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Macro-economic Implications of the “Kyoto” CO₂ Target for the EU

*Report to European Commission DG-
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Macro-economic Implications of the ‘Kyoto’ CO₂ Target for the European Union¹

Results from the GEM-E3² Model

1. Introduction

The so-called Kyoto CO₂ target derives from the European Council’s decision of March 1997, establishing a quantified emission reduction objective for the European Union by 2010.

Although the objective has been specified by member-state and has concerned the bulk of greenhouse gases taken together, the present report retains the target for CO₂ only, as only this relates to energy use and conversion, and considers the target for the EU taken as a whole. The reason for the latter derives from the aim of evaluating the macro-economic costs under the best possible allocation of effort across member-states.

To evaluate this macro-economic costs, the present report designs and quantifies a set of policy scenarios and sensitivity tests. Conclusions arise from the comparison of policy runs with a baseline scenario³ for the EU quantified by using GEM-E3.

The report attempts the derivation of marginal cost curves (or marginal welfare curves) of reaching a range of emission reduction targets. It also considers the impact of adopting different macro-economic accompanying policies that re-distribute revenues in case of using policy instruments based on taxation. The report considers also the case of pollution permits, tradable across Europe, that serve to illustrate the possible gains from optimal allocation of efforts.

An additional policy simulation complements the analysis. This employs a modified version of the model, in which investment is split in productive and energy-saving investment, both entering the optimal behaviour of producers. This analysis allows for the appraisal of the role of the energy efficiency potential as an additional resource to be exploited in order to reach the target. In this way, the macro-economic model simulates the considerations that prevailed in the analysis of Policies and Measures that accompanied the Council’s decision of March 1997.

2. Definition of the Policy Scenarios

The analysis towards the evaluation of the macro-economic implications of the Kyoto target for the EU, is stepwise, involving the following policy experiments:

- 1 Construction of a cost-abatement curve for different emission reduction levels ranging from 5-25%. In these a single goal is applied to the EU as a whole. The goal is formulated as a constraint to the EU general equilibrium for which a shadow price is endogenously computed. This shadow price of the CO₂ emission constraint is further

¹ The views expressed in this paper do not engage the European Commission. The paper and the numerical results must be considered as an outcome of scientific research and are subject to modelling and data limitations. They also are subject to revision.

² The GEM-E3 model, sponsored by the European Commission DG-XII/F1 (Mr. P. Valette) has been constructed by a collaborative project involving NTUA, KUL/CES, University of Mannheim, University of Toulouse, University of Strathclyde and CORE.

³ The baseline scenario is the one previously prepared for the European Commission and reported in “European Macro-economic Projections for Baseline Scenario”, March 1997, Report of NTUA to the EC.

considered as an additional cost to all economic agents applying uniformly as proportional to their emissions. It is further assumed that public finance collect the counterpart of all these additional costs. To derive conclusions relevant to policy, we differentiate scenarios runs according to the rule of recycling of additional costs. Thus we consider three cases:

- 1.1 Case of non-recycling. The additional costs are excluded from the economy and the agents bear the heaviest consequences.
 - 1.2 Case of recycling through reducing labour cost. This corresponds to the so-called double dividend analysis, expecting that benefits will arise both for the environment and employment.
 - 1.3 Case of recycling through relaxing financial constraints to investment. One can expect recycling of additional costs in favour of capital.
- 2 Construction of a cost-abatement curve for different emission reduction levels in the presence of tradable pollution permits. In this a single goal is again applied for the EU as a whole. The pollution permits are grand-fathered. Their presence is expected to allow for more flexibility in the allocation of emission reduction effort as the agents can adjust through trade. The results of this case are not directly comparable to cost recycling cases, mentioned above, as the recycling issue is not involved because there is no agent collecting or redistributing the additional costs derived from the target.

