ETLA
ELINKEINOELÄMÄN TUTKIMUSLAITOS
THE RESEARCH INSTITUTE OF THE FINNISH ECONOMY
Lönnrotinkatu 4 B 00120 Helsinki Finland Tel. 358-9-609 900
Telefax 358-9-601 753 World Wide Web: http://www.etla.fi/

Keskusteluaiheita – Discussion papers

No. 693

Juha Honkatukia

THE EFFECTS OF ENERGY SAVING ON THE COSTS OF ABATEMENT POLICIES IN FINLAND

ISSN 0781-6847 09.11.1999

HONKATUKIA, Juha, **THE EFFECTS OF ENERGY SAVING ON THE COSTS OF ABATEMENT POLICIES IN FINLAND**. Helsinki: ETLA, Elinkeinoelämän Tutkimuslaitos, The Research Institute of the Finnish Economy, 1999, 44 p. (Keskusteluaiheita, Discussion Papers, ISSN, 0781-6847; no. 693).

ABSTRACT: The Kyoto Protocol to the United Nations Framework Convention on Climate Change stipulates reduction targets for emissions of greenhouse gases for industrialised countries for the years 2008-2012. The reduction target for the European Union as a whole is 8 % from 1990 levels, but the targets of the member countries are set in the EU agreement on burden sharing. Finland must restrict her emissions to 1990 levels. This target is strict in view of the fact that Finnish energy technologies are already very efficient. While further energy saving by increasing energy efficiency in consumption may still be viable, it necessitates investments in more efficient equipment. The primary purpose of this study is to present an estimate of the macroeconomic costs of these investments. In the study, we impose energy saving scenarios into a macroeconomic model of the Finnish economy. Our main finding is that energy saving is a costly way to cut emissions. The second aim of the study is to evaluate the effect of abatement by other countries on the Finnish costs of abatement policies. We find that domestic costs can be lower under multilateral abatement than under unilateral abatement, but that this is not always the case. The study also estimates the costs of using economic instruments to discourage the use of fossil fuels in combination with energy saving. We find that the design of domestic policies has as large an effect on the costs of abatement as the actions of other countries.

KEY WORDS: Kyoto Protocol, energy efficiency, carbon penalties, abatement costs, CGE-models

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TIIVISTELMÄ: YK:n ilmastosopimuksen Kioton pöytäkirjan ja Euroopan unionin taakanjakosopimuksen perusteella Suomen päästötavoite on vuoden 1990 taso, joka tulisi saavuttaa vuosien 2008-2012 aikana. Tämä tavoite on vaativa, koska Suomi on jo nyt energiatehokkuudeltaan OECD:n kärkimaita. Lisäsäästöt etenkin energian kulutuksessa ovat mahdollisia, mutta ne vaativat investointeja uuteen ja tehokkaampaan tekniikkaan. Tässä tutkimuksessa arvioidaan näiden investointien aiheuttamia kokonaistaloudellisia kustannuksia. Tutkimuksessa tarkastellaan energiansäästöä energiatehokkuuden parantamisskenaarioiden avulla. Tutkimuksen tärkein tulos on, että energiansäästön avulla ei ole juurikaan mahdollista laskea ilmastopolitiikan kustannuksia. Tutkimuksessa arvioidaan myös ilmastopolitiikan kustannusten riippuvuutta muiden maiden ilmastopolitiikasta. Kotimaiset kustannukset voivat jäädä alemmaksi, jos muutkin maat pyrkivät toteuttamaan päästötavoitteensa. Kotimaisten taloudellisten ohjauskeinojen valinta vaikuttaa kuitenkin rajoitustoimien kokonaistaloudellisiin kustannuksiin yhtä paljon kuin muiden maiden toimet.

ASIASANAT: Kioton pöytäkirja, energiatehokkuus, hiilidioksidiverot, rajoituskustannukset, tasapainomallit

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FOREWORD

This study evaluates the macroeconomic effects on the Finnish economy of emission restrictions implemented with energy saving and economic instruments. The study utilises a computable general equilibrium model of the Finnish economy. Energy saving is studied with scenarios for investment in increased energy efficiency. Economic instruments cover carbon dioxide penalties under various rebate schemes. The study also considers the effects of the abatement policies of other countries on the costs of abatement in Finland.

The study was commissioned by the Finnish Ministry of Finance. The study has been supervised by Financial Counsellor Heikki Sourama of the Ministry of Finance, whom I wish to thank for his insightful comments and suggestions. I am solely responsible for remaining errors and omissions.

Helsinki, 1 November 1999

Juha Honkatukia

1 INTRODUCTION

The Kyoto Protocol to the United Nations Framework Convention on Climate Change sets reduction targets for emissions of greenhouse gases for industrialised countries, to be implemented during the years 2008-2012. The reduction target for the European Union is 8 % from 1990 levels. According to the Protocol, member countries of the European Union can have different targets, the targets being set under an EU agreement on burden sharing.

Under the EU agreement, Finland must reduce her emissions to 1990 level. This task amounts to an approximate ten per cent reduction of her emissions from their 1998 level. However, Finnish emissions are growing, and according to recent projections the required reduction will be closer to 30 per cent from the level that would be reached without the commitment. Reaching the target will thus require investment in energy technology and energy saving, as well as the use of economic instruments, designed to discourage emissions of greenhouse gases.

The opportunities for direct technological measures to reduce emissions are relatively limited in Finland. This is because the energy-efficiency of Finnish energy production is already far above OECD average. Finland is also one of the leading countries in the use of bio-energy. However, according to recent estimates, energy consumption still has significant potential for energy saving via energy efficiency improvements.

The macroeconomic costs of energy saving consist of both the direct cost of investments in more efficient technologies and their effect on the rest of the economy via increased prices and reduced incomes. Rather than attempting to model endogenous investment in new energy technologies, here, we model energy saving as increases in the productivity of energy, achieved at increased marginal cost. Energy efficiency improvements, as well as the entailed investment costs, are based on the most recent estimates on energy saving potential. The potential for these improvements may be in excess of ten per cent of energy consumption. For moderate improvements, the direct costs of improvements are fairly low. However, the costs rise rapidly for larger improvements, as do their negative effects on the economy.

The Kyoto Protocol does not stipulate joint action on the parties with respect to economic measures, even though there is a wide agreement that flexible mechanisms can be used to achieve the emission targets. However, the parties have yet to reach an agreement on the extent to which these mechanisms can be used, as well as the details of the mechanisms themselves. Even within the European Union, it is unlikely that a common policy on emission reduction measures could be agreed on. The burden sharing agreement explicitly allocates significant increases in emissions to some countries and reductions to others. Since this implies that some of the member countries do not have an (official) emission problem, these countries have no incentive to agree on, say, common emission taxes.

Thus the Annex B countries of the Kyoto Protocol to rely on their own policies and measures. The actions of other countries may nevertheless have a significant effects on others, since abatement measures are bound to have an effect on export prices and terms of trade. If export demand is price elastic, domestic emission taxes, for example, will tend to harm exports under unilateral abatement more than they do under multilateral abatement.

Here, we study both unilateral and multilateral abatement. For unilateral abatement, world prices are assumed not to be affected by Finnish abatement, which is realistic at least in

most industries. For multilateral abatement, however, the effects on world prices need to be assessed. Unfortunately, there is no consensus in the literature about the global price effects of multilateral abatement. Thus, we follow the cautious approach of assuming that the effects of abatement on world prices are of the same magnitude as the domestic effects. In this case, there are no terms of trade effects. It is likely, however, that even under multilateral abatement, Finnish price competitiveness would decrease, since her energy intensity is one of the highest among the OECD-countries. Thus, the assumption of no terms-of-trade effects is likely to underestimate the effects of multilateral abatement on Finnish terms of trade.

Economic instruments have been advocated as an efficiency-increasing way to reduce the costs of abatement policies. The rationale is that economic instruments leave allocation decisions to the market and allow abatement to occur at the least cost. In effect, all economic instruments set a penalty on emissions. This penalty can take the form of, say, carbon dioxide taxes. The tax imposes a cost on emissions, which polluters seek to minimise. By choosing the appropriate level for the carbon dioxide tax, regulators can guide the economy towards a given emission target without having to stipulate the emissions of any particular polluter. If the carbon dioxide tax is the same for all polluters, the conditions of the minimisation problem are the same for all polluters and lead to a cost-effective allocation of emission reductions for a given emission target and for a given technology. Under perfect competition, an efficient allocation can also be attained with auctioned emission permits. With auctioned permits, instead of setting the carbon penalty, the regulator sets directly the overall level of emissions by choosing the amount of permits available. Polluters are then required to buy permits to match their emissions. A polluter then chooses an emission level where the marginal cost of abatement equals the price of the permit. If polluters have equal access to the markets for emission permits, abatement will again be efficiently allocated.

The macroeconomic costs of economic instruments of emission control also depend on the combination of other policy measures. It is well known that environmental taxes exacerbate existing distortions in the tax system, most notably via their effect on real wages and labour supply. The so-called double-dividend literature suggests remedying this problem by lowering taxes on labour income or the indirect costs of labour, such as employers' social security contributions. However, aside from environmental gains, this policy will not be beneficial unless the environmental tax is less distortive than the tax it replaces.

The current study considers emission taxes/auctioned permits in connection with two rebate schemes, where the revenues accruing for the government are rebated by either lowering employers' social security contributions or by lump-sum rebates to the consumer. Our focus is in highlighting the differences between the policies rather than in suggesting a realistic policy.

The study is organised as follows. In the next section, we discuss the Finnish emission target in light of past studies. In section three, we present the simulation model utilised in the current study. Section four presents the policy cases covered in the simulations. Section 5 presents our results at a macroeconomic level, while section 6 reports results in energy production and section 7 in some of the key industries of the Finnish economy. Section 8 concludes.

2 THE FINNISH EMISSION TARGET

Finland has arguably agreed to an ambitious emissions target. Abatement with the current technologies may become very costly for Finland. The estimates vary from a reduction of 3-6 per cent of GDP (Honkatukia 1998) to around one per cent reported in a number of studies (e.g Sulamaa and Pohjola 1995, Honkatukia 1997). The differences in the estimates of abatement costs vary according to the assumptions on technology, and also on the time span of the models. Thus the estimates in Honkatukia (1998) are very high partly because the short-run model explicitly rules out the possibility of investment in nuclear power plants and sets restrictions on the mobility of capital between sectors. (At the same time, the model allows for free mobility of labour but does not evaluate the costs of re-schooling employees that this would necessitate.) But in the long run, when adjustment has taken place, the costs of abatement appear significantly lower according to most – even this - model. However, the time-table agreed to in Kyoto is not a long-run one, and the short-run options are therefore of interest.

Table 1. Long-run costs of abatement

	GDP, %	**Consumption, %**	**Employment, %**	**Tax, FIM/tCO2**
Honkatukia (1997)	-1,2	-0,9	-0,4	500
Honkatukia (1996)	-2,5	-12,7	3,08	-
Pohjola (1997)	-1,4	-4,4	-0,6	583
Sulamaa (1995)	-0,3	-	-	1000

How is Finland to meet her target? While being among the most energy-intensive of OECD-countries, she is also one of the most energy efficient. As she possesses far less means to increase the efficiency of her current production technologies than most other countries (e.g. Lehtilä 1995), increasing energy efficiency necessitates, for the most part, costly investment in new technologies, energy saving, or increases of energy imports from her neighbours. However, most of the new technologies will not be commercialised until well after the Kyoto period. Presently, the options available for Finland are thus energy saving or an increase in energy imports.

The use of natural gas has been increasing steadily during the 1990s, as have imports of electricity. Further increases in imports of either involve considerations of reliability as well as excess capacity in the neighbouring countries. Traditionally, Finland has also been loath to rely solely on imports of energy.

The Finnish energy saving potential has recently been estimated by Lehtilä and Tuhkanen (1999). Their findings indicate that efficiency of electricity and heat consumption can be increased even significantly, albeit with a cost. While energy saving proves to have substantial possibilities in aiding Finland to reach her target, energy saving is also something of a mixed blessing, because it imposes costs that in turn affect prices and thus spread to the other sectors of the economy. The present study utilises the estimates of Lehtilä and Tuhkanen, both in regard to the energysavings potential and the costs of energy saving investments.

