Annex I coalition will more than double the costs of the EU-objective.
3. Striving for less ambitious goals than the EU-objective at fixed coalition sizes will lower the emission reduction effort, and reduce the costs of abatement.
4. Striving for less ambitious goals than the EU-objective by a smaller coalition will lower the global emission reduction effort, but increases the costs of abatement
    - Switching from an Annex I coalition to a EU-25 coalition again increases the costs of abatement by a factor of 5, and is thus a less efficient climate policy strategy.
    - Also by no means can EU-25 go for a unilateral strategy and remain within the EU-target.

Impacts from CDM and restrictions on the imports of permits

If CDM-projects in the electricity sectors of non-members are introduced (UA30-C) the carbon price of the Annex-I coalition and thus also the global income losses will more than halve (compare the last marked point on the Annex I line). Annex I countries may fund emission reductions in power plants in non-Annex I areas, acquiring credits for the reductions thus achieved that they may add to the emissions permits already in their possession. This implies that the carbon price will also be felt in the electricity sectors of non-Annex I. CDM-projects will be supplied until marginal abatement costs in power plants equal the permit price. Hence, the permit price will drop, and thus substantially lower the income losses.

But CDM also generates carbon leakage, therefore partly offsetting the initial emission reductions by Annex I, and thus lowering the effectiveness of the instrument. As CDM is funded at marginal costs, power plants will earn infra-marginal profits, and through competition these will be passed on to the consumers of electricity. Hence, the electricity price will fall and demand will rise. CDM will also depress demand for carbon-intensive fuels, such as coal, and lower prices of these fuels, raising demands in other sectors of the economy. Taken together these responses to CDM in the local economy may yield a local carbon leakage of up to 40% of the credits earned by CDM-funding parties (see section 7 for a discussion in more detail).

If import restrictions on either international permit trade and/or CDM are imposed (the RG30, and RA30-C cases), then the permit or carbon price will rise in countries where the import restriction becomes binding and fall elsewhere. Exporters of permits will get a lower price from a decline in demand. And importers will face a higher domestic price and a lower trade price. From a global perspective, restrictions on trading will reduce the number of emission reduction options and thus will increase the income losses of the climate policy.

5 Macro-economic consequences for the Netherlands, EU-25 and non-Annex I

Generally, one would expect the macro-economic costs for coalition members in terms of real national income to increase with rising marginal abatement costs, as indicated by the height of the permit price. This indeed becomes apparent from Figure 5.1 for both EU-25 and the Netherlands. In this figure the effects on national income are decomposed into three components: the change in GDP, the costs of permit trade and a remainder that consists mainly of terms of trade effects. The macro-economic costs for EU-25 range from 0.1 % of real national income (TG10) to 2.2% (UA30) and these scenarios are at the boundaries of the range of permit prices. The costs for the Netherlands are very similar, ranging from 0.1% (TG10) to 2.3% (UE30). Figure 5.1 shows that rising macro-economic costs for EU-25 and especially for the Netherlands are somewhat mitigated by increasing terms of trade effects.

The macro-economic impacts for non-Annex I countries are shown in Figure 5.2. The effects on national income are generally positive under cap-and-trade systems irrespective of whether these countries are members of the coalition or not. If they belong to the coalition they benefit from the sale of emission permits. If they are not part of the coalition the benefits are due to a rise of activity in energy-intensive sectors. Introduction of global carbon taxation is most harmful for these countries, leading to reductions of national income exceeding those of the countries of Annex I.

Figure 5.3 shows the impacts of the scenarios on employment in the energy-intensive and transport sectors in EU-25 and the Netherlands. As total employment is exogenous in the model, these figures indicate a shift of employment from these sectors to elsewhere in the economy. Obviously, shifts in employment will be largest when coalition sizes shrink under cap-and-trade due to migration of energy-intensive production to non-members. In general, percentage deviations from the background scenario without climate change policies are smaller for the Netherlands than for EU-25. When permit trade is restricted however (as in RG30), the Dutch may suffer more than other EU member states because they tend to rely to a larger extent on permit imports.

