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Adriaan Perrels
Heikki Kemppi
Antti Lehtilä

ASSESSMENT OF THE MACRO-ECONOMIC EFFECTS OF DOMESTIC CLIMATE POLICIES FOR FINLAND

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Government Institute for Economic Research

Hämeentie 3, 00530 Helsinki, Finland

Email: etunimi.sukunimi@vatt.fi

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Abstract: This is the final report on macro-economic cost assessment of a domestic climate policy programme for Finland. The core assessment work was done with an energy systems model (EFOM) soft linked with a macro-economic model (KESSU). The study was carried out in co-operation with VTT Energy. The policy programme consisted of both pricing measures and prescriptions. From an engineering-economic viewpoint the use of more nuclear looks economically advantageous, but from a macro-economic viewpoint the advantage is less prominent. Use of energy taxes combined with tax recycling seems from a macro-economic viewpoint less harmful than a purely prescriptive programme. Macro-economic cost of a purely domestic policy package for the first commitment period amount to about 0,5% of Finnish GDP in 2010.

The study was financed by the ministries of Trade and Industry, Environment and VATT/Ministry of Finance.

Key words: climate policy, assessment, carbon tax, energy tax

Tiivistelmä: Tämä raportissa selvitetään kansallisen ilmasto-ohjelman kansantaloudelliset vaikutukset. Pääarvioinnin tehtävä oli tehty energiajärjestys-mallin (EFOM) ja kokonaistaloudellisen mallin (KESSU) avulla. Tutkimus oli tehty yhteistyössä VTT Energian kanssa. Ilmasto-ohjelma sisältää sekä hinta-ohjauskeinot että normit. Insinöörin-taloudellisesta näkökulmasta ydinvoima näyttää edulliselta, mutta kansantaloudellisesta näkökulmasta ydinvoiman etu on vähemmän huomattavaa. Energiaveron käyttö ja samanaikaisen veronkierrätys on vähemmän haittalista kun täysi normipohjainen ohjelma. Kansallisen ohjelman kansantaloudelliset kustannustaso ensimmäisessä velvoiteaikakausissa on arvioitu noin 0,5% Suomen BKT:sta vuonna 2010.

Kauppa ja teollisuusministeriö ja ympäristöministeriö ja lisäksi VATT/Valtio-varainministeriö rahoittivat tutkimuksen.

Asiasanat: ilmastomuutospolitiikka, arviointi, hiilivero, energiavero

VATT and the development of climate policy

Climate policy is clearly a sustainable issue in national policy making for years to come. Climate change and climate change mitigation strategies constitute a complex challenge with many dimensions, which requires new knowledge, findings and, applications from many different sciences. Complexity also involves economic scientific questions following from climate policy. Therefore climate change is regarded as an important research topic for the service portfolio of VATT. Furthermore, considering the challenge it embodies for economic policy making climate change was also positioned in the research strategy of VATT.

Economic questions related to climate change touch upon various parts of economic science. Notwithstanding the classification of climate change under the heading of *globalisation* in the research strategy, it relates also to other issues in the same matrix such as sustainable development, economic structural change, and EU integration. In addition, the research questions following from climate policies require an integrated understanding of energy- and environmental economics, altogether representing a dimension of economics in its own right. The Research Area (department) named *'Environment and Infrastructure'* is one of the four in VATT. Climate change research fits naturally well in that area.

In the Research Area 'Environment and Infrastructure' has been created a section 'energy and environment', in which climate change related studies constitute a significant part of the portfolio. The section 'energy and environment' has the prospect to develop new research trajectories, which are beneficial also for other research activities in VATT. This shows the meaning and purpose of the strategy, that is, to create value added by means of cross-fertilisation. For example, sustainable development and climate change are closely related topics.

The experiences with the Kyoto-study offer a good basis thanks to which new studies and tools can be launched. For example, one project for the years 2001 and 2002 is the extension of a general equilibrium model in a way that makes it very suitable for assessment of international aspects of climate policy.

The complexity of climate change demands often co-operation. The Kyoto-study implied extensive co-operation with VTT Energy. Hopefully, VTT will be also a partner in various future studies. Furthermore, it appears that the contacts with the Finnish Environment Institute culminated already in two co-operations, one regarding Best Available Technology benchmarking and another for the Finnish Academy named 'Analysis of nutrient cycles in ecological and socio-economic systems for policy purposes'. Also international co-operation will be extended.

Reino Hjerppe,
Director-general of VATT

Foreword

Early in the year 1999 the Ministries of Trade and Industry and of Environment commissioned to the Government Institute for Economic Research an assessment study concerning the macro-economic cost for Finland of fulfilling the Kyoto Protocol. The first phase of the study – usually denoted as Kyoto 1 – started in April 1999 and lasted until April 2000. It had an investigative character.

From May 2000 onwards a second phase – denoted as Kyoto 2 – started, which lasted until the end of December 2000. In this phase model simulations were carried out to evaluate the domestic climate programme (KIO). The model simulations required a close co-operation between VATT and the National Technical Research Centre (VTT). In addition, during later stages of the project information exchange was arranged regularly with The Research Institute of the Finnish Economy (ETLA) and The Finnish Environmental Research centre (SYKE).

The study has been guided by a expert group and a steering group. The expert group consisted of the researchers from VATT and VTT Energy and representatives from Ministry of Trade and Industry (Pekka Tervo), Ministry of Environment (Magnus Cederlöf, Antero Honkasalo) and the Ministry of Finance (Heikki Sourama).