In all the above simulations, we consider the following:

- The equilibrium is obtained simultaneously in all the member-states linked through endogenous bilateral trade flows, formulated according to the Armington assumption.
- Trade of the EU with the rest-of-the-world can freely adjust, while the price setting behaviour of the rest-of-the-world remains invariant.
- Producers and consumers choose the optimal allocation of production factors (all inputs are flexibly adjusting) restricted by a production possibility frontier or a pattern for budget allocation of consumers.
- Unemployment is assumed in the baseline scenario, allowing a flexibility of labour force supply. However, real wage rates can vary responding to changes of labour demand, so as to represent the bargaining power of labour unions.
- The model evaluates emissions, concentrations and damages. The latter are quantified via the Externe coefficients. Welfare is measured by the model through the concept of equivalent variation. Welfare is evaluated at two levels: economic welfare that excludes environmental externalities, but includes gains from higher employment; total welfare that also includes the value of avoided environmental damages (from all pollutants, not only from CO₂).
- The model output includes standard macro-economic indicators, country and sectoral details, all measured as percent differences of counterfactual policy scenarios from the baseline.
- The emission reduction scenarios assume a gradual imposition of the constraint, starting from 2001. The dynamic runs are completed in 2010 when the full target is imposed.

3. Results

3.1. The baseline scenario

The baseline scenario simulates a dynamic path of the EU economy up to 2010. It is derived from exogenous assumptions about the evolution of technology progress associated to production factors, the change of the world context (prices and demand) and a continuation of current pattern of public finance policy.

The growth of the EU economy is sustained at an annual average of 2.2% while CO₂ emissions grow in total by 7% in 2010 compared to 1990. The relative decoupling of emissions and

economic growth is due to the combined effect of energy productivity gains and a restructuring in favour of higher value added commodities.

The Kyoto target for CO₂ is about -12% from the emission level of 1990, as other greenhouse gases will be reduced as well, leading to a total reduction of -15% by 2010. As in the baseline scenario, emissions increase by 8%, the Kyoto target for CO₂ is -20% from the emissions of 2010.

The following table summarises the results for the baseline scenario.

Baseline Scenario			
in % per year	GDP	Energy Demand	Emissions from 1990
Austria	2.0%	-0.1%	99
Belgium	2.1%	0.1%	101
Germany (West)	2.2%	-0.1%	99
Denmark	2.0%	0.5%	109
Finland	2.2%	0.1%	101
France	2.1%	0.4%	107
Greece	3.1%	1.4%	124
Ireland	3.0%	1.2%	120
Italy	2.0%	0.9%	115
Netherlands	2.4%	0.5%	109
Portugal	3.4%	3.7%	162
Spain	2.6%	1.3%	121
Sweden	2.0%	0.3%	105
Un. Kingdom	2.3%	0.3%	105
EU-14	2.2%	0.5%	108

3.2. The emission constrained cases - evaluation of shadow costs

As mentioned, the emission constrained cases are acting by imposing additional costs to all producers and consumers. This additional cost, being necessary to reach the target, depends on the equilibrium shadow cost per unit of emissions which is computed at the EU level. Mathematically, the mechanism is exactly equivalent to the imposition of that level of carbon tax (uniform across the EU) that is necessary to reach the target.

3.2.1. No-recycling

As also mentioned, it is assumed that the amount corresponding to all additional costs is collected within public finance. If this amount is not further distributed, all agents face increasing costs of energy use without any compensation.

In that case, the emission reduction target acts very restrictively to the economy, leading to recession. This can be explained by the fact that the amount corresponding to the additional costs could be otherwise consumed and invested.

In case of non recycling, the Kyoto -20% target (compared to baseline) in 2010 has significant macro-economic implications. The Gross Domestic Product of the EU is found reduced by -1.1% in 2010, consumption (-2.85%) and production decrease and unemployment increases (531 thousand jobs are lost in 2010). Recession leads to a relative fall of domestic prices, as demand curves shift more rapidly than supply curves. Consumer prices, for example, decrease by -0.37% in 2010, leading to some preservation of exports to the rest-of-the-world (just stabilised with respect to baseline) and a fall of imports. Because of the fall of labour demand, the real wage rate decreases as well. The Kyoto target requires additional costs that amount to 3.64% of the EU GDP in 2010. The shadow price of the Kyoto constraint is found equal to 208 ECU'85 per ton of carbon. The economic welfare is consequently reduced (-0.58%), while the avoidance of environmental damages cannot compensate this fall, leading to a decrease of total welfare by -0.45%. This policy, under the assumption of non recycling of additional costs, corresponds to a loss of 400 ECU per capita for the whole EU, during the 2000-2010 decade.