Figure 5.1 Impacts on real national income, EU-25 and the Netherlands, 2020

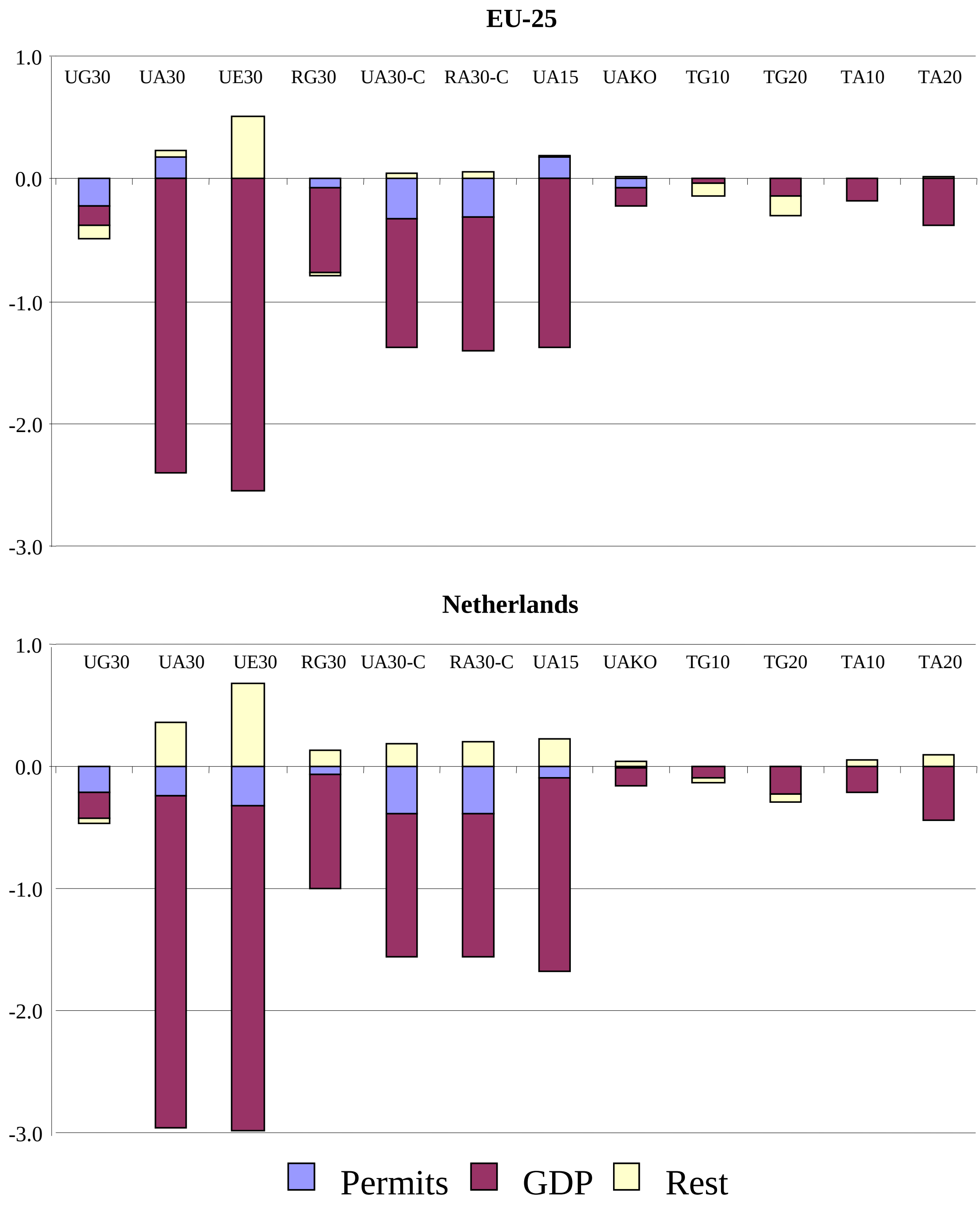


Figure 5.2 **Impacts on real national income, non-Annex I, 2020**

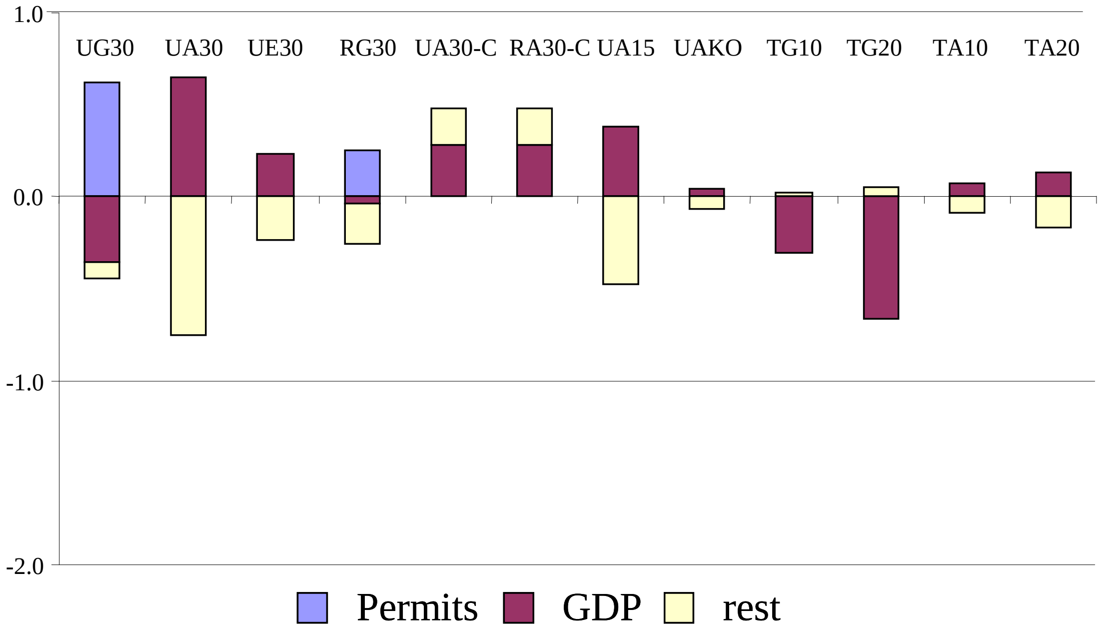
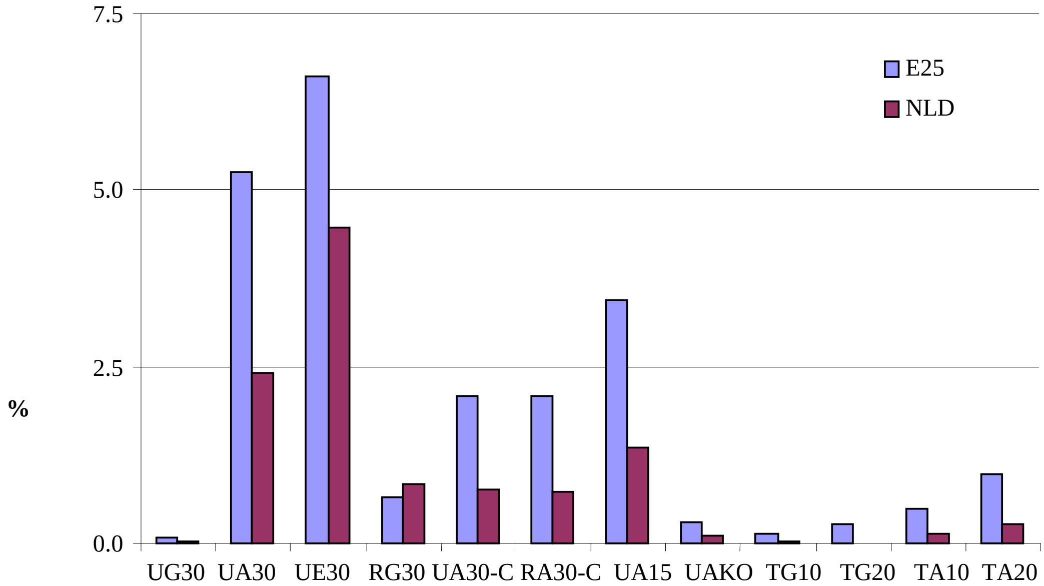