While Finland has thus far not conceived an economic policy for abatement, she was among the first countries in the world to introduce carbon dioxide taxes. She is thus likely to include economic instruments as part of her abatement policy. The practical policy appears likely to consist of emission trading and voluntary quotas in key industries and emission taxes in especially consumption sectors. Although Finland has already implemented a green tax reform by increasing emission taxes simultaneously with lowering income taxes, the question of the appropriate policy combination still remains, since abatement policies are likely to require increases in carbon penalties.

While the marginal reduction costs of emissions should equal the carbon penalty under the various instruments, their macroeconomic consequences may be very different. This is due to the fact that all measures affect the aggregate price level as well as the prices of pollutants, thereby distorting markets for other goods and, in particular, the labour market. To prevent these negative effects of abatement policies, this distortion should be alleviated. Emission taxes and auctioned permits generate the revenue for the policy-maker to do this by lowering other distortive taxes. The environmental gains will then be beneficial, if environmental taxes are less distortive than the tax they replace. There are also non-revenue-generating command and control policies that do yield this socially optimal result – e.g. certain environmental subsidies - but these will not be discussed in the current study.

3 THE MODEL

The macroeconomic model is based on Honkatukia (1997). In the model, each sector of the economy is taken to consist of symmetric firms, the number of which corresponds to the Finnish economy in the base year of the model data. These firms use the products of other sectors, capital, and labour as inputs for their production. In each industry, domestic firms compete with imports from the rest of the world. Domestic exports also compete in the world market with exports from other countries.

The use of inputs is modelled on the basis of the input-output structure in the base year, but is assumed to be endogenous to an extent in the simulations. In particular, relative prices affect the use of domestic versus import goods from each industry. This intrasectoral substitutability between domestic and import goods depends on the price elasticity of demand within the sectors consuming these goods. Furthermore, the use of inputs from different sectors is also flexible. There is, in other words, intersectoral substitutability as well as intrasectoral in the model.

The cost shares of goods have been evaluated from the 1990 input-output tables. The elasticities of substitution between domestic and foreign products have been obtained from the GTAP-database.

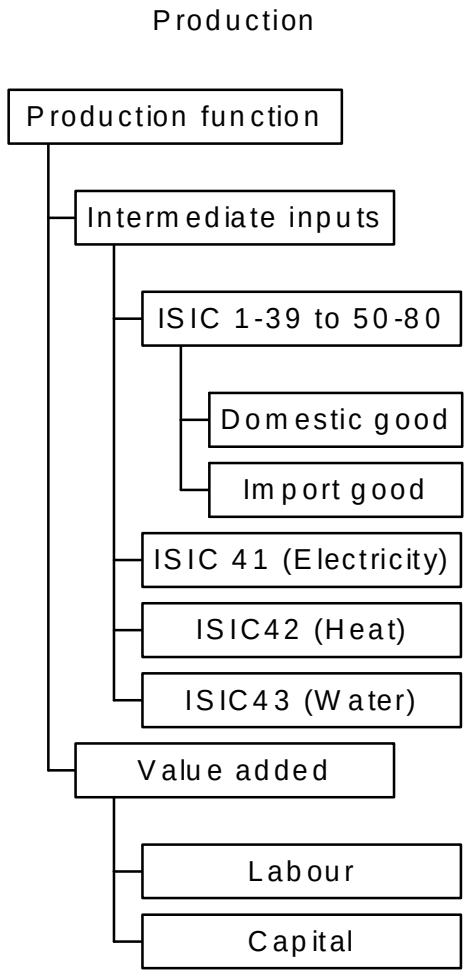
The model comprises the following 31 sectors.

Table 2. Industries

ISIC-code		Industry
ISIC10	Agric	Agriculture, less forestry
ISIC12	Forest	Forestry
ISIC20	Mining	Mining and quarrying, less other mining
ISIC29	Coal	Other mining (Peat, coal)
ISIC31	Food	Food, beverages and tobacco
ISIC32	Textile	Textiles, apparel and leather
ISIC33	Wood	Wood products and furniture
ISIC341	Paper	Paper and paper products
ISIC342	Printing	Printing and publishing
ISIC35	Petrol	Petroleum refineries and products
ISIC353	Chemical	Chemical products less petroleum
ISIC354	Gas	Natural gas
ISIC36	Mineral	Non-metallic mineral products
ISIC37	Metal	Basic metal industry
ISIC381	Machinery	Metal products
ISIC383	Emachinery	Electrical machinery
ISIC384	Tequipment	Transport equipment
ISIC39	Other	Other manufacturing
ISIC41	Electricity	Electric power generation
ISIC40111	Hydro	Hydro-electric power
ISIC40119	Cond	Separate power
ISIC4012	Distri	Electricity and heat distribution
ISIC40114	Nuclear	Nuclear power
ISIC42	Heat	Heat generation
ISIC40112	Sheat	Separate heat
ISIC422	CHP	Combined heat and power
ISIC43	Water	Water supply
ISIC50	Constr	Construction
ISIC71	Transp	Transportation
ISIC80	Service	Private services
ISIC90	Public	Public services

While the structure of the production function is the same in each industry, the elasticities of substitution between different inputs and the cost shares are sector-specific. In general, all industries thus have different technologies. The structure of production is summarised in the following figure.

Figure 1. Production structure



The energy sectors in the model comprise of ISIC12, accounting for wood, ISIC29 (imports of coal and domestic production of peat), ISIC353 (transportation fuels, fuel oils), ISIC354 (natural gas), ISIC41 (electricity) and ISIC42 (heat). Since we allow for substitution between energy as well as other inputs, changes in emission taxes will affect energy prices. On impact, the relative price of inputs is thus affected, and according to substitution possibilities, firms will respond by increasing the use of other inputs. This, in turn, will affect the prices of these inputs, and so both prices and quantities must adjust until a new equilibrium is established. It is notable that this mechanism may also affect the terms of trade, if unilateral abatement is assumed. In this case, Finnish prices generally rise as a consequence of abatement measures, but foreign prices do not, which has a negative effect on price competitiveness.

From the point of view of the social consequences of the Kyoto Protocol the effects on production are not the ultimate concern of the model. Rather, production is seen as the means to generate the national income to finance the consumption of the population. Thus, from a welfare theoretical point of view, policies should be judged by their effects on welfare this consumption generates, rather than on the basis of changes in production.

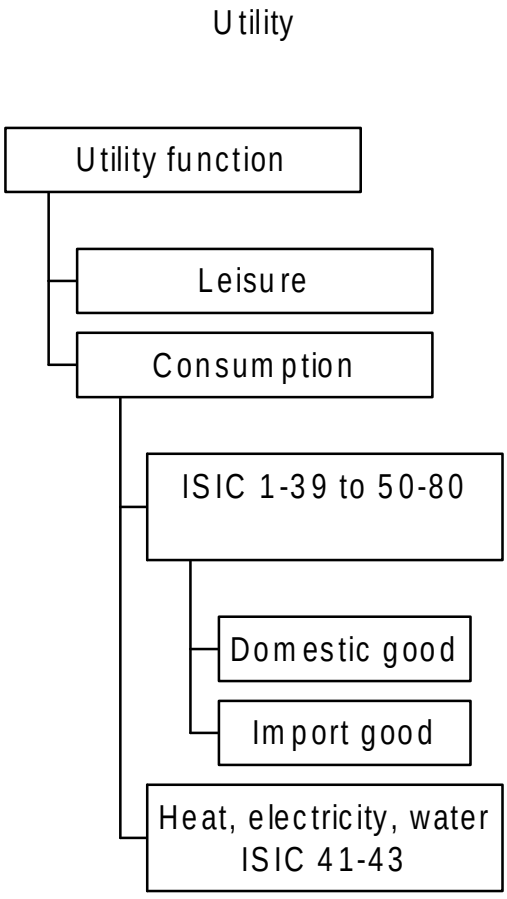
In the model we follow standard microeconomic practice and assume that welfare is described by a utility function. In the main text, we assume that utility stems from both consumption and leisure. This means that she has to make a decision on labour supply. We

assume that the consumer supplies labour in a perfectly competitive labour market. Consequently, there is no unemployment. This assumption is obviously an unrealistic simplification in the short run, but more feasible in terms of a longer term, such as the ten-year transition towards meeting the Kyoto targets. In an appendix, we consider the case of unionized labour markets, where there may be unemployment as well.

Finally, the consumer makes the energysaving-investment decisions in the model, facing exogenous (world) rates of return on investment on capital. The allocation of capital between various industries is governed by the demand for capital stemming from the industries.

The utility function has a similar structure as production. Consumption demand elasticities also stem from GTAP. Other utility function parameters are adopted from the estimates for Finland of Kenc and Perraudin (1996). The structure of the utility function is presented in the figure below.

Figure 2. Utility structure



In calibrating the model, it is assumed that 1990 represented a steady state for the economy. The choice of the base year is partly mandated by the availability of data, partly by a judgement on the representativeness of the data.

4 POLICY CASES

The analyses of the effects of abatement policies are conducted in terms of policy simulations, where policy assumptions are changed one at a time. The results of these simulations are then compared to the base scenario of the model, which gives the business-as-usual solution of the model. The base scenario is not meant to be an accurate prediction, but rather, gives the solution of the model under the underlying assumptions on exogenous variables.

In the base scenario, it is assumed that world demand and real public expenditures grow at an annual rate of two per cent. The structure of public expenditure has been fixed to its 1990 level, as have been public employment and investment. Nominal taxes are also fixed whence any changes in the government finances result in corresponding changes in lump-sum taxes. The current account is assumed fixed at an exogenous level. Thus, in all policy scenarios, domestic prices and income adjust to equate supply and demand. Import prices are also taken to be exogenous. Finally, energy efficiency is assumed to improve autonomously and costlessly by some 5 per cent during the next ten years. The assumptions on sectoral potential for energy efficiency growth are based on Lehtilä and Tuhkanen (1999).

Domestic production adjusts to meet this demand in the most productive way subject to the technological constraints of the economy. Two of these constraints are of particular importance. First, it is assumed that labour force remains stagnant. However, the productivity of labour is assumed to grow at an exogenous rate of two per cent per annum. Secondly, the capital stock is assumed to be endogenous and adjust to a new steady-state level determined by the demand for capital at the exogenous rate of return. Thus, even in the base scenario, capital stock is growing in the model.

In the policy simulations, the basic assumption of the model are left intact, while various abatement policy alternatives are introduced. The model is then solved for the new steady state under the policy in question.

While there are substantial uncertainties regarding the actual base year emission level, due methodologically open issues such as the definition of sinks, and since the emissions due to fossil fuels are known fairly accurately. Here, it will be assumed that 90 per cent of the target must be achieved by reducing carbon dioxide emissions. In the Finnish case, reductions of methane emissions are likely to account for most of the remainder.

The emission target set for Finland under the EU agreement is 1990 levels. Here, we consider considerably higher target levels as well. This serves to illustrate the rising marginal costs of abatement. To an extent, it also indicates how Kyoto mechanims might be of use in achieving the emission target. However, Kyoto mechanisms involve costs which are not accounted for by the current model but which affect some of the results. In particular, the costs of emission rights acquired through Kyoto mechanisms would have an effect on domestic emission taxes and thereby on the rest of the economy as well.

The specific policies studied in the simulations cover the issues raised in section two above. We evaluate the effects of domestic economic measures by assuming that each of them is used to penalise emissions. The domestic instrument considered are carbon dioxide taxes, which can also be viewed as prices for auctioned permits.

We make two important assumptions concerning the instruments. First, we assume that penalties are based on the current structure of emission taxes. This assumption means there are some special alleviations for peat and natural gas. While this assumption may not be

realistic, there is currently no indication that the structure of energy taxes is about to be changed in the near future. Second, we assume that electricity taxes are adjusted by as much as carbon taxes, as has been the case during the past years. The sectoral differentiation of electricity taxes is also assumed to prevail. We assume that the revenue from the carbon penalty/tax is returned to the consumer either in the form of lump-sum transfers or by lowering the employers' social security conditions.