The distribution of results across the member-states, depending on the industrial structure and the pattern of use of fossil fuels, reveal some differences. To explain them, one should consider the re-adjustment of intra-EU trade (which increases by 0.33% in 2010), serving to partly alleviating the

effects. GDP reduction effects range from -0.7% in 2010 (compared to -1.1% for whole EU), observed for France, Sweden, Finland, up to -1.6% and beyond, observed for Belgium, Netherlands, Greece and Spain. Reduction of emissions range from -15% to -25% in 2010 (compared to baseline), which is rather narrow. Total welfare changes depend also on concentrations of acid rain pollutants, as they are found significantly reduced as a side effect of the CO₂ target. Some countries, like Belgium and Netherlands bear significant effects from trade.

3.2.2. Recycling through the reduction of labour costs

Revenue recycling in the form of lower indirect labour costs operates through lowering the rate of employers' social security contribution. In this case, we consider that this reduction operates uniformly in all sectors, independently of their relative labour costs or the pre-existing level of the rate. We determine *ex-post* the level of reduction of the rate of social security contribution of employers that is necessary to compensate exactly the additional revenues from the additional excise tax. The model iterates among the possible values of rate reduction and determines the one needed in the new equilibrium achieved.

By scenario construction, the reduction of CO₂ emissions is also -20% in 2010 compared to the baseline.

In the case of recycling through labour, the economy reuses the amount corresponding to the additional costs and therefore it preserves more activity, than in the case of non recycling. Thus, the adjustment is on one hand more difficult, as more emissions have to be abated (compared to the case of non recycling), but on the other hand easier, as the relative cost of energy (compared to labour) is higher. The model run indicates that to reach -20% in 2010, the shadow abatement cost is 240 ECU'85 per ton of carbon which is higher than in the case of non-recycling.

In addition to environmental benefits, this scenario leads to employment benefits. Around 1.5 million new jobs are possible in 2010, leading to a gain in economic welfare of 0.88% (compared to baseline). Total welfare increases even more (1%) because of the double dividend.

However, GDP (-0.65% in 2010) and production activity are found slightly depressed, mainly because of competitiveness losses in trade, as domestic prices readjust upwards (5% for consumer prices and 0.18% for GDP deflator) pushed by higher real wage rates. The latter increase because of upwards trends in labour demand.

As a result of these mechanisms private consumption boosts (1%). The effects on investment act towards depression (-0.5%), which can be explained by considering the relative costs of production factors and sectoral restructuring that evolves away of capital (hence energy) intensive sectors.

The long term effects of this policy are not analysed, as the model lacks mechanisms through which changes in factor productivity would influence long term trends of technology progress.

3.2.3. Recycling through the reduction of investment costs

In this case, the amount collected by public finance, corresponding to the additional costs, is used to subsidize the cost of investment of firms. This can be interpreted as a relaxation of financing constraints of the economy, leading to lower lending rates for private investment.

In the production side, energy as a production factor becomes more expensive, while capital becomes cheaper in the long run. The change of relative factor costs induces substitution in favour of capital, leading to higher investments (+2.4% in 2010 compared to the baseline). Given the nesting of the production budgeting structure, the fall of cost of capital makes it more attractive than the bulk of labour, energy and materials. Thus, labour as well tends to be substituted for capital (employment is found slightly smaller than in the baseline), although at a lesser degree than that for energy. This effect acts on the labour market, where households re-adjust their wages to keep their jobs: the real wage rate is found slightly decreasing (-1.6% by 2010).

Due to the combination of the higher level of investments and the resulting increase in production capacity and the reduction in the real wage rate, prices increase much less than in the double dividend for labour scenario (+0.69% by 2010). This, combined with the reduction of the energy bill, leads to a significant decrease in the volume of imports (-4.7%) while exports are reduced by much less (-1.4%). The net result is then the improvement of the current account. The model run

indicates that to reach -20% in 2010, the shadow abatement cost is 216 ECU'85 per ton of carbon, a result which is slightly higher than in the case of non-recycling, but 10% lower than in the labour recycling case (even though the labour and capital recycling scenarios lead to the same reduction in GDP by 2010).