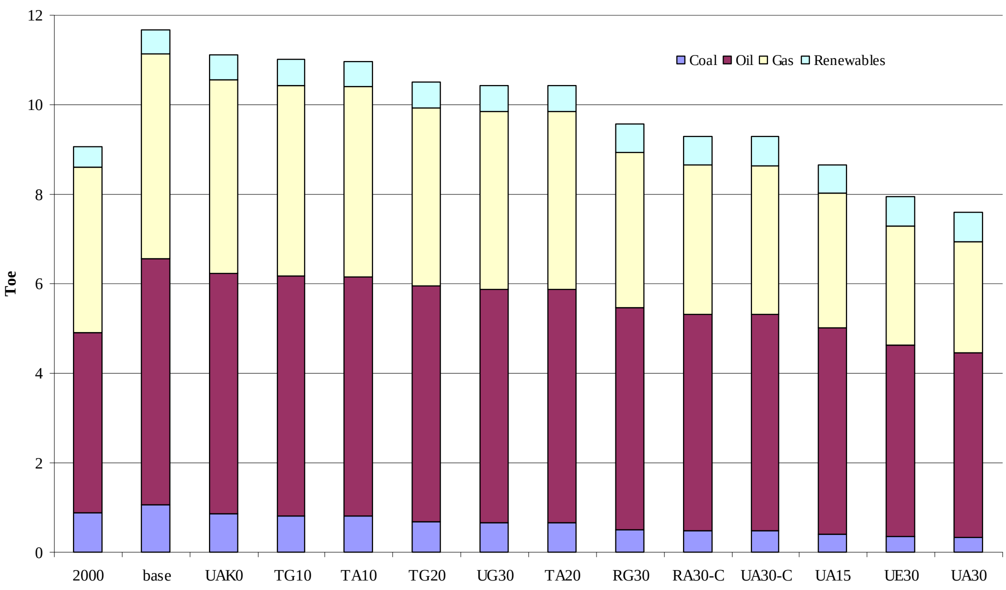
Figure 5.3 **Impacts Percentage deviation of employment in energy-intensive and transport sectors, EU-25 and the Netherlands, 2020**



6 Energy consumption in the Netherlands

Reductions of GHG-emissions may be accomplished by substitution[4], fuel switching and a reduction of overall economic activity. In our scenarios substitution is the dominant force. This implies that emission reductions are predominantly achieved by substitution to less energy-intensive inputs in production and to less energy-intensive goods and services in final consumption. Hence, emissions abatement is to a major extent (in an order of 80%) achieved by improved energy efficiencies resulting in reduced energy requirements per unit of GDP. To a minor extent (of about 20%) reductions are achieved by switching to less-carbon intensive energy carriers (yielding reduced emissions per unit of energy) and for the remaining part by reductions in overall economic activity (as measured by GDP).

Figure 6.1 Energy consumption by carrier, the Netherlands, in Toe, 2000 and 2020



The scenarios studied show considerable variations in total energy consumption. For example, Dutch energy consumption (see figure 6.1) is almost 35% below the baseline in the scenario with 30% emissions reduction for Annex I only (UA30), but the shortfall from the baseline is much less in the scenarios ‘Kyoto forever’ (UAKO) and carbon taxation at 10 euro (TG10 and TA10).

[4] This is the combined effect of energy savings and structural changes

If major reductions in energy use occur, the usage of coal is reduced most in relative terms (fuel-switching), while the reduction of the usage of gas tends to dominate in absolute terms. Hence, the figure indicates the limited possibilities to substitute gas for oil in transportation. The role of renewables remains rather limited. Its usage does increase somewhat over time, but in absolute terms its role is small.