Terms-of-trade effects are evaluated by studying two alternative schemes. In the first, we allow for terms-of-trade changes by assuming that world prices are fixed but Finnish prices adjust. Under this assumption, Finnish exports become dependent on the change in relative prices. This assumption is also made in the base scenario, to which all results are compared (we report only base scenario growth, not changes under the alternative assumption). The assumption corresponds to the case where Finland abates unilaterally. Since unilateral abatement is arguably not very likely, we also consider the case where there are no terms-of-trade changes. In this case, world prices are assumed to change by as much as Finnish prices within each sector. As a consequence, world real demand is assumed to fall in proportion with the price rise. This case most likely exaggerates the effects of abatement on prices in other countries, since in most of them, marginal abatement costs are lower than in Finland. However, there is currently no consensus on the effects of abatement on world prices, let alone sets of estimates at the level of detail necessary for the current study. We conjecture that the effects are likely to fall between the two extreme cases considered here.

Finally, energy saving is considered with the help of energy saving scenarios. We consider an increase of the energy efficiency in the use of electricity and heat by 2.5 to 12.5 per cent, accomplished by investments in new technology. To capture the increased costs of energy due to investment in energy efficiency, yearly marginal costs are assumed to rise from 300 to 500 FIM per ton carbon dioxide (with 50 FIM increments) as a consequence of these increases. Improvements in the efficiency of energy production are not considered, since their scope is very limited during the Kyoto period.

It should be noted that energy saving does not exclude the substitution of energy for other inputs, nor does it rule out substitution between different energy sources. Consequently, changes in energy efficiency do not necessarily lead to one-to-one changes in the consumption of fuels and energy. Instead, they may affect the allocation of energy

Table 3. Simulations

Energy saving	0-12.5 %	
With terms-of-trade-effects		
Emission target 1990-1990+50%		Carbon taxes with lump-sum rebates
		Carbon taxes with social security payment rebates
Without terms-of-trade-effects		
Emission target 1990-1990+50%		Carbon taxes with lump-sum rebates
		Carbon taxes with social security payment rebates

consumption in the economy. This is because energy consumption is endogenous in the current model. In contrast, in many technology-based evaluations of energy saving, total energy demand is fixed, whence increases in energy efficiency automatically lead to reductions in primary energy demand.

The different policy combinations evaluated in the study are summarised in the table below.

5 MACROECONOMIC EFFECTS OF ABATEMENT POLICIES

In this section, we report the effects of abatement policies at the macroeconomic level. The results are given as percentage changes compared to the base scenario of the model. The effects of abatement policies are captured by changes in aggregate emissions and emission taxes. The consequences of these policies are then reported with respect to some key macroeconomic variables.

The welfare effects of abatement policies can be summarised by studying consumption, employment, and the change in welfare. Abatement policies affect consumers via several channels. First, by raising the prices of energy-intensive goods, they affect consumption. Second, by affecting consumer prices they also affect the real wage. This has an affect on the relative price of leisure and consumption, and causes a change in labour supply. Consumers' welfare is then, negatively affected by abatement, if abatement causes the consumption of goods and leisure to decrease. Finally, consumption is also affected by changes in wage income, taxes and transfers, the cost of living, and also by changes in the steady-state capital income. These changes can be most comprehensively summarised by the equivalent variation in income.

The other macroeconomic variables reported include investment, exports, and imports. The aggregate effects of abatement on the economy are then summarised by changes in GDP.

5.1 Effects on emissions

Table 4 reports the reductions of emissions of carbon dioxide in comparison to the base scenario, for different emission targets based on the 1990 level, and for different scenarios of energy saving investments.

In the base scenario, carbon dioxide emissions grow by 47,9 per cent during the next decade (with fixed terms of trade it would grow by 49,2 per cent). Strict compliance to the emission target would necessitate cutting carbon dioxide emissions by 31 per cent from their base scenario level. For comparison, Lehtilä and Tuhkanen (1999) estimate that a reduction of 28 per cent would suffice. Since their estimate takes into account the considerable potential for reducing the emissions of other greenhouse gases, simply basing the estimate on carbon dioxide may overestimate the need for reductions.

Our results indicate that when energy demand is endogenous, energy saving does not suffice to bring about the necessary reductions in emissions. In the current model, changes in energy technology generally lead to changes in energy consumption, which, in the aggregate, may even grow despite new technologies' being introduced. In contrast, Lehtilä

and Tuhkanen assume that a given energy need is satisfied by adjusting technologies and using less primary energy.

5.2 Emission taxes

Table 5 reports the emission taxes connected to each emission target and energy saving scenario. If the 1990 level were to be attained by reducing emissions of carbon dioxide only, very high taxes would be needed. Energy saving increases the necessary level of taxes in most cases. Since it is already causing increases in energy costs, further discouragement of energy use requires even larger price signals.

For comparison, Lehtilä and Tuhkanen (1999) estimate that the carbon tax should be set at 230 FIM per tonne carbon dioxide to meet the target. Thus, the macroeconomic model predicts a higher level of taxes. It is notable, however, that the model takes into account the spillovers between sectors, which technology-oriented models neglect. In contrast, technology does have an effect here, but since new technologies are here introduced at an exogenous rate, the model cannot capture the emergence of an optimal technology structure. Moreover, Lehtilä and Tuhkanen consider a uniform carbon dioxide tax, whereas the current model assumes considerable differences between sectors according to current practice.

The taxes are higher under multilateral abatement than under unilateral abatement for moderate emission targets. The reason for this is that emission taxes make domestic exports relatively more expensive under unilateral abatement. This effect amplifies the reduction of domestic activity that is necessary for cutting emissions. For stricter emission targets, however, multilateral abatement yields lower taxes under lump-sum rebates but not under social security rebates.

5.3 Effects on consumption

The effects of abatement on private consumption are reported in table 6. In the base scenario, consumption grows by 18,3 per cent by the year 2010 (and would grow by 20 per cent if terms of trade were fixed in the base scenario). Under the abatement scenarios, consumption clearly cannot attain such growth under unilateral abatement. The effects are very different under multilateral abatement, where only strict adherence to the emission commitment causes consumption to fall with respect to the base scenario.

The effects of both policy measures and energy saving emerge clearly from the results in table 6. The strictest target is the most costly in terms of consumption. The “green tax reform” scenario, where carbon tax revenue is used to correct the distortion in the labour market, is less costly than lump-sum rebates in terms of consumption foregone. Energy saving, on the other hand, affects consumption negatively under unilateral abatement but can have positive effects under multilateral abatement.

5.4 Effects on employment

Table 7 gives the effects on employment. Carbon taxes have a negative effect on employment unless combined with a corrective use of revenue, such as the social security contribution rebate here. The increase in employment is higher the stricter the emissions target. Under unilateral abatement employment effects are slightly higher than under

multilateral abatement. The reason for this is that terms-of-trade increase the gain obtained from social security rebates, since they increase the positive effect of rebates on industries by increasing their price competitiveness.

5.5 Effects on welfare

Table 8 gives the combined effect of consumption and leisure. This effect consists of the consumption of goods and leisure. In the base scenario, welfare would increase by 19,2 per cent (20.5 per cent without terms-of-trade effects). Under abatement, this level would not be achieved under the strictest targets. Lump-sum rebates yield lower losses of utility, at least in terms of the equivalent variation in income. It is notable, however, that these results contain no information about the environmental gains.

The equivalent variation can be interpreted as the amount of income consumers would be willing to lose at the outset in order not to have to adjust. In other words, it gives the loss in income that policies would correspond to. The results indicate that welfare is negatively affected at the strict restriction levels Finland is committed to. For lower emission targets, however, there may be welfare gains. There is even indication of double dividends. But since the results indicate a welfare loss for the current emission targets when excluding environmental gains, these targets can only be motivated on environmental grounds, not on economical.

Energy saving decreases welfare under unilateral abatement and may even double the welfare losses of abatement. This effect can be interpreted as being due to loss in purchasing power caused by the price increases caused by more expensive energy technologies that energy saving necessitates. On the other hand, under multilateral abatement there are welfare gains, suggesting that income has an effect as well.

The results also stem from the effects of employment on leisure and thus on utility. Would the results be similar if labour markets were not competitive? An appendix addresses this question with a model, where employment is determined by a wage-setting monopoly union, and where it does not affect the consumer's utility. The results seem to suggest that under imperfect competition in the labour markets, the rebate scheme may play a more important role, if the social security system is only partially indexed. Under a fully indexed social security system, unionist labour supply would not respond to the rebate scheme at all and thus a "green tax reform" would not be of consequence.

5.6 Effects on consumer prices

Table 9 reports the effects of abatement on consumer prices. The base scenario increase in consumer prices is 2,4 per cent (2.0 without term-of-trade effects). Consumer prices rise as a consequence of abatement. Thus, for a given income, the purchasing power of consumers is negatively affected. Energy saving tends to raise consumer prices somewhat, since it increases the marginal costs of production. Terms-of-trade effects, in turn, increase the price effects.

5.7 Effects on nominal wages

Table 10 gives the changes in nominal wages. Under lump-sum rebates, wages fall as a consequence of the changed demand for labour. Under the social security rebate, however,

both employment and nominal wages increase. This is due to the decrease in indirect labour costs financed with the carbon tax revenue. However, real wages mostly fall even under this scheme, since the rise in consumer prices exceed the increase in nominal wages. Terms-of-trade effects decrease the wage effects.

Energy saving has a larger effect on wages than on consumer prices. Thus, the increase in relative input prices due to both carbon taxes and energy saving investments affects the labour markets and causes a decrease in wages. In other words, the larger the direct abatement costs for firms, the more adjustment there has to be in the labour markets to minimise the consequent costs.

5.8 Effects on investment

Table 11 gives the effects of abatement on investment. In the base scenario, the capital stock – and thus steady state investment – would grow by 16,4 per cent (18,5 per cent if neglecting terms-of-trade effects). Thus, while abatement reduces investment by several percentage points from this level, there is still substantial growth. This is due to our assumptions about productivity growth as well as growth in export demand.

It is notable that the abatement schemes have an effect on investment. The social security rebate has the smaller effects on investment, whereas energy saving and terms-of-trade effects magnify the effects on investment. This is not surprising, since we assume that the return on capital is fixed to an internationally given level. Note, however, that investment in energy saving affects investments elsewhere in the economy. This is partly due to the effect on marginal cost due to energy saving, but also to the fact that energy saving increases productivity and thus necessitating less capital. The effects of energy saving are thus partly utilised in terms of lower capital stocks, not in terms of less energy consumption.

5.9 Effects on exports

Export effects are reported in table 12. Export growth in the base scenario would be 24,4 per cent (17,2 neglecting terms-of-trade effects). Exports are reduced under all schemes. This is simply due to increases in export prices due to the costs of abatement. Again, however, abatement schemes have an effect. It is notable that the social security rebate yields lower losses than lump-sum rebate. Energy saving increases marginal costs and thus has negative effects on price competitiveness. Terms of trade make a small difference when reductions are not combined with energy saving and a larger one in connection with energy saving.

5.10 Effects on imports

Table 13 gives the changes in imports. Imports increase by 23,9 per cent in the base run with terms-of-trade effects and by 17,6 per cent without them. It can be seen that imports are also reduced under all schemes. This is due to our requirement that foreign debt cannot change. Thus, when exports decrease, so must imports, but not necessarily by as much, since terms-for-trade may have changed. For this reason, the results mirror the those on exports. If we allowed for changes in foreign debt, the effects would not be quite as large,

at least for the Kyoto period. In the long run, however, the trade deficit would have to be such as to support Finnish foreign debt. In other words, if abatement decreases incomes, then consumption would eventually have to follow suit.

5.11 Effects on GDP

The effects on GDP are reported in table 14. In the base scenario, GDP would grow by 19,8 per cent (20,9 per cent neglecting terms-of-trade effects), or at an annual rate of 1,8 per cent. Abatement causes a reduction in growth under the strictest emission targets in all schemes. GDP decreases least under social security rebate. Energy saving increases the loss, as do terms-of-trade effects.

6 EFFECTS ON ENERGY SECTORS

In this section, we report the results for energy production and power generation.