In the short run, domestic economic activity is depressed, as households' disposable income decreases in real terms, because of production side adjustments. Investment increase, as a component of final demand, is not enough to compensate the fall of private consumption.

The composition of economic activity differs from the double dividend case. Because of the fall of interest rates, not only investment in the production side but also acquisitions of durable goods increase, in the demand side as well. In total, the equipment goods industry benefit more than the consumption goods industry, a result that is opposite from that of the double dividend case.

The dynamic effects also differ. In the capital recycling case, the dynamic effects are the most important from a policy perspective: they indicate the existence of a trade-off over time. In fact, as investments increase, production constraints induced by the stock of capital are dynamically relaxed, leading to an upwards shift of economy's production capacity, further leading to decreasing equilibrium prices of domestic commodities⁴. Short run competitiveness losses are thus compensated after some time, leading to a revival of economic activity. This further implies gradually higher demand for production factors, including labour. Thus, dynamically, the labour market adjustments lead to canceling out losses in real wages, that further supports disposable income and private consumption. The combined effects of these movements, will imply higher GDP and more employment in the long run.

Again in these scenarios, we did not take into account technical progress changes that may have been induced by the changes in the economy, after the additional energy charges.

3.3. Pollution Permits Case

A market for pollution permits is created when a limited amount of "property rights" on emissions are distributed to the economic agents. These represent a right to pollute, proportional to the amount of property rights owned by the polluter. These rights can be traded between economic agents (and between EU countries).

These rights are distributed according to a grand-fathering⁵ principle. The economic agent has then to compare the cost of reducing emissions below its endowment, to the benefit from selling his permits to the market. At the equilibrium point, the permit price will be equal to the marginal cost of abatement allowing for maximum flexibility in the adjustment of the economy.

The pollution permits case does not assume any accompanying macro-economic policy that would aim at removing some other distortion (for example in the labour or capital markets, as in the cases of recycling through labour or capital mentioned above) and obtaining additional gains from that removal. To this respect, the pollution permits case is comparable to the non-recycling case, as in both cases there are no accompanying policies. It is expected however that the additional flexibility of economy adjustment provided by the trade of pollution permits would make possible to reach an optimal allocation of resources under the environmental constraint, as compared to the case of non recycling, where the allocation remains sub-optimal⁶.

As a matter of fact, to obtain -20% less emissions in 2010, the pollution permits case leads to lower GDP losses (-0.6% in 2010) and even positive total welfare gains (+0.05%), compared to the non recycling case. This justifies the statement about the superiority of pollution permits as regards allocative efficiency.

The lesser depression of economic activity, in the case of pollution permits compared to the non recycling case, leads to higher marginal cost per ton of carbon (277 ECU'85). This is even higher

⁴ These effects cannot be seen in the present model results as such effects would become apparent after 2010.

⁵ Grandfathering is the distribution process in which economic agents are endowed with an amount of permits proportionate to their initial volume of emissions.

⁶ An auctioneering system for pollution permits would mathematically be equivalent to our non recycling case.

than in the case of double dividend (through labour), as there relative factor costs allowed for bigger factor and sector substitutions. However, in the permit system competitiveness loss effects are smaller than in the case of double dividend (for labour). This is related to the labour market that faces a downwards trend of labour demand leading to a decrease of real wage rates, hence private consumption, further implying compression of domestic costs. The production possibilities lead to relatively higher capital demand to face increasing energy-related charges, that leads to a preservation of investment, contrary to the double dividend (for labour) case. The long term effects would then be important. The sectoral and country distribution effects are also different.

3.4. Energy-saving Investment

3.4.1. Model specification

In this exercise the model is modified (named GEM-E3 Ver 2.a) to incorporate the additional possibility of investing in energy-saving technology. In this context economic agents are assumed to have the possibility to increase the productivity of energy (i.e. consume less energy inputs per unit of output) by investing some resources to accumulate an energy-saving technology stock.

The decision whether and how much to invest on energy saving technology is in this model variant an **endogenous decision of the economic agents**.