7 CDM and leakage in non-member countries

In our simulations, CDM is modelled as a special case of emissions trading. We focus on projects in the electricity sector. Annex I countries may acquire Emission Reduction Units (ERUs) by investing in more efficient power generation in non-Annex I. It is to be noted that there is no overall emissions target for non-Annex I and the amount of ERUs is to be assessed against an ex ante baseline (see box).

CDM in WorldScan

The Clean Development Mechanism (CDM) belongs to the ‘flexibility mechanisms’ of the Kyoto protocol. These mechanisms were devised to assist Annex I countries to fulfil their commitments in a flexible and co-operative manner. At the same time they provided an opportunity for developing countries, not bound to reduce their emissions under the protocol, to participate in the process of global GHG mitigation. CDM performs a three-fold function as it assists non-Annex I countries to achieve sustainable development, contributes to the ultimate goal of stabilization of GHG concentrations in the atmosphere, and assists Annex I countries to meet their emission reduction ceilings

CDM has been designed to be innovative, and market-based, encouraging developed countries to invest in projects in the developing ones. Emissions resulting from the project should be lower than what would have occurred had the prevalent technology been used. Emission reductions should be real, measurable, and long term.

Establishment of emission reductions additionality (additional reduction in emissions) is a prerequisite under CDM. However, in order to establish additionality of projects it becomes necessary to define a baseline against which the additionalities can be assessed and carbon credits for the project determined. Baselines can be assessed at project or firm level but may also pertain to the sectoral level.

CDM and leakage

CDM may lose much of its efficiency, due to serious carbon leakage. The reasons for this leakage are threefold

- CDM may lead to lower electricity prices and this will induce additional demand for electricity
- primary energy supply may be inelastic and the resulting drop in energy prices may mitigate ex ante reductions in energy demand.

- the economy may become more competitive boosting production, and thus increasing emissions

Lower electricity prices

The price of emission reduction units is determined at the margin. As the amount of emissions the electricity sector is willing to reduce goes up, this price increases at a progressive rate (due to the convexity of the abatement curve). In a competitive market for CDM, host sectors will have a producers' surplus. Actual abatement costs are lower than the revenues from CDM. This producers' surplus is assumed to lead to lower electricity prices ex post. These lower prices will induce higher electricity demand and this may counterbalance the ex ante emissions reduction. The leakage that results, depends crucially on the assumption that CDM leads to lower electricity prices. In a setting where the government acts as a broker for CDM-projects, it is conceivable that the electricity sector is only compensated for its actual abatement costs and that the government recycles the surplus into the overall economy. In this case electricity prices will hardly be affected and leakage will be less.

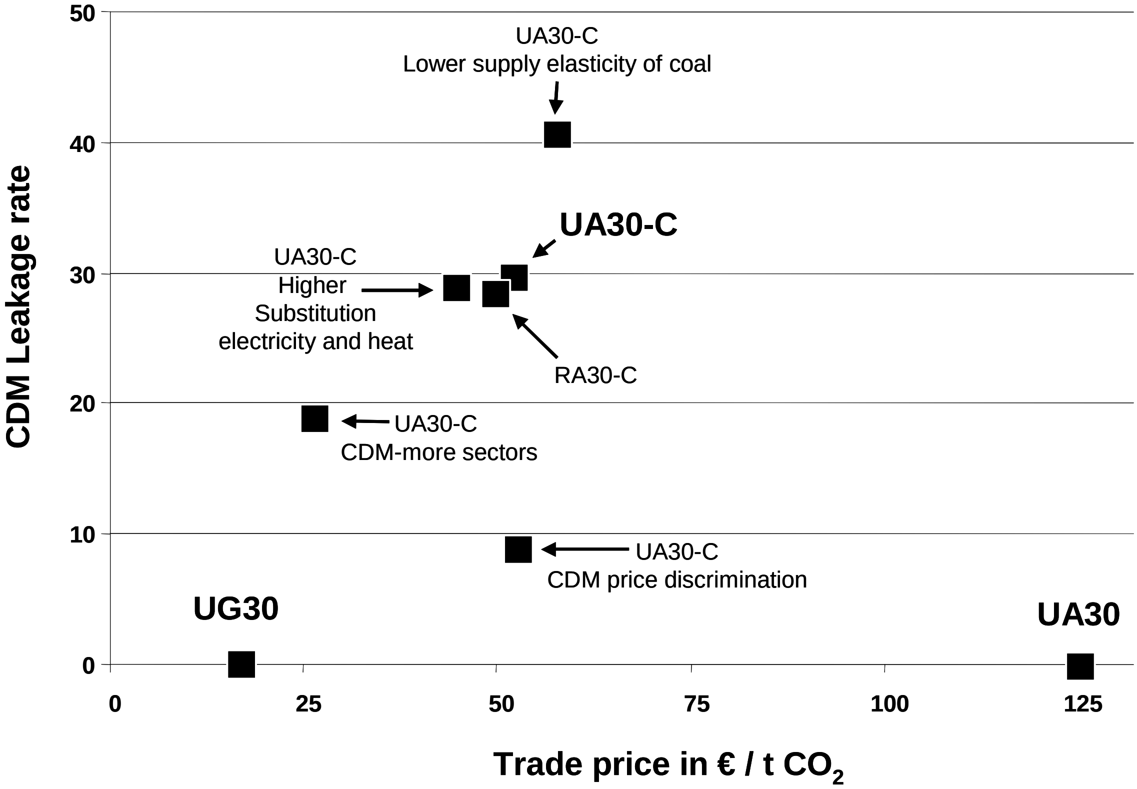
Inelastic energy supply

Primary energy prices may react to a drop in energy demand in the electricity sector. Cheaper energy will boost energy demand in other sectors and carbon leakage will result. If trade in fossil fuels is difficult and energy markets are more or less regionally confined, the energy prices in non-Annex I will be affected more.