6.1 Peat production

In table 15, we report the effects on peat production. Peat production grows by 25,7 per cent in the base scenario, and while abatement causes a large decrease in all schemes with terms-of-trade effects, the level of peat production grows significantly from the current level in most of them. Underlying this result is our assumption that emission taxes retain their current structure, where the tax on peat is only a sixth of the tax on coal and fuel oils. If there are no terms-of-trade effects, production of peat actually grows, since by assumption its relative price with its closest import competitor, coal, is not affected by domestic measures in this case.

6.2 Oil refining

Table 16 gives the changes in oil refining. In the business-as-usual scenario, this sector would grow by 69,4 per cent (71,9 per cent neglecting terms-of-trade effects). Thus, the halving of its production would cause a reduction even in comparison to starting levels if emission targets were to be met by reductions of carbon dioxide only. However, under the milder targets for carbon dioxide, the decreases are smaller and imply a stagnant development for this sector.

Oil refining is reduced least under the lump-sum rebate scheme. Energy saving increases the negative effects under all schemes, but only slightly. Thus in this sector as well energy saving in other sectors appears to facilitate a greater consumption of the products of oil refining, for example fuel oils.

6.3 Electricity generation and imports of electricity

Table 18 gives the results for electric power generation and imports of electricity.

This coincides with the consumption of electric power, and in the base scenario would grow by nearly 59,4 per cent (59,3 per cent neglecting terms-of-trade effects). Compared to current consumption, there is thus significant growth under all abatement schemes. The reduction necessary to meet the emission target is smallest under lump-sum rebates and multilateral abatement. Energy saving actually causes – at least initially - smaller reductions in electricity generation and imports, because it is precisely the efficiency of electricity consumption that it is being increased. The increased efficiency makes electricity more attractive, even though electricity taxes are raised.

6.4 Heat generation

In table 19, heat generation is reported. Heat generation grows by 12,1 per cent per (12,7 cent neglecting terms-of-trade effects) in the BAU-scenario, and thus the strictest target would necessitate reducing heat generation slightly. Here, the lump-sum rebate causes the largest impacts. Energy saving magnifies the reduction in heat generation, whereas terms of trade have an effect via the rest of the economy, even though heat has no foreign competitors.

7 EFFECTS ON SOME INDUSTRIES

In this section, we give results for the key export industries as well as for the domestic sectors most affected by abatement policies.

7.1 Paper and pulp industries

While in recent years exports have grown faster in other industries, paper and pulp industries are still among the three largest industries. Moreover, some 90 per cent of their production is exported, making then invaluable for the Finnish economy.

In table 20 paper and pulp production is reported. In the BAU-scenario, this industry grows by 24,5 per cent by 2010 (22,8 per cent neglecting terms-of-trade effects). Social security rebates would necessitate smaller cuts in emissions than the lump-sum rebate.

Energy saving increases the reduction of production. This is due to the cost increases it imposes on the industry, which deteriorate its price competitiveness in the export markets. Under unilateral abatement, paper and pulp industries are not nearly as badly affected, although even then strict emission targets necessitate cuts in production compared to the base scenario.

7.2 Basic metal industries

In table 21 we report the effects on basic metal industries. In the base scenario, this industry grows by 28,7 per cent (23,1 per cent without terms-of-trade effects). Thus it would face severe cuts in production under unilateral abatement. The cuts would be much smaller under multilateral abatement, but reductions would still be necessary. Lump-sum rebates would be slightly more costly for this industry. Energy saving also has slightly

negative results under unilateral abatement in this industry as well, the reason being its effects on price competitiveness.

7.3 Electronics industries

In table 22, the effects on electronics industry are reported. This industry grows by 26,1 (22,1 per cent neglecting terms-of-trade effects) per cent in the base scenario, and abatement increases its growth under unilateral abatement. This is due to its low energy-intensity. Thus it benefits from the fall of real wages more than increased carbon taxes harm it. Gains are highest under social security rebates. Energy saving increases growth in this sector slightly. Interestingly, under multilateral abatement, the edge in price competitiveness disappears. This reflects the assumption of similar price changes in domestic as well as world prices, but highlights the fact that multilateral abatement could cause not only positive effects on price competitiveness but also negative. Electronics industries would only benefit if emission tax revenues were rebated via cutting social security contributions.

7.4 Transportation and communications

In table 23, we give the results for the transport sector. In the base scenario, the sector grows by 21,5 per cent (21,5 also per cent neglecting terms-of-trade effects). Under abatement, this sector would thus not decrease from its present level and would even grow somewhat. As energysaving appears to increase traffic slightly this sector benefits from energy saving elsewhere in the economy, since energy saving leaves room for this sector to utilise the fossil fuels not needed in other sectors. In other words, under a binding national emission target, increased emissions from one sector have to be made good by reductions in other sectors. The social security rebate is most beneficial for transports, whereas terms of trade have fairly small effects.

7.5 Retailing and private services

Table 24 contains the results for retailing private services. In the base scenario, these sectors would grow by 18,3 per cent (22,4 per cent neglecting terms-of-trade effects). Under abatement, their growth would be in most cases be enhanced. As in the case of electronics industry, this is due to the negative effect on real wages abatement has. The effect is only exacerbated by social security rebates. Thus, provided labour is fully mobile between sectors, abatement has a positive effect on the relatively sheltered sectors of the economy. Terms-of-trade effects favour this sector, because they shift demand from imports to domestic sectors and from consumption to services.

8 CONCLUSIONS

Under the Kyoto Protocol and the EU agreement on abatement, Finland must restrict her emissions to 1990 levels. Most recent projections predict that by 2008 the required reduction could be closer to 30 per cent. Abatement is thus likely to have significant

economic consequences, especially in view of the fact that Finnish energy technology is already very efficient. In this study, we have evaluated the effects of energysaving and economic measures on the costs of abatement, under both unilateral and multilateral abatement.

Although Finnish energy technologies are very efficient, it has been estimated that significant improvements can be made in the efficiency of Finnish energy technology. The primary finding of this study is that improvements in energy efficiency have repercussions that in general increase the macroeconomic costs of abatement. This is due to the loss in competitiveness investments in energy efficiency cause by increasing export prices, and to the negative effect on labour supply due to increases in domestic consumer prices. Moreover, we find that energy saving via increased energy efficiency in a particular sector of the economy does not imply energy saving on the aggregate, when the country faces binding emission constraints. Rather, energy saving enables consumption of energy to be kept up in energy intensive sectors, such as transports, where it would otherwise have to be cut more drastically. In this respect, our results differ markedly from results obtained with technology-oriented models. Here, aggregate energy demand is endogenous, whence increases in efficiency do not necessarily lead to an overall decrease in energy use, whereas in technology-oriented models, aggregate energy demand is often exogenous whereby energy efficiency improvements lead to decreased demand of primary energy. Finally, increases in energy efficiency can necessitate higher carbon penalties for a given emission target. The reason for this is that further emission reductions are more costly for energy efficient technologies than for technologies that are less so.

We also find that different economic measures yield different macroeconomic outcomes.This reflects the well known result that economic instruments for achieving emission targets impose extra burdens on the economy. Here, we find that the way emission tax revenue is rebated does matter. For the strictest emission targets, which correspond to the Finnish commitment at Kyoto, we find that lump-sum rebates yield lower losses than employers' social security contribution rebate. Thus, there are no double dividends. However, the social security rebates yield lower reductions in GNP and consumption, as well as larger increases in employment. For smaller reductions, however, we find that even double dividends could be possible. However, these lower reductions are not likely to materialise unless widespread use of the Kyoto mechanisms is introduced. The current model does not consider the costs of Kyoto mechanisms and some of the results change if these costs are included.

The negative impacts on welfare are largely due to a decrease in leisure. Whether this effect fully reflects the situation in Finland is open to debate. It is arguable that increases in employment might very well be beneficial, given the high level of unemployment. However, a more realistic model of the labour market must also take into account the effect of imperfect competition in the labour markets. We nevertheless find that the effects of abatement on GNP are larger under imperfect competition in the labour markets than they are under perfect competition, while the opposite is true for effects on consumption. The effects on employment may be larger or smaller in unionist labour markets, but, more to the point, they appear to be more sensitive to the rebate scheme than in perfectly competitive labour markets. Our results therefore suggest that given rigidities in the labour market, the choice of economic instruments for abatement should be carefully considered.

The study also considered the effects of abatement by other countries on the costs of abatement in Finland. Unilateral abatement was modelled under the assumption that domestic prices adjust to changes in domestic policies but world prices do not. Since

export demand is price elastic, domestic price competitiveness is harmed by unilateral abatement. While this effect causes losses in exports, however, it also magnifies the effectiveness of carbon penalties in reducing emissions by cutting the production of energy-intensive exports. Consequently, we find that higher carbon penalties can be necessary if world price changes reflect domestic price changes exactly, as we assume to be the case. We also find that energy saving is attractive under multilateral abatement. This finding stems from our assumption that world prices reflect domestic price changes. Nevertheless, under moderate emission targets multilateral abatement yields double dividends for Finland, although GDP is harmed even in this case. However, the design of domestic policies has as large an effect on the costs of abatement as the actions of others.

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Table 4. Emissions

Energy saving	0.0	2.5	5.0	7.5	10.0	12.5
With terms-of-trade -effects, lump-sum rebates						
No target	0.0	0.0	0.0	0.0	0.0	0.0
1990+40%	-3.4	-3.4	-3.4	-3.4	-3.4	-3.4
1990+30%	-10.3	-10.3	-10.3	-10.3	-10.3	-10.3
1990+20%	-17.2	-17.2	-17.2	-17.2	-17.2	-17.2
1990+10%	-24.1	-24.1	-24.1	-24.1	-24.1	-24.1
1990	-31.0	-31.0	-31.0	-31.0	-31.0	-31.0
With terms-of-trade -effects, social security payment rebates						
1990+40%	-3.4	-3.4	-3.4	-3.4	-3.4	-3.4
1990+30%	-10.3	-10.3	-10.3	-10.3	-10.3	-10.3
1990+20%	-17.2	-17.2	-17.2	-17.2	-17.2	-17.2
1990+10%	-24.1	-24.1	-24.1	-24.1	-24.1	-24.1
1990	-31.0	-31.0	-31.0	-31.0	-31.0	-31.0
Without terms-of-trade -effects, lump-sum rebates						
No target	0.0	0.0	0.0	0.0	0.0	0.0
1990+40%	-3.4	-3.4	-3.4	-3.4	-3.4	-3.4
1990+30%	-10.3	-10.3	-10.3	-10.3	-10.3	-10.3
1990+20%	-17.2	-17.2	-17.2	-17.2	-17.2	-17.2
1990+10%	-24.1	-24.1	-24.1	-24.1	-24.1	-24.1
1990	-31.0	-31.0	-31.0	-31.0	-31.0	-31.0
Without terms-of-trade -effects, social security payment rebates						
1990+40%	-3.4	-3.4	-3.4	-3.4	-3.4	-3.4
1990+30%	-10.3	-10.3	-10.3	-10.3	-10.3	-10.3
1990+20%	-17.2	-17.2	-17.2	-17.2	-17.2	-17.2
1990+10%	-24.1	-24.1	-24.1	-24.1	-24.1	-24.1
1990	-31.0	-31.0	-31.0	-31.0	-31.0	-31.0

Table 5. Carbon dioxide tax, FIM

Energy saving	0.0	2.5	5.0	7.5	10.0	12.5
With terms-of-trade -effects, lump-sum rebates						
No target	82	82	82	82	82	82
1990+40%	156	174	195	219	248	281
1990+30%	345	367	393	421	460	520
1990+20%	423	441	465	497	548	615
1990+10%	444	462	484	514	559	601
1990	513	540	576	574	571	567
With terms-of-trade -effects, social security payment rebates						
1990+40%	162	183	206	234	266	304
1990+30%	373	400	426	466	532	632
1990+20%	415	429	451	479	520	618
1990+10%	434	451	472	498	533	597
1990	513	585	583	581	578	574
Without terms-of-trade -effects, lump-sum rebates						
No target	82	82	82	82	82	82
1990+40%	164	181	199	221	246	281
1990+30%	340	360	384	410	441	472
1990+20%	398	410	423	435	449	463
1990+10%	405	418	432	446	462	479
1990	419	430	442	455	471	491
Without terms-of-trade -effects, social security payment rebates						
1990+40%	171	190	211	239	280	327
1990+30%	367	391	419	450	476	482
1990+20%	498	503	508	513	520	528
1990+10%	531	553	562	569	578	588
1990	544	564	585	608	615	613