Producers in the standard version of the GEM-E3 model demand the cost-minimizing mix of factors needed for production (capital, labour, energy and intermediate goods). Based on the demand they face, their existing production capacity and their expectation about the future they also invest to increase their productive capital stock. In the new model variant GEM-E3 Ver 2.a, there is an additional production factor, the stock of energy-saving technology, that serves to reduce the amount of energy needed to produce the same output, in other words it acts in favour of increasing the productivity of energy.

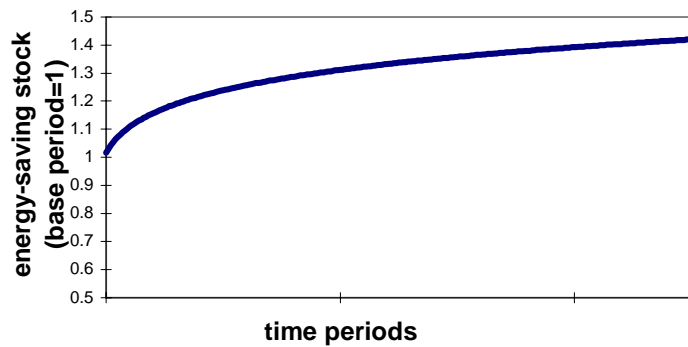
We use the term “energy-savings” to indicate all technologies that may improve energy productivity.

Producers compare the benefit of having one more unit of additional energy saving technology (that will induce lower energy costs for all subsequent time periods) to the cost of acquiring this additional unit. Through their cost-minimizing behaviour, they decide (as the solution of their inter-temporal problem of allocating their resources) together with the demand for production factors and the one for productive investments, the optimal investment in energy saving technology. This investment does not affect their productive capital stock, but is an additional demand for goods (which for example may be equipment goods).

In addition, in the new model variant GEM-E3 Ver 2.a, consumers have the possibility to choose among two classes of durable goods: “ordinary” ones, and more energy efficient ones, say “advanced technology”, whose acquisition price is however higher. A trade-off between higher acquisition costs for durables and lower energy (operation) costs, is thus introduced in the decision making of the consumer.

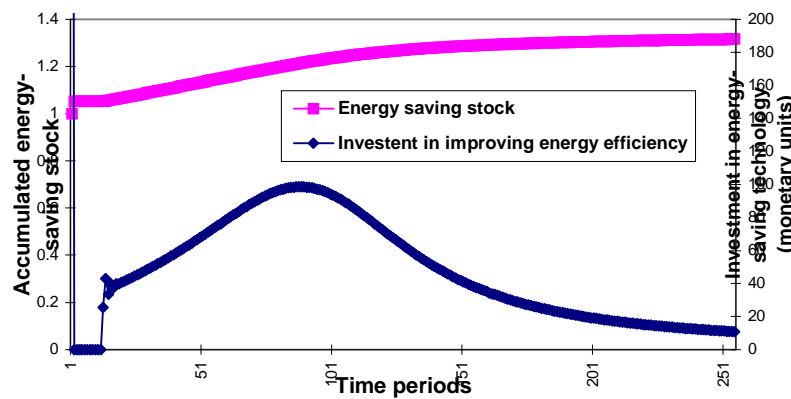
The investments related to energy-saving accumulate to form an energy-savings capacity (stock) that of course will have permanent effects on energy productivity. Similarly, the choice of more efficient durable goods will also have permanent effects on the use of energy in households. The relationship between the energy-saving stock and its effectiveness for energy savings exhibits decreasing marginal returns (saturation effect). For example if a constant investment on energy savings is accumulated per year, the resulting increase to the stock is increasing at decreasing rates, as illustrated in the figure:

Figure 1: Energy-Saving Stock under a constant investment in energy-saving technology



The basic algebraic formulation links the energy-saving expenditure to the stock of energy-saving capital and the increase of that stock (in other terms its marginal effectiveness). For example, if the energy use costs increases, the firm may quickly invest on energy-saving as long as the accumulated energy-saving capital remains low. Beyond a certain level of saturation, the firm may decrease further investment on energy-saving, as the marginal effectiveness of the capital decreases and the corresponding expenditure that is necessary to maintain a certain level of effectiveness increases non-linearly. This is illustrated in the following figure:

Figure 2: Energy Saving Investment and Stock under a continuous 3% increase of energy prices every year



The following remarks must be added:

- The energy-saving stock acts cumulatively, i.e. energy-saving technology accumulated by year t continues to be available in all subsequent years at no additional cost. A stock of energy-saving technology once acquired cannot be scrapped.
- The energy saving technology is depletable, i.e. there is an upper limit to the amount of energy productivity gains that can be achieved, a limit which depends on the particular economic agent and country (see figure 1 above).
- The desired amount of energy-saving technology depends mainly on the relative price of energy compared to the cost of acquiring it (which in its turn depends on the stock of energy-saving technology already accumulated, see figure 2 above) and the share of energy inputs in production costs.