Central case

Figure 7.1 shows the consequences of extending the 30% emissions reduction scenario for Annex I with CDM-opportunities in electricity generation in non-Annex I countries. Seizing these opportunities will lower the carbon price from 125 euro per ton CO_2 (UA30) to 51 euro per ton in our central case (UA30-C). The global income losses decline by more than 50 percent through CDM. Still, local leakage in non-Annex I countries will amount to 30% of the emissions reduced by undertaking CDM-projects there. Thus, global emission reductions will go down (see Figure 4.1). Hence, the credits earned in this way are less effective in abating global emissions than a global permit system with unrestricted trade (UG30). To further investigate the importance of CDM leakages, alternative assumptions have been assessed.

Figure 7.1 **Carbon tax in euro per ton CO_2 and CDM-leakage as a percentage of CDM-emissions reduction in non-Annex I countries, 2020**



Sensitivity analysis

Leakage depends crucially on the institutional design of CDM. Hence, we carried out a sensitivity analysis under alternative assumptions. If CDM and permit trade is put under a 50% permit import ceiling, both the permit and CDM-price will slightly go down and local leakage will be marginally smaller. These ceilings however do lead to more demand for CDM credits, and less permit trade between Annex I countries. But as with imposing restrictions on global unrestricted permit trade, the permit trade price will go down. If the local supply elasticity of coal is reduced (from 20 to 1) and hence the sensitivity of the local coal price for shifts in coal demand is raised, the carbon price will increase to 60 euro per ton CO_2. Because of the higher carbon price the leakage may rise to 40%. If it becomes easier to substitute electricity for heat, the carbon price will slightly fall, and leakage is hardly affected. The leakage rate can be brought down (to around 20%), if CDM-opportunities are also offered in non-electricity sectors, such as in the energy-intensive steel, petrochemical, and ferrous-metals industries. There will be more emission reduction options, and hence the carbon price will fall to 27 euro per ton CO_2, thus lowering the leakage rate. Further, if electricity producers in the hosting countries cannot negotiate a permit price at the marginal cost level, but only get compensated for the average costs of emission reduction, then local leakage will decline dramatically. In this case the permit price remains the same while financial transfers to hosting countries will decline. This can only be done with additional efforts to monitor the actual costs of CDM projects, which are not included in the WorldScan model[5].

[5] The importance of these costs to compliance is beyond the scope of this paper. Still, the idea of introducing flexibility mechanisms in the Kyoto Protocol was one of the goals to lower the monitoring costs, and enabling governments to restrict themselves to negotiate targets and timetables. The permit market will identify the most efficient options to reduce emissions, instead of the government having to search for the cheap options. By widespread application of CDM in post-Kyoto-era, governments can reduce CDM leakages by setting up monitoring systems, which seem to imply rising monitoring costs.

8 Conclusions

It goes without saying that – of the scenarios considered in this document - a global coalition is the preferred post-Kyoto policy setting for achieving global climate change objectives from an economic efficiency point of view. Within this setting unrestricted permit trade or a universal carbon tax will ensure that abatement takes place at the lowest possible costs. Yet, in the arena of policy negotiations other objectives may be reigning and these may impair the achievement of such a set-up.

If cap and unrestricted trade are maintained but coalitions are shrinking, costs for coalition members will rise as will global emissions. Opening CDM opportunities in non-member countries will alleviate these costs at the expense of somewhat higher emissions due to local leakage. Hence, in general CDM-credits are less effective in abating global warming than regular permits. Local leakage and compliance costs may be reduced however, if CDM-opportunities are supplied worldwide in many sectors of non-member countries.

Requiring that permit imports should not exceed 50% of reduction targets will lower the price of permit trade and affect the burden sharing over countries. In particular, compliance costs will rise in countries for which this requirement is binding and decrease elsewhere.

Relaxing caps will reduce compliance costs at the expense of increased emissions. Neglecting income effects, the imposition of a uniform carbon tax for coalition members will be just as effective in abating global warming as a cap-and-trade scheme, provided the time profiles of carbon taxes coincide. The distributional consequences can be quite different though. If, for example, a global cap-and-trade scheme with permit allocation according to ‘Contraction and Convergence’ is replaced by a universal carbon tax, compliance costs will diminish for Annex I countries but become substantial for developing countries. Revenues of carbon taxation are a versatile source for income transfers that would make burden sharing more equitable. However, domestic pressure to recycle these revenues back into the own economy is likely to prevent these transfers from happening. The grandfathering schemes under cap-and-trade seem to provide a more solid basis for international burden sharing. Hence, a cap-and-trade system might be the more promising scheme to bring consensus amongst negotiating parties.