Table 6. Consumption

Energy saving	0.0	2.5	5.0	7.5	10.0	12.5
With terms-of-trade -effects, lump-sum rebates						
No target	0.0	-0.2	-0.3	-0.6	-0.9	-1.3
1990+40%	-0.1	-0.3	-0.5	-0.7	-1.0	-1.3
1990+30%	-0.6	-0.8	-0.9	-1.2	-1.6	-2.1
1990+20%	-1.1	-1.2	-1.4	-1.7	-2.1	-2.6
1990+10%	-1.5	-1.7	-1.9	-2.2	-2.6	-3.0
1990	-2.7	-3.0	-3.4	-4.0	-4.8	-5.4
With terms-of-trade -effects, social security payment rebates						
1990+40%	0.2	0.1	0.0	-0.1	-0.3	-0.5
1990+30%	0.3	0.2	0.1	-0.1	-0.3	-0.6
1990+20%	0.0	-0.1	-0.2	-0.4	-0.6	-0.9
1990+10%	-0.6	-0.7	-0.8	-1.0	-1.3	-1.6
1990	-1.9	-2.2	-2.8	-3.4	-4.2	-4.9
Without terms-of-trade -effects, lump-sum rebates						
No target	2.6	2.5	2.3	2.1	1.8	1.4
1990+40%	3.0	3.1	3.2	3.3	3.4	3.5
1990+30%	3.1	3.3	3.4	3.6	3.7	3.8
1990+20%	1.8	1.8	1.9	2.0	2.0	2.0
1990+10%	0.0	0.1	0.1	0.2	0.2	0.3
1990	-2.5	-2.4	-2.3	-2.3	-2.4	-2.6
Without terms-of-trade -effects, social security payment rebates						
1990+40%	3.4	3.5	3.7	3.9	4.2	4.5
1990+30%	4.2	4.4	4.7	5.0	5.2	5.3
1990+20%	3.5	3.6	3.7	3.8	3.9	3.9
1990+10%	1.7	1.9	2.1	2.2	2.4	2.5
1990	-0.9	-0.6	-0.3	-0.1	-0.1	-0.2

Table 7. Employment

Energy saving	0.0	2.5	5.0	7.5	10.0	12.5
With terms-of-trade -effects, lump-sum rebates						
No target	0.0	0.1	0.1	0.2	0.3	0.5
1990+40%	-0.3	-0.4	-0.5	-0.6	-0.7	-0.8
1990+30%	-1.0	-1.1	-1.3	-1.4	-1.5	-1.8
1990+20%	-0.9	-1.0	-1.1	-1.2	-1.4	-1.6
1990+10%	-0.5	-0.5	-0.6	-0.7	-0.8	-0.9
1990	0.0	-0.1	-0.1	-0.1	0.1	0.4
With terms-of-trade -effects, social security payment rebates						
1990+40%	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2
1990+30%	-0.3	-0.3	-0.3	-0.3	-0.3	-0.4
1990+20%	0.1	0.1	0.1	0.1	0.1	0.1
1990+10%	0.5	0.5	0.5	0.6	0.6	0.6
1990	1.0	1.1	1.1	1.2	1.4	1.6
Without terms-of-trade -effects, lump-sum rebates						
No target	-0.2	-0.2	-0.1	0.0	0.1	0.2
1990+40%	-0.6	-0.7	-0.8	-0.9	-1.1	-1.3
1990+30%	-1.3	-1.4	-1.6	-1.7	-1.9	-2.1
1990+20%	-1.1	-1.1	-1.2	-1.3	-1.3	-1.4
1990+10%	-0.5	-0.5	-0.6	-0.7	-0.8	-0.9
1990	0.3	0.3	0.2	0.1	0.1	0.0
Without terms-of-trade -effects, social security payment rebates						
1990+40%	-0.4	-0.4	-0.5	-0.5	-0.6	-0.7
1990+30%	-0.6	-0.7	-0.8	-0.8	-0.9	-0.9
1990+20%	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5
1990+10%	0.1	0.0	0.0	0.0	0.0	-0.1
1990	0.8	0.8	0.7	0.6	0.6	0.7

Table 8. Equivalent variation

Energy saving	0.0	2.5	5.0	7.5	10.0	12.5
With terms-of-trade -effects, lump-sum rebates						
No target	0.0	-0.1	-0.3	-0.5	-0.8	-1.1
1990+40%	0.2	0.1	0.1	0.0	-0.1	-0.2
1990+30%	0.4	0.4	0.3	0.3	0.1	0.0
1990+20%	0.0	0.0	-0.1	-0.2	-0.3	-0.5
1990+10%	-0.6	-0.7	-0.7	-0.9	-1.0	-1.2
1990	-1.7	-1.8	-2.0	-2.4	-3.0	-3.6
With terms-of-trade -effects, social security payment rebates						
1990+40%	0.2	0.1	0.1	0.0	-0.1	-0.2
1990+30%	0.4	0.4	0.3	0.2	0.1	-0.1
1990+20%	-0.1	-0.1	-0.2	-0.3	-0.5	-0.6
1990+10%	-0.7	-0.8	-0.9	-1.0	-1.2	-1.4
1990	-1.9	-2.1	-2.5	-3.0	-3.6	-4.2
Without terms-of-trade -effects, lump-sum rebates						
No target	1.7	1.6	1.5	1.3	1.0	0.8
1990+40%	2.3	2.4	2.5	2.7	2.9	3.1
1990+30%	2.9	3.1	3.2	3.5	3.7	3.9
1990+20%	1.8	1.9	2.0	2.1	2.2	2.3
1990+10%	0.3	0.4	0.5	0.6	0.7	0.8
1990	-1.8	-1.7	-1.6	-1.5	-1.5	-1.6
Without terms-of-trade -effects, social security payment rebates						
1990+40%	2.3	2.4	2.6	2.7	2.9	3.2
1990+30%	3.0	3.1	3.4	3.6	3.8	3.8
1990+20%	2.5	2.5	2.6	2.6	2.7	2.7
1990+10%	1.0	1.1	1.3	1.4	1.5	1.5
1990	-1.1	-0.9	-0.7	-0.5	-0.5	-0.6

Table 9. Consumer prices

Energy saving	0.0	2.5	5.0	7.5	10.0	12.5
With terms-of-trade -effects, lump-sum rebates						
No target	0.0	0.0	0.1	0.1	0.1	0.1
1990+40%	0.5	0.7	0.9	1.2	1.6	2.0
1990+30%	1.6	1.9	2.2	2.5	2.9	3.6
1990+20%	1.5	1.7	1.9	2.2	2.7	3.4
1990+10%	0.9	1.0	1.2	1.5	1.9	2.3
1990	0.7	0.9	1.2	1.3	1.4	1.1
With terms-of-trade -effects, social security payment rebates						
1990+40%	0.5	0.7	1.0	1.3	1.7	2.2
1990+30%	1.8	2.0	2.3	2.7	3.3	4.2
1990+20%	1.3	1.4	1.6	1.9	2.3	3.1
1990+10%	0.7	0.8	1.0	1.3	1.6	2.1
1990	0.6	1.0	1.1	1.3	1.2	1.0
Without terms-of-trade -effects, lump-sum rebates						
No target	-0.8	-0.7	-0.7	-0.7	-0.7	-0.6
1990+40%	-0.3	-0.1	0.1	0.4	0.6	1.0
1990+30%	0.8	1.0	1.3	1.5	1.9	2.2
1990+20%	0.8	0.9	1.1	1.2	1.4	1.6
1990+10%	0.4	0.6	0.7	0.9	1.1	1.3
1990	0.1	0.2	0.4	0.5	0.7	1.0
Without terms-of-trade -effects, social security payment rebates						
1990+40%	-0.2	0.0	0.2	0.4	0.8	1.2
1990+30%	0.9	1.1	1.3	1.6	1.9	2.0
1990+20%	1.4	1.4	1.5	1.6	1.7	1.9
1990+10%	1.1	1.3	1.4	1.5	1.7	1.9
1990	0.7	0.9	1.1	1.3	1.5	1.6

Table 10. Nominal wages

Energy saving	0.0	2.5	5.0	7.5	10.0	12.5
With terms-of-trade -effects, lump-sum rebates						
No target	0.0	-0.1	-0.2	-0.3	-0.5	-0.8
1990+40%	-0.9	-1.3	-1.6	-2.1	-2.7	-3.5
1990+30%	-3.2	-3.6	-4.0	-4.5	-5.3	-6.5
1990+20%	-3.8	-4.1	-4.6	-5.1	-6.0	-7.2
1990+10%	-3.7	-4.0	-4.4	-5.0	-5.8	-6.6
1990	-4.7	-5.1	-5.7	-6.6	-7.5	-8.0
With terms-of-trade -effects, social security payment rebates						
1990+40%	0.5	0.5	0.6	0.6	0.6	0.7
1990+30%	1.3	1.4	1.5	1.5	1.6	1.7
1990+20%	1.5	1.5	1.5	1.5	1.5	1.6
1990+10%	1.4	1.4	1.4	1.4	1.3	1.2
1990	0.6	0.5	-0.1	-0.9	-1.8	-2.7
Without terms-of-trade -effects, lump-sum rebates						
No target	3.5	3.4	3.3	3.2	3.0	2.7
1990+40%	3.3	3.4	3.4	3.3	3.3	3.2
1990+30%	2.1	2.2	2.2	2.2	2.1	2.0
1990+20%	0.4	0.5	0.5	0.5	0.5	0.5
1990+10%	-1.2	-1.2	-1.2	-1.2	-1.2	-1.3
1990	-3.6	-3.5	-3.5	-3.5	-3.7	-3.9
Without terms-of-trade -effects, social security payment rebates						
1990+40%	4.9	5.3	5.7	6.2	6.7	7.4
1990+30%	6.7	7.2	7.7	8.4	8.9	9.2
1990+20%	6.6	6.9	7.1	7.4	7.6	7.9
1990+10%	4.7	5.2	5.5	5.9	6.2	6.6
1990	2.0	2.5	3.0	3.5	3.7	3.8

Table 11. Investment

Energy saving	0.0	2.5	5.0	7.5	10.0	12.5
With terms-of-trade -effects, lump-sum rebates						
No target	0.0	0.0	0.0	0.0	0.0	-0.1
1990+40%	-1.5	-1.9	-2.5	-3.1	-3.9	-4.9
1990+30%	-5.2	-5.7	-6.2	-6.8	-7.9	-9.5
1990+20%	-5.6	-6.0	-6.6	-7.3	-8.5	-10.0
1990+10%	-5.0	-5.4	-5.9	-6.5	-7.5	-8.5
1990	-5.5	-6.0	-6.7	-7.4	-8.2	-8.5
With terms-of-trade -effects, social security payment rebates						
1990+40%	-1.4	-1.9	-2.4	-3.0	-3.8	-4.8
1990+30%	-5.0	-5.5	-5.9	-6.8	-8.3	-10.3
1990+20%	-4.6	-4.9	-5.3	-5.9	-6.8	-8.7
1990+10%	-4.0	-4.3	-4.7	-5.3	-6.0	-7.3
1990	-4.8	-5.8	-6.5	-7.4	-8.0	-8.4
Without terms-of-trade -effects, lump-sum rebates						
No target	4.9	4.9	4.9	4.9	4.8	4.7
1990+40%	4.3	4.2	4.0	3.9	3.6	3.2
1990+30%	1.7	1.6	1.4	1.2	0.9	0.6
1990+20%	0.1	0.1	0.0	-0.1	-0.1	-0.3
1990+10%	-1.0	-1.1	-1.1	-1.2	-1.4	-1.5
1990	-2.7	-2.8	-2.8	-2.9	-3.1	-3.4
Without terms-of-trade -effects, social security payment rebates						
1990+40%	4.4	4.3	4.2	4.0	3.6	3.1
1990+30%	2.0	1.9	1.8	1.6	1.5	1.5
1990+20%	0.0	0.1	0.1	0.2	0.2	0.2
1990+10%	-1.5	-1.5	-1.5	-1.4	-1.4	-1.4
1990	-3.1	-3.1	-3.2	-3.2	-3.3	-3.3