Through this mechanism, the model incorporates an important dynamic mechanism, which is related to the depletable character of the energy savings potential. This mechanism involves a trade-off over time, as the firms (or consumers), may prefer to invest on energy savings (allocating less expenditure to consumption or investment) expecting to then use energy more productively.

The model variant is applied to the analysis of the EU Kyoto targets, under the same terms of the other exercises mentioned in the previous sections. To better appreciate the dynamics of the results the model simulation goes up to 2020, with the additional assumption that after 2010 there is no

additional environmental policy implemented within the EU above what is needed to keep emissions stable to their 2010 levels.

3.4.2. Simulation results

Two scenarios were simulated by this model variant: the “no recycling case” (for the specification of the scenario see paragraph 3.2.1 and the “recycling through reduction of labour taxes case” (for the specification of the scenario see paragraph 3.2.2).

The main additional mechanism operating in GEM-E3 ver. 2.0a is the as follows: following the increase in energy prices, producers and consumers, apart from substituting (as before), also invest in energy saving technology. Thus, compared to the main model simulations (presented in the previous paragraphs), an amount of resources that was previously allocated to consumption and productive investments is now dedicated to the energy-saving investments. This investment in energy-saving technology has two important implications: on one hand it leads to less dependency on imports (as energy is mostly an imported good) and on the other it boosts domestic demand in those specific directions that deliver the energy-saving technology, such as the equipment goods industry. This has a positive impact both on GDP and on investments. As the potential for energy savings is gradually depleted, energy-saving investments become lower, however the gains in energy efficiency obtained during this period remain. At the transition period (up to 2010), employment is higher than in the main model results (as the result of increased activity) but is then gradually reduced towards the steady state to a level lower than in the main model simulation.

Table 1: Direct Average cost of the implementation of energy-saving technology and their direct effects on CO2 emissions

	Cumulative expend. in energy saving technology (in MECU)	Abated Emissions (ktn CO2)	Average cost (ECU/tn CO2)	Average cost (ECU/tn C)
Agriculture	1427	113626	12.6	46.1
Electricity	9317	388908	24.0	87.8
Ferrous, non-ferrous ore and metals	4806	326345	14.7	54.0
Chemical products	2793	138657	20.1	73.9
Other energy intensive industries	1884	96746	19.5	71.4
Electrical goods	121	14536	8.3	30.4
Transport equipment	239	24776	9.6	35.4
Other equipment goods industries	188	20397	9.2	33.8
Consumer goods industries	1293	105602	12.2	44.9
Building and construction	1185	97445	12.2	44.6
Telecommunication services	77	10014	7.7	28.1
Transports	3932	205483	19.1	70.2
Credit and insurance	178	19108	9.3	34.1
Other market services	3891	259567	15.0	55.0
Non-market services	1875	164699	11.4	41.7
Totals	35353	2034977	17.4	63.7

GDP losses are much alleviated, also due to terms-of-trade effects that are in the transitory period important.

The table shows the cumulative expenditure in energy-saving technology and the corresponding gains in the productivity of energy.

As a result of the above mechanism the following main differences between GEM-E3 ver.20a and the main model results are observed:

No-recycling case

- The required shadow abatement cost is considerably lower with the new model, even though GDP falls considerably less, an effect which is the direct outcome of the exploitation of the additional energy-saving possibilities. The marginal cost is 199 ECU/tn CO₂ instead of 208, with GDP decreasing by -0.77% in 2010 (compared to the baseline) instead of -1.1% observed with the main model.