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Appendix Tables

Tabel A.1 Baseyear data (2000)

	Population (millions)	National Income (billions $)	Primary Energy (toe)	Emissions (GtC)	Energy Intensity (USA=100)	Carbon intensity (USA=100)
EU-25	543	9124	167	1,21	77	96
Netherlands	16	381	10	0,05	106	72
Germany	82	2175	33	0,25	63	100
France	60	1478	18	0,11	52	79
United Kingdom	59	1418	23	0,16	68	95
USA	283	9091	215	1,63	100	100
Former Soviet Union	292	601	85	0,58	595	90
Annex I	1310	24807	552	4,05	94	97
Non Annex I	4746	6959	300	2,40	182	106
Latin America	514	2086	52	0,36	106	90
Middle East	315	805	48	0,35	253	95
Rest-of-the World	3917	4066	199	1,70	207	112
World	6056	31765	852	6,45	113	100

Tabel A.2 Baseline GLOBAL ECONOMY, average yearly growth 2000-2020, and reduction target allocations under contraction and convergence

	Population % yr-1	National Income % yr-1	Primary Energy % yr-1	Emissions % yr-1	Assigned Amount % change compared to 1990	Assigned Amount % change compared to 2020 without climate policies
EU-25	0.4	2.8	1.9	1.8	-16	-43
Netherlands	0.7	3.0	1.3	1.0	-30	-47
Germany	0.5	2.5	1.4	1.3	-46	-53
France	0.5	2.7	1.6	1.8	10	-28
United Kingdom	0.4	2.6	1.9	1.7	-34	-52
USA	0.8	2.9	1.2	1.2	-51	-68
Former Soviet Union	0.1	4.6	1.7	1.6	-45	-35
Annex I	0.4	2.7	1.5	1.5	-30	-53
Non Annex I	1.3	5.6	4.4	4.3	238	8
Latin America	1.1	3.9	4.5	4.6	300	27
Middle East	2.0	4.1	3.5	3.5	230	14
Rest-of-the World	1.2	6.5	4.5	4.3	226	2
World	1.1	3.4	2.7	2.7	49	-22

Table A.3 Global coalition, 30% cap and unrestricted trade (UG30), 2020

	CO2 (TgC)	Target comp. 1990	Target comp. 2020	CO2 (%)	C-tax (€/tCO2)	NI (%)	Energy-Intensive (%)	All other Sectors (%)
EU-25	1.50	-16	-43	-14	16	-0.5	-1	0
Netherlands	0.05	-30	-47	-12	16	-0.5	0	-1
Germany	0.28	-46	-53	-12	16	-0.5	0	0
France	0.14	10	-28	-9	16	-0.2	0	0
United Kingdom	0.20	-34	-52	-13	16	-0.5	1	0
USA	1.68	-51	-68	-19	16	-0.5	-1	0
Former Soviet Union	0.60	-45	-35	-24	16	-1.2	-7	-4
Annex I	4.45	-30	-53	-18	16	-0.5	-1	0
Non Annex I	4.08	238	8	-26	16	0.3	-4	-1
Latin America	0.77	300	27	-13	16	0.2	-2	-1
Middle East	0.59	230	14	-14	16	0.0	-4	-4
Rest-of-the World	2.72	226	2	-32	16	0.4	-4	-1
World	8.53	49	-22	-22	16	-0.26	-2	-1

Table A.4 Annex I coalition, 30% cap and unrestricted trade (UA30), 2020

	CO2 (TgC)	Target comp. 1990	Target comp. 2020	CO2 (%)	C-tax (€/tCO2)	NI (%)	Energy-Intensive (%)	All other Sectors (%)
EU-25	0.95	-16	-43	-46	125	-2.2	-10	-2
Netherlands	0.03	-30	-47	-42	125	-2.6	-10	-3
Germany	0.19	-46	-53	-42	125	-2.7	-10	1
France	0.10	10	-28	-34	125	-1.2	-5	-1
United Kingdom	0.13	-34	-52	-44	125	-2.3	-4	-2
USA	0.91	-51	-68	-56	125	-2.2	-12	-3
Former Soviet Union	0.28	-45	-35	-65	125	0.8	-41	-14
Annex I	2.56	-30	-53	-53	125	-2.0	-11	-3
Non Annex I	5.68		8	2		0.0	5	0
Latin America	0.91		27	3		-0.1	5	0
Middle East	0.70		14	2		-0.9	9	-4
Rest-of-the World	4.07		2	2		0.1	5	1
World	8.24		-22	-25		-1.4	-5	-1

Table A.5 EU25 coalition, 30% cap and unrestricted trade (UE30), 2020

	CO2 (TgC)	Target comp. 1990	Target comp. 2020	CO2 (%)	C-tax (€/tCO2)	NI (%)	Energy-Intensive (%)	All other Sectors (%)
EU-25	1.00	-16	-43	-43	100	-2.0	-11	-2
Netherlands	0.04	-30	-47	-39	100	-2.3	-11	-2
Germany	0.19	-46	-53	-40	100	-2.4	-11	0
France	0.11	10	-28	-32	100	-1.3	-7	-1
United Kingdom	0.14	-34	-52	-41	100	-2.1	-6	-2
USA	2.09		-68	1		0.0	1	0
Former Soviet Union	0.81		-35	2		-0.2	5	-1
Annex I	4.70		-53	-13		-0.7	-4	-1
Non Annex I	5.58		8	1		0.0	1	0
Latin America	0.89		27	1		0.0	1	0
Middle East	0.69		14	1		-0.3	3	-1
Rest-of-the World	4.00		2	1		0.1	1	0
World	10.28		-22	-6		-0.5	-2	0