Table 12. Exports

Energy saving	0.0	2.5	5.0	7.5	10.0	12.5
With terms-of-trade -effects, lump-sum rebates						
No target	0.0	0.0	0.0	0.0	-0.1	-0.2
1990+40%	-1.1	-1.3	-1.5	-1.7	-2.0	-2.3
1990+30%	-3.6	-3.7	-3.9	-4.0	-4.3	-4.7
1990+20%	-4.9	-5.0	-5.1	-5.3	-5.6	-6.1
1990+10%	-5.7	-5.8	-5.9	-6.0	-6.3	-6.6
1990	-6.6	-6.7	-6.8	-6.9	-7.0	-7.2
With terms-of-trade -effects, social security payment rebates						
1990+40%	-1.0	-1.1	-1.2	-1.4	-1.6	-1.9
1990+30%	-3.1	-3.2	-3.3	-3.4	-3.6	-4.0
1990+20%	-4.2	-4.2	-4.2	-4.3	-4.5	-4.9
1990+10%	-5.0	-5.0	-5.0	-5.1	-5.2	-5.5
1990	-5.9	-6.1	-6.1	-6.1	-6.3	-6.5
Without terms-of-trade -effects, lump-sum rebates						
No target	-3.5	-3.6	-3.6	-3.7	-3.8	-3.9
1990+40%	-4.1	-4.3	-4.4	-4.7	-4.9	-5.3
1990+30%	-4.8	-5.0	-5.2	-5.5	-5.8	-6.1
1990+20%	-4.9	-5.0	-5.2	-5.3	-5.5	-5.8
1990+10%	-4.7	-4.8	-5.0	-5.1	-5.4	-5.6
1990	-4.5	-4.6	-4.7	-4.9	-5.1	-5.3
Without terms-of-trade -effects, social security payment rebates						
1990+40%	-4.1	-4.3	-4.5	-4.7	-5.1	-5.5
1990+30%	-4.9	-5.1	-5.3	-5.6	-5.9	-6.1
1990+20%	-5.3	-5.4	-5.5	-5.6	-5.8	-6.0
1990+10%	-5.2	-5.4	-5.5	-5.6	-5.8	-6.0
1990	-5.0	-5.2	-5.3	-5.5	-5.7	-5.8

Table 13. Imports

Energy saving	0.0	2.5	5.0	7.5	10.0	12.5
With terms-of-trade -effects, lump-sum rebates						
No target	0.0	0.0	0.0	0.0	0.0	-0.1
1990+40%	-0.8	-0.9	-1.1	-1.2	-1.4	-1.7
1990+30%	-2.7	-2.8	-2.9	-3.0	-3.1	-3.4
1990+20%	-3.7	-3.7	-3.8	-3.9	-4.2	-4.5
1990+10%	-4.4	-4.4	-4.5	-4.6	-4.8	-5.0
1990	-5.2	-5.2	-5.3	-5.4	-5.6	-5.7
With terms-of-trade -effects, social security payment rebates						
1990+40%	-0.7	-0.8	-0.9	-1.0	-1.1	-1.3
1990+30%	-2.3	-2.3	-2.4	-2.4	-2.6	-2.9
1990+20%	-3.1	-3.1	-3.1	-3.2	-3.3	-3.6
1990+10%	-3.8	-3.8	-3.8	-3.9	-3.9	-4.1
1990	-4.5	-4.6	-4.8	-4.9	-5.0	-5.2
Without terms-of-trade -effects, lump-sum rebates						
No target	-3.5	-3.6	-3.8	-4.0	-4.3	-4.6
1990+40%	-3.8	-3.9	-4.1	-4.3	-4.5	-4.8
1990+30%	-4.1	-4.2	-4.4	-4.6	-4.9	-5.2
1990+20%	-4.7	-4.9	-5.1	-5.3	-5.6	-5.9
1990+10%	-5.6	-5.8	-6.0	-6.2	-6.5	-6.9
1990	-6.3	-6.4	-6.5	-6.7	-7.0	-7.3
Without terms-of-trade -effects, social security payment rebates						
1990+40%	-3.8	-4.0	-4.2	-4.4	-4.6	-4.9
1990+30%	-4.2	-4.3	-4.5	-4.8	-5.1	-5.4
1990+20%	-4.8	-4.9	-5.2	-5.4	-5.7	-6.1
1990+10%	-5.5	-5.7	-6.0	-6.2	-6.6	-6.9
1990	-6.4	-6.5	-6.7	-6.9	-7.1	-7.4

Table 14. Gross Domestic Product

Energy saving	0.0	2.5	5.0	7.5	10.0	12.5
With terms-of-trade -effects, lump-sum rebates						
No target	0.0	-0.1	-0.1	-0.3	-0.4	-0.6
1990+40%	-0.6	-0.8	-1.0	-1.3	-1.7	-2.1
1990+30%	-2.0	-2.2	-2.4	-2.7	-3.2	-3.9
1990+20%	-2.4	-2.6	-2.8	-3.2	-3.7	-4.4
1990+10%	-2.4	-2.6	-2.8	-3.2	-3.6	-4.1
1990	-3.1	-3.4	-3.7	-4.2	-4.8	-5.2
With terms-of-trade -effects, social security payment rebates						
1990+40%	-0.4	-0.6	-0.8	-1.0	-1.3	-1.7
1990+30%	-1.5	-1.7	-1.9	-2.2	-2.8	-3.5
1990+20%	-1.6	-1.7	-1.9	-2.2	-2.5	-3.2
1990+10%	-1.7	-1.8	-2.0	-2.3	-2.6	-3.1
1990	-2.5	-3.0	-3.4	-3.9	-4.4	-4.8
Without terms-of-trade -effects, lump-sum rebates						
No target	2.5	2.5	2.4	2.4	2.3	2.1
1990+40%	2.4	2.4	2.4	2.4	2.4	2.3
1990+30%	1.6	1.6	1.7	1.7	1.6	1.5
1990+20%	0.7	0.7	0.8	0.8	0.8	0.8
1990+10%	-0.1	-0.1	0.0	0.0	0.0	0.0
1990	-1.4	-1.4	-1.4	-1.4	-1.5	-1.6
Without terms-of-trade -effects, social security payment rebates						
1990+40%	2.6	2.6	2.7	2.7	2.7	2.6
1990+30%	2.1	2.2	2.3	2.4	2.4	2.5
1990+20%	1.3	1.4	1.5	1.6	1.7	1.7
1990+10%	0.4	0.5	0.6	0.7	0.8	0.9
1990	-0.9	-0.8	-0.7	-0.6	-0.6	-0.6

Table 15. Production of peat

Energy saving	0.0	2.5	5.0	7.5	10.0	12.5
With terms-of-trade -effects, lump-sum rebates						
No target	0.0	0.3	0.6	0.9	1.1	1.2
1990+40%	2.0	2.9	3.7	4.5	5.2	5.8
1990+30%	5.0	5.6	6.2	3.7	-3.9	-14.0
1990+20%	3.5	0.1	-3.9	-8.8	-16.9	-23.9
1990+10%	0.0	-2.8	-6.2	-10.3	-16.0	-20.5
1990	-9.7	-12.6	-15.2	-14.9	-16.2	-16.9
With terms-of-trade -effects, social security payment rebates						
1990+40%	2.5	3.5	4.5	5.5	6.4	7.2
1990+30%	6.4	7.2	4.4	-3.1	-13.1	-24.6
1990+20%	6.5	4.0	0.2	-4.3	-10.3	-22.1
1990+10%	3.0	0.4	-2.7	-6.4	-11.1	-18.3
1990	-8.4	-13.2	-14.2	-15.5	-16.5	-17.3
Without terms-of-trade -effects, lump-sum rebates						
No target	-0.7	0.2	1.1	2.2	3.4	4.9
1990+40%	3.9	5.1	6.4	7.7	9.1	11.1
1990+30%	11.3	12.2	13.2	14.3	15.4	16.5
1990+20%	17.2	18.1	19.1	20.3	21.5	22.9
1990+10%	24.9	26.0	27.2	28.5	29.9	31.6
1990	30.4	30.9	31.4	31.9	32.4	32.9
Without terms-of-trade -effects, social security payment rebates						
1990+40%	4.5	5.9	7.3	9.0	11.4	13.8
1990+30%	12.9	14.0	15.1	16.3	17.5	18.8
1990+20%	19.3	20.3	21.3	22.4	23.7	25.2
1990+10%	26.8	27.8	29.0	30.4	31.9	33.7
1990	34.7	35.4	36.0	36.7	37.0	37.0

Table 16. Oil refining

Energy saving	0.0	2.5	5.0	7.5	10.0	12.5
With terms-of-trade -effects, lump-sum rebates						
No target	0.0	-1.0	-2.5	-4.2	-6.3	-8.8
1990+40%	-3.6	-4.4	-5.3	-6.4	-7.6	-9.0
1990+30%	-11.2	-12.0	-12.9	-13.8	-15.2	-17.1
1990+20%	-21.4	-22.3	-23.4	-24.8	-26.6	-28.9
1990+10%	-33.3	-34.3	-35.5	-36.9	-38.7	-40.8
1990	-46.5	-47.7	-49.1	-49.6	-50.1	-50.3
With terms-of-trade -effects, social security payment rebates						
1990+40%	-3.6	-4.4	-5.3	-6.4	-7.7	-9.1
1990+30%	-11.4	-12.2	-13.0	-14.2	-16.1	-18.9
1990+20%	-22.1	-23.1	-24.2	-25.6	-27.4	-30.1
1990+10%	-34.1	-35.1	-36.3	-37.8	-39.6	-42.0
1990	-47.5	-48.4	-48.9	-49.5	-49.8	-50.1
Without terms-of-trade -effects, lump-sum rebates						
No target	-0.4	-1.7	-3.1	-4.7	-6.6	-8.8
1990+40%	-4.3	-5.2	-6.2	-7.3	-8.7	-10.5
1990+30%	-12.8	-13.6	-14.5	-15.6	-16.8	-18.3
1990+20%	-22.9	-23.7	-24.6	-25.7	-26.9	-28.4
1990+10%	-33.1	-33.8	-34.6	-35.5	-36.5	-37.7
1990	-39.1	-39.3	-39.4	-39.5	-39.5	-39.4
Without terms-of-trade -effects, social security payment rebates						
1990+40%	-4.3	-5.2	-6.2	-7.6	-9.5	-11.6
1990+30%	-13.0	-13.8	-14.7	-15.8	-17.2	-18.9
1990+20%	-22.7	-23.6	-24.6	-25.7	-27.0	-28.5
1990+10%	-32.8	-33.5	-34.3	-35.3	-36.4	-37.7
1990	-40.9	-41.2	-41.5	-41.8	-41.4	-41.5

Table 17. Generation and imports of electricity

Energy saving	0.0	2.5	5.0	7.5	10.0	12.5
With terms-of-trade -effects, lump-sum rebates						
No target	0.0	3.5	7.9	12.9	18.8	25.7
1990+40%	-3.7	-1.0	2.1	5.7	9.8	14.5
1990+30%	-11.2	-8.8	-6.0	-2.8	0.7	4.2
1990+20%	-14.1	-11.6	-8.9	-5.9	-2.9	0.3
1990+10%	-15.2	-12.8	-10.1	-7.1	-4.0	-0.1
1990	-17.9	-15.8	-13.7	-10.1	-8.9	-15.0
With terms-of-trade -effects, social security payment rebates						
1990+40%	-3.7	-1.0	2.1	5.7	9.7	14.4
1990+30%	-11.3	-8.9	-6.1	-3.2	-0.4	2.2
1990+20%	-13.0	-10.4	-7.5	-4.2	-0.7	1.8
1990+10%	-14.2	-11.7	-8.8	-5.6	-2.0	1.4
1990	-17.1	-16.1	-13.0	-9.4	-11.6	-17.1
Without terms-of-trade -effects, lump-sum rebates						
No target	-0.3	3.4	7.6	12.5	18.2	24.9
1990+40%	-3.8	-1.1	2.1	5.8	10.1	14.0
1990+30%	-10.2	-7.7	-4.9	-1.6	2.3	6.8
1990+20%	-12.6	-10.0	-7.0	-3.4	0.7	5.6
1990+10%	-13.8	-11.4	-8.5	-5.2	-1.3	3.3
1990	-15.9	-13.4	-10.4	-7.0	-3.3	0.9
Without terms-of-trade -effects, social security payment rebates						
1990+40%	-3.9	-1.1	2.1	5.3	7.9	11.1
1990+30%	-10.3	-7.8	-5.0	-1.7	2.4	7.8
1990+20%	-14.0	-11.3	-8.1	-4.4	0.0	5.1
1990+10%	-15.7	-13.5	-10.5	-7.0	-3.0	1.8
1990	-17.9	-15.5	-12.7	-9.4	-5.5	-0.8