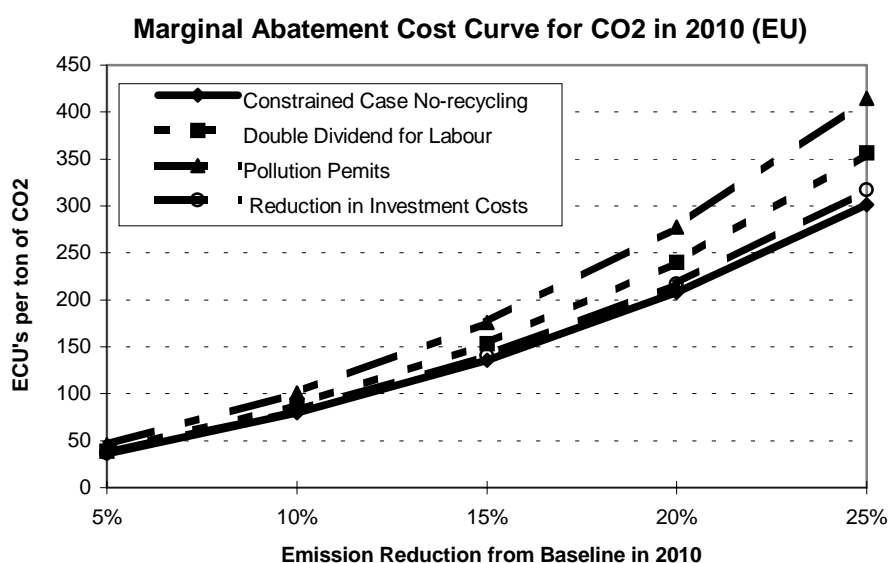
- Employment losses are lower, at least up to 2010, as the energy-saving investments help keep demand. After 2010, in the absence of additional environmental policy and since part of the energy saving potential has already been exploited, energy-saving investments drop abruptly, so that in 2020 they are close to the figure obtained with the main model.
- Energy-saving investments (that reach 1.4% of productive investments in year 2010) also lead to some demand for the equipment goods sectors, a fact which in turn partially alleviates the negative impact of the environmental constraint on investments, which drop by -1.2% as opposed to -1.4% in the main model simulation.

Recycling through reduction of labour taxes

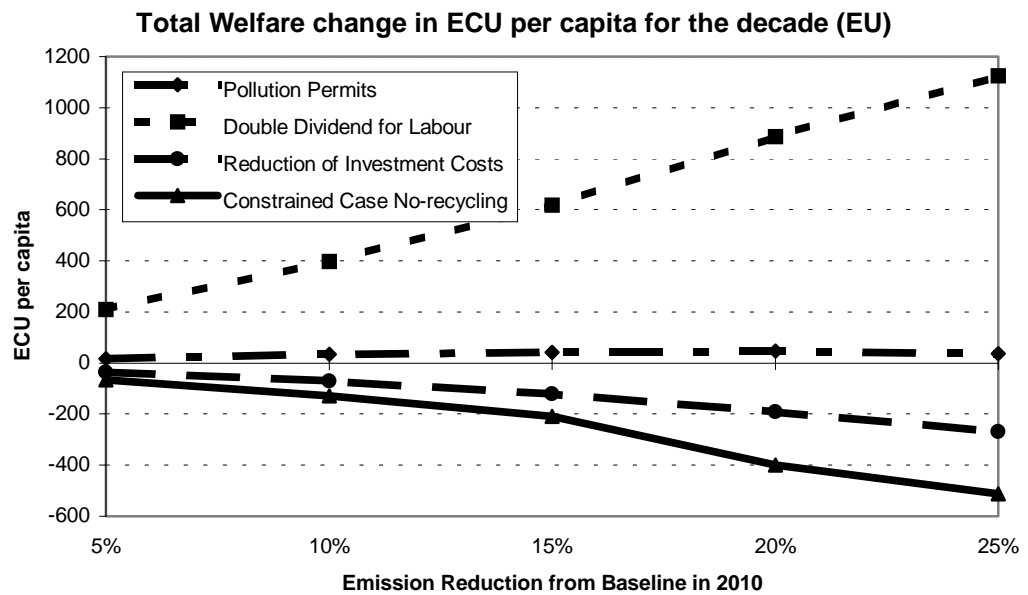
- Employment gains are again effected as described in paragraph 3.2.2. In the transitory period (up to 2010) employment is even higher than in the main model simulation (1675 thousand employed persons as opposed to 1460 with the main model), but is gradually reduced to 1342 thousand by year 2020.
- GDP losses are much alleviated both in the short and the longer term. The decrease in GDP is reduced by half, up to 2010 (-0.33% as opposed to -0.65% in the main model simulation) mainly because of the demand for energy-saving investments and after this point by terms-of-trade effects related to the fact that less energy imports are needed. In the first years of the environmental policy GDP is even slightly increasing.
- Terms-of-trade gains from the rest-of-the-world again explain part of the positive results.