Table A.6 Annex I coalition, 30% cap and unrestricted trade, with CDM (UA30-C), 2020

	CO2 (TgC)	Target comp. 1990	Target comp. 2020	CO2 (%)	C-tax (€/tCO2)	NI (%)	Energy-Intensive (%)	All other Sectors (%)
EU-25	1.23	-16	-43	-30	51	-1.3	-4	-1
Netherlands	0.04	-30	-47	-26	51	-1.4	-4	-1
Germany	0.24	-46	-53	-26	51	-1.5	-4	1
France	0.12	10	-28	-20	51	-0.7	-2	0
United Kingdom	0.17	-34	-52	-28	51	-1.3	-1	-1
USA	1.27	-51	-68	-39	51	-1.3	-5	-1
Former Soviet Union	0.43	-45	-35	-46	51	-1.7	-22	-8
Annex I	3.46	-30	-53	-36	51	-1.3	-5	-1
Non Annex I	4.92		8	-11	51	1.1	2	2
Latin America	0.85		27	-4	51	0.5	2	1
Middle East	0.66		14	-4	51	0.8	3	1
Rest-of-the World	3.42		2	-14	51	1.2	2	2
World	8.39		-22	-23	51	-0.6	-3	0

Table A.7 Global coalition, 30% cap, permit imports =<50%, (RG30), 2020

	CO2 (TgC)	Target comp. 1990	Target comp. 2020	CO2 (%)	C-tax (€/tCO2)	NI (%)	Energy-Intensive (%)	All other Sectors (%)
EU-25	1.36	-16	-43	-22	76	-0.8	-3	-1
Netherlands	0.05	-30	-47	-24	41	-0.9	-4	-2
Germany	0.24	-46	-53	-27	49	-1.0	-5	0
France	0.13	10	-28	-14	29	-0.3	0	0
United Kingdom	0.17	-34	-52	-26	44	-0.7	-2	-2
USA	1.38	-51	-68	-34	39	-0.5	-5	-2
Former Soviet Union	0.65	-45	-35	-17	11	-0.9	-4	-4
Annex I	3.97	-30	-53	-27	76	-0.6	-3	-1
Non Annex I	4.56	238	8	-18	8	0.1	-1	-1
Latin America	0.83	300	27	-6	8	0.0	0	-1
Middle East	0.64	230	14	-7	8	-0.4	0	-4
Rest-of-the World	3.10	226	2	-22	8	0.2	-1	-1
World	8.53	49	-22	-22	76	-0.4	-2	-1

Table A.8 Annex I coalition, 30% cap, permit imports =<50%, with CDM (RA30-C), 2020

	CO2 (TgC)	Target comp. 1990	Target comp. 2020	CO2 (%)	C-tax (€/tCO2)	NI (%)	Energy-Intensive (%)	All other Sectors (%)
EU-25	1.22	-16	-43	-30	77	-1.3	-5	-1
Netherlands	0.04	-30	-47	-26	50	-1.4	-4	-1
Germany	0.24	-46	-53	-27	51	-1.5	-4	1
France	0.12	10	-28	-20	50	-0.7	-2	0
United Kingdom	0.17	-34	-52	-28	50	-1.3	-1	-1
USA	1.27	-51	-68	-39	50	-1.3	-5	-1
Former Soviet Union	0.43	-45	-35	-46	50	-1.8	-22	-8
Annex I	3.46	-30	-53	-36	77	-1.3	-5	-1
Non Annex I	4.92		8	-11	50	1.1	2	2
Latin America	0.85		27	-4	50	0.5	2	1
Middle East	0.66		14	-4	50	0.8	3	1
Rest-of-the World	3.42		2	-14	50	1.2	2	2
World	8.39		-22	-23		-0.593	-3	0

Table A.9 Annex I coalition, 15% cap and unrestricted trade (UA15), 2020

	CO2 (TgC)	Target comp. 1990	Target comp. 2020	CO2 (%)	C-tax (€/tCO2)	NI (%)	Energy-Intensive (%)	All other Sectors (%)
EU-25	1.12	2	-30	-36	73	-1.2	-6	-1
Netherlands	0.04	-15	-36	-32	73	-1.4	-6	-2
Germany	0.22	-35	-43	-32	73	-1.6	-6	0
France	0.12	34	-13	-25	73	-0.5	-3	-1
United Kingdom	0.15	-20	-42	-34	73	-1.3	-2	-2
USA	1.13	-41	-61	-46	73	-1.4	-8	-2
Former Soviet Union	0.37	-34	-21	-54	73	0.8	-30	-11
Annex I	3.11	-15	-42	-42	73	-1.2	-8	-2
Non Annex I	5.63		8	2		0.0	3	0
Latin America	0.90		27	2		-0.1	3	0
Middle East	0.69		14	1		-0.7	6	-3
Rest-of-the World	4.03		2	2		0.1	3	0
World	8.74		-17	-20		-0.8	-3	-1