Table 18. Generation of heat

Energy saving	0.0	2.5	5.0	7.5	10.0	12.5
With terms-of-trade -effects, lump-sum rebates						
No target	0.0	-3.4	-3.5	-3.8	-4.1	-4.5
1990+40%	-1.4	-1.7	-2.2	-2.8	-3.5	-4.4
1990+30%	-4.3	-4.7	-5.2	-7.5	-8.2	-9.1
1990+20%	-8.4	-8.7	-9.1	-9.8	-10.7	-12.0
1990+10%	-9.1	-9.4	-9.9	-10.6	-11.5	-12.6
1990	-11.8	-12.4	-13.9	-15.0	-15.4	-15.9
With terms-of-trade -effects, social security payment rebates						
1990+40%	-1.2	-1.5	-2.0	-2.5	-3.1	-3.9
1990+30%	-3.8	-4.2	-7.3	-8.1	-9.2	-11.0
1990+20%	-7.6	-7.8	-8.2	-8.7	-9.5	-10.9
1990+10%	-8.4	-8.7	-9.2	-9.8	-10.6	-11.7
1990	-11.6	-14.0	-14.1	-14.3	-14.7	-15.3
Without terms-of-trade -effects, lump-sum rebates						
No target	-1.3	-1.3	-1.4	-1.6	-2.0	-2.5
1990+40%	-2.0	-2.4	-2.8	-3.4	-4.0	-5.1
1990+30%	-4.6	-5.0	-5.4	-6.0	-6.7	-7.4
1990+20%	-6.3	-6.6	-7.1	-7.6	-8.2	-8.9
1990+10%	-8.2	-8.6	-9.0	-9.5	-10.2	-10.9
1990	-10.5	-10.6	-10.9	-11.3	-11.9	-12.6
Without terms-of-trade -effects, social security payment rebates						
1990+40%	-1.8	-2.1	-2.5	-3.2	-4.3	-5.4
1990+30%	-4.0	-4.4	-4.8	-5.3	-5.9	-6.5
1990+20%	-5.9	-6.2	-6.6	-7.0	-7.6	-8.2
1990+10%	-7.8	-8.1	-8.5	-9.0	-9.6	-10.3
1990	-10.3	-10.4	-10.7	-11.0	-11.5	-12.1

Table 19. Production of paper and pulp

Energy saving	0.0	2.5	5.0	7.5	10.0	12.5
With terms-of-trade -effects, lump-sum rebates						
No target	0.0	0.0	0.2	0.2	0.0	-0.3
1990+40%	-2.6	-2.9	-3.3	-3.9	-4.7	-5.7
1990+30%	-8.5	-8.7	-9.1	-9.7	-10.6	-12.1
1990+20%	-11.1	-11.2	-11.6	-12.2	-13.4	-15.0
1990+10%	-12.2	-12.3	-12.5	-13.1	-14.1	-15.1
1990	-14.4	-14.7	-15.3	-14.4	-14.2	-16.2
With terms-of-trade -effects, social security payment rebates						
1990+40%	-2.6	-2.9	-3.3	-4.0	-4.8	-5.8
1990+30%	-8.6	-8.9	-9.4	-10.2	-11.6	-13.9
1990+20%	-10.3	-10.3	-10.6	-11.0	-11.9	-14.1
1990+10%	-11.3	-11.4	-11.6	-12.0	-12.7	-14.2
1990	-13.9	-15.1	-14.1	-13.1	-13.9	-15.9
Without terms-of-trade -effects, lump-sum rebates						
No target	-2.7	-2.6	-2.6	-2.7	-2.7	-2.9
1990+40%	-3.9	-4.1	-4.3	-4.7	-5.1	-5.7
1990+30%	-6.1	-6.3	-6.6	-6.9	-7.3	-7.8
1990+20%	-6.6	-6.7	-6.8	-7.0	-7.2	-7.5
1990+10%	-6.6	-6.7	-6.9	-7.1	-7.3	-7.7
1990	-6.6	-6.6	-6.7	-6.8	-7.0	-7.3
Without terms-of-trade -effects, social security payment rebates						
1990+40%	-3.8	-4.0	-4.3	-4.7	-5.3	-6.0
1990+30%	-6.1	-6.3	-6.6	-6.9	-7.3	-7.4
1990+20%	-7.4	-7.3	-7.4	-7.4	-7.6	-7.8
1990+10%	-7.6	-7.7	-7.8	-7.9	-8.1	-8.3
1990	-7.7	-7.7	-7.9	-8.1	-8.1	-8.2

Table 20. Production of basic metals

Energy saving	0.0	2.5	5.0	7.5	10.0	12.5
With terms-of-trade -effects, lump-sum rebates						
No target	0.0	0.2	0.2	0.1	-0.1	-0.4
1990+40%	-4.7	-5.5	-6.4	-7.6	-8.9	-10.5
1990+30%	-15.0	-15.7	-16.6	-17.7	-19.3	-21.7
1990+20%	-19.7	-20.3	-21.1	-22.2	-24.2	-26.6
1990+10%	-22.2	-22.8	-23.6	-24.6	-26.3	-27.8
1990	-27.1	-28.0	-29.2	-38.5	-47.4	-48.4
With terms-of-trade -effects, social security payment rebates						
1990+40%	-4.7	-5.5	-6.4	-7.6	-9.0	-10.6
1990+30%	-15.1	-15.9	-16.8	-18.2	-20.5	-23.9
1990+20%	-18.3	-18.7	-19.4	-20.3	-21.7	-25.1
1990+10%	-20.9	-21.4	-22.0	-22.9	-24.2	-26.4
1990	-26.3	-29.3	-38.3	-48.7	-53.7	-54.7
Without terms-of-trade -effects, lump-sum rebates						
No target	-5.5	-5.4	-5.4	-5.5	-5.5	-5.7
1990+40%	-6.9	-7.1	-7.5	-7.8	-8.3	-9.0
1990+30%	-9.6	-9.9	-10.3	-10.7	-11.2	-11.7
1990+20%	-10.5	-10.7	-10.9	-11.1	-11.4	-11.7
1990+10%	-10.9	-11.0	-11.2	-11.5	-11.8	-12.2
1990	-11.5	-11.6	-11.8	-12.0	-12.4	-12.8
Without terms-of-trade -effects, social security payment rebates						
1990+40%	-6.9	-7.1	-7.4	-7.9	-8.5	-9.2
1990+30%	-9.6	-9.9	-10.2	-10.7	-11.0	-11.2
1990+20%	-11.3	-11.3	-11.4	-11.5	-11.6	-11.9
1990+10%	-11.9	-12.1	-12.2	-12.4	-12.5	-12.8
1990	-12.5	-12.6	-12.9	-13.2	-13.3	-13.5

Table 21. Production of electronics and electronic appliances

Energy saving	0.0	2.5	5.0	7.5	10.0	12.5
With terms-of-trade -effects, lump-sum rebates						
No target	0.0	0.1	0.3	0.4	0.7	0.9
1990+40%	0.3	0.5	0.7	1.0	1.4	1.8
1990+30%	1.4	1.6	1.8	2.1	2.7	3.5
1990+20%	1.8	2.1	2.4	2.8	3.5	4.3
1990+10%	2.1	2.4	2.7	3.1	3.8	4.4
1990	3.5	3.9	4.5	5.0	5.7	6.3
With terms-of-trade -effects, social security payment rebates						
1990+40%	0.8	1.1	1.4	1.9	2.4	3.1
1990+30%	2.9	3.3	3.7	4.5	5.7	7.4
1990+20%	3.1	3.4	3.9	4.4	5.2	6.9
1990+10%	3.4	3.8	4.2	4.7	5.5	6.7
1990	5.2	6.2	6.8	7.5	8.1	8.6
Without terms-of-trade -effects, lump-sum rebates						
No target	0.0	0.0	0.1	0.1	0.2	0.3
1990+40%	-0.4	-0.5	-0.7	-0.8	-0.9	-1.1
1990+30%	-1.1	-1.2	-1.4	-1.5	-1.8	-1.8
1990+20%	-1.3	-1.4	-1.5	-1.6	-1.7	-1.8
1990+10%	-1.0	-1.1	-1.2	-1.3	-1.5	-1.6
1990	0.1	-0.1	-0.4	-0.6	-0.8	-0.8
Without terms-of-trade -effects, social security payment rebates						
1990+40%	0.0	0.0	0.0	0.0	0.0	0.0
1990+30%	0.1	0.1	0.1	0.0	0.0	0.0
1990+20%	0.4	0.5	0.3	0.2	0.2	0.2
1990+10%	0.9	0.8	0.7	0.7	0.6	0.6
1990	1.9	1.7	1.4	1.4	1.4	1.4

Table 22. Transportation and communications

Energy saving	0.0	2.5	5.0	7.5	10.0	12.5
With terms-of-trade -effects, lump-sum rebates						
No target	0.0	0.0	0.0	0.0	-0.1	-0.1
1990+40%	-1.4	-1.7	-2.1	-2.6	-3.1	-3.7
1990+30%	-4.8	-5.2	-5.7	-6.0	-6.7	-7.7
1990+20%	-6.2	-6.5	-6.9	-7.4	-8.2	-9.3
1990+10%	-6.9	-7.2	-7.5	-8.0	-8.8	-9.5
1990	-8.6	-9.1	-9.7	-9.5	-9.4	-9.2
With terms-of-trade -effects, social security payment rebates						
1990+40%	-1.2	-1.5	-1.8	-2.2	-2.6	-3.2
1990+30%	-4.3	-4.6	-4.9	-5.4	-6.2	-7.4
1990+20%	-5.0	-5.2	-5.5	-5.9	-6.4	-7.6
1990+10%	-5.8	-6.0	-6.3	-6.7	-7.2	-8.0
1990	-7.7	-8.5	-8.3	-8.2	-8.0	-7.9
Without terms-of-trade -effects, lump-sum rebates						
No target	-0.5	-0.5	-0.6	-0.6	-0.6	-0.7
1990+40%	-1.8	-2.0	-2.4	-2.8	-3.2	-3.8
1990+30%	-4.3	-4.6	-5.0	-5.4	-5.9	-6.4
1990+20%	-5.0	-5.2	-5.5	-5.7	-6.0	-6.3
1990+10%	-5.2	-5.4	-5.7	-6.0	-6.3	-6.6
1990	-5.9	-6.1	-6.4	-6.7	-7.1	-7.6
Without terms-of-trade -effects, social security payment rebates						
1990+40%	-1.6	-1.8	-2.1	-2.5	-3.0	-3.6
1990+30%	-3.8	-4.1	-4.5	-4.9	-5.2	-5.3
1990+20%	-5.2	-5.3	-5.4	-5.5	-5.7	-5.8
1990+10%	-5.6	-5.9	-6.1	-6.2	-6.4	-6.6
1990	-6.2	-6.4	-6.7	-7.0	-7.4	-7.5