4. Concluding Remarks

The following scheme presents the marginal abatement costs associated to the emission reduction constraint in 2010:



The following scheme presents change of total welfare (including externalities):



The following remarks are drawn from the above:

- the macro-economic cost of the Kyoto target is significant; accompanying policies should be seriously considered;
- if there exists in the economy the potential to achieve significant efficiency gains in energy use at a moderate cost, then the negative impact of environmental constraints on the economy may be lower. In this case additional benefits from terms-of-trade effects may further reduce the cost of the policy.
- the distributional effects (sectors, countries) and the long term effects (investment, labour productivity, etc.) depend heavily on the choice of accompanying policy and on the degree of flexibility of adjustment of economic agents;
- the pollution permit system allow for maximum flexibility but they do not allow for implementing accompanying policies financed by the collection of additional costs;
- the indicator “marginal cost per unit of carbon” may be misleading in macro-economic terms as it does not take into account the impact of the policy on the economy; the change in welfare (including gains from the environment) and other standard macro-economic indicators (such as GDP) must be used instead;
- the marginal abatement curves reveal steepness of the curve beyond a certain emission reduction target (beyond -15% in 2010 from baseline and mainly around -25%).

Table 1.1: Pollution Permits. EU target: -5%
(numbers indicate percent changes from baseline except if defined otherwise)

Macroeconomic Aggregates for EU-14

	2001	2003	2005	2007	2010
Gross Domestic Product	0.00%	-0.01%	-0.02%	-0.03%	-0.06%
Employment*	4	9	27	41	57
Private Investment	0.00%	0.01%	0.02%	0.03%	0.03%
Private Consumption	-0.01%	-0.07%	-0.12%	-0.20%	-0.30%
Domestic Demand	-0.01%	-0.06%	-0.09%	-0.15%	-0.22%
Exports in volume	0.00%	0.00%	-0.02%	-0.03%	-0.05%
Imports in volume	-0.03%	-0.22%	-0.37%	-0.61%	-0.88%
Intra trade in the EU	0.00%	0.00%	-0.02%	-0.03%	-0.04%
Energy consumption in volume	-0.09%	-0.69%	-1.16%	-1.88%	-2.72%
Consumers' price index	0.01%	0.09%	0.14%	0.23%	0.33%
GDP deflator in factor prices	0.00%	0.00%	-0.01%	-0.02%	-0.04%
Real wage rate	-0.01%	-0.08%	-0.13%	-0.22%	-0.32%
Tax revenues as % of GDP***	0.01%	0.06%	0.10%	0.16%	0.24%
Current account as % of GDP***	0.00%	0.03%	0.05%	0.07%	0.10%
Marginal abatement cost (ECU'85/tn C)	1.4	11.2	18.9	31.0	45.6
Total atmospheric emissions					
CO2	-0.20%	-1.13%	-2.08%	-3.47%	-5.04%
NOX	-0.15%	-0.66%	-1.36%	-2.44%	-3.66%
SO2	-0.30%	-2.06%	-3.55%	-5.72%	-8.12%
VOC	-0.08%	0.02%	-0.36%	-0.99%	-1.72%
PM	-0.36%	-2.29%	-3.99%	-6.47%	-9.19%
Equivalent Variation of total welfare					
Economic welfare**		-0.01%			
Economic and environmental welfare**		0.02%			
Economic and environmental welfare changes (ECU per capita)		17.67			

* in thousand employed persons

** as percent of GDP (last simulation year)

*** absolute difference from baseline