Table A.10 Annex I coalition, Kyoto cap and unrestricted trade (UAKO), 2020

	CO2 (TgC)	Target comp. 1990	Target comp. 2020	CO2 (%)	C-tax (€/tCO2)	NI (%)	Energy-Intensive (%)	All other Sectors (%)
EU-25	1.60		-29	-8	7	-0.2	-1	0
Netherlands	0.06	20	-10	-7	7	-0.1	-1	0
Germany	0.30	-21	-31	-7	7	-0.2	-1	0
France	0.15	2	-34	-5	7	-0.1	0	0
United Kingdom	0.22	-13	-37	-7	7	-0.2	0	0
USA	1.84		-8	-11	7	0.0	-1	-1
Former Soviet Union	0.68	3	23	-14	7	0.3	-5	-2
Annex I	4.84		-10	-10	7	-0.1	-1	0
Non Annex I	5.55		8	0		0.0	0	0
Latin America	0.88		27	0		0.0	0	0
Middle East	0.69		14	0		-0.1	1	-1
Rest-of-the World	3.98		2	0		0.0	0	0
World	10.39		-1	-5		-0.1	0	0

Table A.11 Global coalition, carbon tax of 20 euro/tCO_2 (TG20), 2020

	CO2 (TgC)	Target comp. 1990	Target comp. 2020	CO2 (%)	C-tax (€/tCO2)	NI (%)	Energy-Intensive (%)	All other Sectors (%)
EU-25	1.46			-16	20	-0.3	-1	-1
Netherlands	0.05			-14	20	-0.3	0	-1
Germany	0.28			-14	20	-0.3	-1	0
France	0.14			-10	20	-0.1	0	0
United Kingdom	0.20			-15	20	-0.2	1	-1
USA	1.61			-22	20	-0.2	-2	-1
Former Soviet Union	0.57			-28	20	-1.1	-9	-6
Annex I	4.29			-21	20	-0.3	-1	-1
Non Annex I	3.89			-30	20	-0.6	-4	-2
Latin America	0.74			-16	20	-0.6	-3	-1
Middle East	0.57			-17	20	-1.1	-5	-6
Rest-of-the World	2.58			-35	20	-0.6	-4	-2
World	8.19			-25	20	-0.4	-2	-1

Table A.12 Global coalition, carbon tax of 10 euro/tCO_2 (TG10), 2020

	CO2 (TgC)	Target comp. 1990	Target comp. 2020	CO2 (%)	C-tax (€/tCO2)	NI (%)	Energy-Intensive (%)	All other Sectors (%)
EU-25	1.57			-10	10	-0.1	0	0
Netherlands	0.06			-8	10	-0.1	0	-1
Germany	0.29			-8	10	-0.1	0	0
France	0.15			-6	10	0.0	0	0
United Kingdom	0.21			-9	10	-0.1	0	0
USA	1.79			-14	10	-0.1	-1	-1
Former Soviet Union	0.66			-17	10	-0.5	-5	-3
Annex I	4.72			-13	10	-0.1	-1	-1
Non Annex I	4.37			-21	10	-0.2	-2	-1
Latin America	0.80			-9	10	-0.3	-1	-1
Middle East	0.62			-9	10	-0.5	-3	-3
Rest-of-the World	2.95			-26	10	-0.2	-2	-1
World	9.09			-17	10	-0.1	-1	-1

Table A.13 Annex I coalition, carbon tax of 20 euro/tCO_2 (TA20), 2020

	CO2 (TgC)	Target comp. 1990	Target comp. 2020	CO2 (%)	C-tax (€/tCO2)	NI (%)	Energy-Intensive (%)	All other Sectors (%)
EU-25	1.45			-17	20	-0.4	-2	-1
Netherlands	0.05			-15	20	-0.3	-2	-1
Germany	0.27			-15	20	-0.3	-2	0
France	0.14			-11	20	-0.2	-1	0
United Kingdom	0.20			-15	20	-0.3	-1	-1
USA	1.60			-23	20	-0.2	-3	-1
Former Soviet Union	0.57			-28	20	-1.0	-11	-5
Annex I	4.26			-21	20	-0.3	-3	-1
Non Annex I	5.57			1	0	0.0	1	0
Latin America	0.89			1	0	0.0	1	0
Middle East	0.69			0	0	-0.2	2	-2
Rest-of-the World	3.99			1	0	0.1	1	0
World	9.82			-10	20	-0.2	-1	-1

Table A.14 Annex I coalition, carbon tax of 10 euro/tCO_2 (TA10), 2020

	CO2 (TgC)	Target comp. 1990	Target comp. 2020	CO2 (%)	C-tax (€/tCO2)	NI (%)	Energy-Intensive (%)	All other Sectors (%)
EU-25	1.56			-10	10	-0.2	-1	0
Netherlands	0.06			-9	10	-0.2	-1	-1
Germany	0.29			-9	10	-0.2	-1	0
France	0.14			-7	10	-0.1	0	0
United Kingdom	0.21			-9	10	-0.1	0	-1
USA	1.78			-14	10	-0.1	-2	-1
Former Soviet Union	0.65			-18	10	-0.4	-6	-3
Annex I	4.69			-13	10	-0.1	-1	-1
Non Annex I	5.56			0	0	0.0	1	0
Latin America	0.89			0	0	0.0	1	0
Middle East	0.69			0	0	-0.1	1	-1
Rest-of-the World	3.98			0	0	0.0	1	0
World	10.25			-6	10	-0.1	-1	0