Table 23. Retailing and private services

Energy saving	0.0	2.5	5.0	7.5	10.0	12.5
With terms-of-trade -effects, lump-sum rebates						
No target	0.0	-0.1	-0.2	-0.4	-0.6	-0.8
1990+40%	-0.5	-1.0	-1.5	-2.2	-2.9	-3.8
1990+30%	-1.6	-2.1	-2.8	-3.8	-4.8	-6.0
1990+20%	-0.9	-1.4	-2.0	-2.7	-3.7	-4.9
1990+10%	1.1	0.6	0.1	-0.6	-1.5	-2.4
1990	2.4	1.8	1.0	0.2	-0.1	0.5
With terms-of-trade -effects, social security payment rebates						
1990+40%	-0.2	-0.6	-1.1	-1.7	-2.3	-3.1
1990+30%	-0.7	-1.3	-2.1	-2.8	-3.8	-5.0
1990+20%	0.6	0.2	-0.2	-0.8	-1.5	-2.6
1990+10%	2.5	2.1	1.7	1.2	0.5	-0.4
1990	3.8	2.4	2.0	1.5	1.6	2.0
Without terms-of-trade -effects, lump-sum rebates						
No target	2.0	1.9	1.9	1.8	1.7	1.6
1990+40%	1.3	1.1	0.8	0.5	0.2	-0.3
1990+30%	0.4	0.2	-0.1	-0.5	-0.8	-1.2
1990+20%	0.8	0.6	0.4	0.1	-0.1	-0.5
1990+10%	1.4	1.2	1.0	0.8	0.5	0.2
1990	2.1	2.0	1.7	1.5	1.2	0.9
Without terms-of-trade -effects, social security payment rebates						
1990+40%	1.8	1.6	1.5	1.3	1.1	0.8
1990+30%	1.6	1.4	1.3	1.1	0.8	0.7
1990+20%	1.8	1.7	1.6	1.5	1.3	1.1
1990+10%	2.4	2.3	2.2	2.0	1.8	1.6
1990	3.1	3.0	2.8	2.6	2.4	2.2

Appendix

This appendix considers abatement under imperfectly competitive labour markets. Since the Appendix mainly serves as a sensitivity check to the assumption of perfect competition, we restrict the discussion to the case with terms-of-trade effects.

Here, we assume that labour markets function imperfectly. Consequently, we assume that wages are being set by a monopoly union to maximise the income of the union. The union's income consists of the wage income, earned by the employed, and unemployment benefits, earned by the unemployed. Under these assumptions, the union sets wages as a mark-up over the unemployment benefit. The union does not care about the utility of the consumer, but it does take the wage elasticity of labour demand into account. Since the consumption-leisure choice becomes irrelevant in this model, we assume that utility is derived from consumption only. Thus, the only modifications to the model in the main text are the introduction of an imperfectly competitive wage setting-mechanism and the replacement of the utility function by the consumption index for goods. All of the other assumptions of the model are retained.

It is well known that unless nominal wages are at least to an extent rigid, employment is not sensitive to policies affecting labour demand under monopoly unions. In this case, none of the policies considered earlier would have an effect on employment. Thus, we assume that unemployment benefits reflect changes in the wage level imperfectly. Specifically, we assume that 25 per cent of the benefits consist of payments fixed in nominal terms. This assumption captures roughly the fact that unemployed are entitled to a wage-dependent benefit at the beginning of their unemployment spell, which greatly exceeds the government provided basic social security.

Effects on emissions

Table A1 gives the emission levels in the model. This effect consists of the consumption of goods and leisure. In the base scenario, emissions would increase by 44,3 per cent, slightly less than in the models of the main text. To reach the 1990 level, they would have to be cut by 29,4 per cent.

Emission taxes

Table A2 gives the emission taxes. By and large, the results are in line with the models in the main text. However, the taxes are somewhat lower for lump-sum rebates and considerably higher for social security rebates. The effect of Energy saving on taxes is also larger than under perfect competition in the labour markets.

Effects on consumption

Table A3 gives the effect of abatement on consumption and, since leisure does not affect utility, on welfare. In the base scenario, consumption would increase by 16 per cent. Under abatement, it would have to remain 4,7 per cent lower at the worst. The losses reported in the main text were somewhat higher, since the base-scenario growth of consumption was also higher.

Effects on employment

Table A4 gives the effects on employment. Employment would grow much more under imperfectly competitive labour markets under lump-sum rebates than under either perfect competition or under social security rebates. In most cases employment would actually contract under imperfect competition and social security rebates. The effects on employment are much larger and much more sensitive to the rebate scheme than under perfect competition. They are also qualitatively different, which is of significance.

Effects on nominal wages and consumer prices

Table A5 gives the changes in wages. The results concerning employment are easily seen to stem from changes in wages. Under lump-sum rebates, wages have to fall to ensure equilibrium, whereas under social security rebates, the reduction of labour costs is to a large extent accomplished via lower indirect labour costs. Table A6, reporting changes in consumer prices, shows that real wages actually rise under social security rebates in some cases.

Effects on aggregate demand

Finally, Table A7 gives the effects on aggregate demand. In the BAU case, aggregate demand rises by 17,8 per cent, less than under perfect competition. The decrease in aggregate demand, however, is much larger under the monopoly union – this despite the large changes in real wages. The negative effects are larger under lump-sum rebates for moderate Energy saving, but with maximum Energy saving taking place, they are ultimately larger under social security rebates.

Table A1. Emissions

Energy saving	0.0	2.5	5.0	7.5	10.0	12.5
With terms-of-trade -effects, lump-sum rebates						
1990+40%	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1
1990+30%	-8.2	-8.2	-8.2	-8.2	-8.2	-8.2
1990+20%	-15.2	-15.2	-15.2	-15.2	-15.2	-15.2
1990+10%	-22.3	-22.3	-22.3	-22.3	-22.3	-22.3
1990	-29.4	-29.4	-29.4	-29.4	-29.4	-29.4
With terms-of-trade -effects, social security payment rebates						
1990+40%	-1.1	-1.1	-1.1	-1.1	-1.1	-1.1
1990+30%	-8.2	-8.2	-8.2	-8.2	-8.2	-8.2
1990+20%	-15.2	-15.2	-15.2	-15.2	-15.2	-15.2
1990+10%	-22.3	-22.3	-22.3	-22.3	-22.3	-22.3
1990	-29.4	-29.4	-29.4	-29.4	-29.4	-29.4

Table A2. Carbon dioxide tax

Energy saving	0.0	2.5	5.0	7.5	10.0	12.5
With terms-of-trade -effects, lump-sum rebates						
1990+40%	96.3	110.4	125.3	129.3	123.5	114.7
1990+30%	276.1	292.2	309.2	326.6	319.5	310.9
1990+20%	336.4	352.9	370.5	389.3	386.8	377.6
1990+10%	396.9	415.4	434.0	454.1	456.0	446.7
1990	467.1	490.6	495.4	506.2	502.8	499.1
With terms-of-trade -effects, social security payment rebates						
1990+40%	104.5	121.2	140.4	162.5	188.4	194.5
1990+30%	268.5	288.7	311.6	338.2	369.2	391.9
1990+20%	478.6	485.6	493.7	503.5	515.4	510.7
1990+10%	493.4	502.0	512.5	525.6	543.0	553.9
1990	557.0	564.9	574.0	590.7	677.8	678.5

Table A3. Consumption

Energy saving	0.0	2.5	5.0	7.5	10.0	12.5
With terms-of-trade -effects, lump-sum rebates						
1990+40%	0.3	0.1	-0.1	-0.2	-0.4	-0.6
1990+30%	-0.4	-0.5	-0.7	-0.9	-1.1	-1.3
1990+20%	-1.5	-1.6	-1.8	-2.0	-2.1	-2.3
1990+10%	-2.6	-2.7	-2.9	-3.0	-3.2	-3.4
1990	-3.8	-4.0	-4.1	-4.3	-4.5	-4.7
With terms-of-trade -effects, social security payment rebates						
1990+40%	0.3	0.3	0.1	0.0	-0.2	-0.4
1990+30%	0.1	0.0	-0.2	-0.3	-0.4	-0.6
1990+20%	-0.5	-0.7	-0.8	-1.0	-1.2	-1.5
1990+10%	-1.6	-1.8	-1.9	-2.1	-2.3	-2.6
1990	-2.9	-3.1	-3.2	-3.4	-3.6	-3.9

Table A4. Employment

Energy saving	0.0	2.5	5.0	7.5	10.0	12.5
With terms-of-trade -effects, lump-sum rebates						
1990+40%	0.7	0.8	1.0	1.3	1.6	2.0
1990+30%	2.1	2.2	2.4	2.6	3.0	3.4
1990+20%	4.2	4.4	4.5	4.7	5.1	5.5
1990+10%	6.5	6.7	6.8	7.0	7.4	7.8
1990	9.2	9.3	9.5	9.8	10.2	10.7
With terms-of-trade -effects, social security payment rebates						
1990+40%	0.8	0.7	0.6	0.5	0.4	0.8
1990+30%	-0.5	-0.6	-0.8	-0.9	-1.1	-1.0
1990+20%	-1.5	-1.6	-1.7	-1.8	-1.9	-1.3
1990+10%	-1.7	-1.8	-1.8	-1.9	-2.0	-1.8
1990	-1.0	-1.2	-1.4	-1.5	0.8	1.0

Table A5. Nominal wages

Energy saving	0.0	2.5	5.0	7.5	10.0	12.5
With terms-of-trade -effects, lump-sum rebates						
1990+40%	-0.3	-0.4	-0.6	-0.9	-1.4	-1.8
1990+30%	-1.9	-2.0	-2.2	-2.5	-2.9	-3.3
1990+20%	-4.3	-4.4	-4.6	-4.8	-5.2	-5.7
1990+10%	-6.7	-6.8	-7.0	-7.2	-7.6	-8.0
1990	-9.3	-9.4	-9.6	-9.9	-10.3	-10.6
With terms-of-trade -effects, social security payment rebates						
1990+40%	-0.3	-0.2	-0.1	0.0	0.1	-0.4
1990+30%	1.2	1.4	1.5	1.7	1.9	1.8
1990+20%	2.5	2.7	2.8	2.9	3.0	2.3
1990+10%	2.7	2.8	2.9	3.1	3.2	2.9
1990	1.8	2.1	2.4	2.5	-0.4	-0.6

Table A6. Consumer prices

Energy saving	0.0	2.5	5.0	7.5	10.0	12.5
With terms-of-trade -effects, lump-sum rebates						
1990+40%	-0.1	-0.1	0.0	-0.1	-0.1	-0.2
1990+30%	-0.5	-0.4	-0.4	-0.4	-0.4	-0.5
1990+20%	-0.8	-0.8	-0.8	-0.7	-0.8	-0.8
1990+10%	-1.2	-1.2	-1.1	-1.1	-1.1	-1.2
1990	-1.4	-1.4	-1.4	-1.4	-1.4	-1.4
With terms-of-trade -effects, social security payment rebates						
1990+40%	0.2	0.4	0.6	0.9	1.2	1.2
1990+30%	1.2	1.4	1.7	2.0	2.3	2.6
1990+20%	2.2	2.3	2.4	2.6	2.8	2.6
1990+10%	1.5	1.6	1.7	1.9	2.1	2.2
1990	1.2	1.3	1.4	1.6	2.5	2.6

Table A7. Aggregate demand

Energy saving	0.0	2.5	5.0	7.5	10.0	12.5
With terms-of-trade -effects, lump-sum rebates						
1990+40%	0.0	-0.1	-0.3	-0.6	-0.9	-1.3
1990+30%	-1.3	-1.4	-1.6	-1.8	-2.1	-2.5
1990+20%	-3.0	-3.1	-3.3	-3.5	-3.8	-4.1
1990+10%	-4.6	-4.7	-4.9	-5.0	-5.3	-5.7
1990	-6.7	-6.9	-7.0	-7.2	-7.5	-7.8
With terms-of-trade -effects, social security payment rebates						
1990+40%	-0.4	-0.6	-0.9	-1.3	-1.7	-2.1
1990+30%	-2.0	-2.3	-2.6	-3.0	-3.4	-3.9
1990+20%	-4.0	-4.1	-4.3	-4.5	-4.8	-5.0
1990+10%	-4.2	-4.3	-4.5	-4.8	-5.1	-5.4
1990	-5.4	-5.4	-5.5	-5.8	-8.1	-8.3