The Steering group was composed of Under-secretary of State Mr. Johnny Åkerholm (Ministry of Finance), Director-general Mr. Taisto Turunen (Ministry of Trade and Industry), Director-general Mr. Pekka Jalkanen (Ministry of Environment), and Director-general Mr. Reino Hjerppe (Government Institute of Economic Research – VATT, chairman of the steering group).

This foreword needs to conclude however with the tragic and deplorable notification that Mikael Björnberg, a valued contributor to the study on behalf of VTT, died in a fatal accident in November 2000. We remember him as a highly esteemed researcher.

Adriaan Perrels
Project leader

Summary

As a consequence of signing the Kyoto Protocol Finland is one of the many countries that has to reduce its greenhouse gas emissions. In order to fulfil that commitment Finland is putting up a climate strategy. Within the framework of that strategy a domestic programme is defined. The strategy formulation including the programme lay-out is led by a ministerial working group, which is assisted by the ministries of Agriculture and Forestry, Environment, Trade and Industry, and Transport and Communication, while also the ministries of Finance and of Foreign Affairs are involved in the policy definition and the negotiations. The ministry of Trade and Industry is responsible for the co-ordination of the production of a domestic programme, abbreviated as KIO (Kansallinen Ilmasto Ohjelma). The present report concerns the evaluation of macro-economic effects of that KIO programme.

The study has been carried out by the Government Institute of Economic Research (VATT) in co-operation with the Energy Institute of the National Technical Research Centre (VTT Energy).

This assessment focuses on the economic consequences of the first commitment period of the Kyoto Protocol, which refers to the average emission level in the period 2008 - 2012 compared to the 1990 emission level. In the case of Finland the total of greenhouse gas emissions in 2008 - 2012 (period average, expressed in CO_2-equivalents) should be the same as the 1990 level. The greenhouse gas emission level of Finland in 1990 amounted to 75,2 Megaton CO_2-equivalent. In the year 2010 the emission level would have been risen to 91,2 Megaton in absence of the climate policy programme studied here. Consequently, Finland has to reduce its emission level with 16 Megaton CO_2-equivalent.

There are several greenhouse gas emissions, namely:

- Carbon dioxide (CO_2), represents about 84% of the greenhouse gas emissions in Finland
- di-nitrogen oxide (N_20)
- Methane (CH_4)
- So-called new gases (HFC, PFC, SF_6)

Carbon dioxide is closely related to fossil fuel use (coal, oil, gas), agriculture and industry are for example an important cause of di-nitrogen oxide, while methane emissions are caused by agriculture and waste treatment. The new gases constitute a very small but presently growing share of the total GHG emissions. The emissions of new gases stem from industrial processes.

Burning of biomass (wood, hay, etc.) causes carbon dioxide emissions as well, but thanks to the relatively short regeneration cycle they are regarded as greenhouse gas neutral fuels in the framework of the Kyoto Protocol.

Cost effective ways to reduce emissions are:

- land fill gas (methane) exploitation
- switching from fossil fuels to non-fossil fuels such as biomass, nuclear energy, and wind power
- energy saving (i.e. using less energy to perform the same process or task)

All these elements are present in the domestic programme in several ways. However, since these options are interacting and since companies and households can be induced by different kinds of policy instruments, it is useful to check how economic impacts differ between alternative policy packages.

Step by step the involved ministries agreed on a collection of closely related but at some points essentially different programme alternatives. Initially two alternatives were formulated, one (KIO1) excluding the option for extra nuclear power and the other one (KIO2) including that option. Apart form that aspect these original draft programmes were otherwise as much as possible equal in terms of extra energy taxes and other measures such building performance standards. Subsequently, the extra energy taxation was diminished to skip overshooting of the emission target and/or the increase of taxes for gasoline and diesel was skipped.

This resulted in six alternatives, being:

1.	KIO1*	KIO1 with less extra taxation to skip overshooting of the target
2.	KIO2*	KIO2 with less extra taxation to skip overshooting
3.	KIO1-NONLV*	this is the same as KIO1-NONLV
4.	KIO2-NONLV*	KIO2-NONLV with less extra taxation to skip overshooting of the target
5.	KIO1-NONEV KIO1	without any rise in energy taxes; intensified other measures instead
6.	KIO2-NONEV KIO2	without any rise in energy taxes; intensified other measures instead

With respect to the programme alternatives 1-4 various ways of tax recycling (giving back the excess revenues to households and companies) were experimented. One option means that 50% is given back to households via income tax and the other 50% via social security payments of employers. A second option is to recycle everything via income tax. The central or prime options were regarded those in which the recycling was 50/50. This means the programme alternatives 1-4 with 50/50 recycling. For the last two this is irrelevant, as in those options increase of income tax was deemed necessary.

In the official ministerial reports the following distinction is presented (in connection with 50/50 recycling where applicable).

Final ministerial nomenclature and abbreviations in this report	**Electric power option 1**	**Electric power option 2**
Energy taxation alternative 1	KIO1*	KIO2*
Energy taxation alternative 2	KIO1-NONLV*	KIO2-NONLV*
Energy taxation alternative 3	KIO1-NONEV	KIO2-NONEV

The programmes have been assessed by means of the joint use of the energy systems model EFOM and the econometric model KESSU. Distribution effects for households have been reviewed with the aid of detailed statistics from Statistics Finland. Finally, a small multi-criteria assessment (MCA) has been carried out.

The main findings of the study can be summarised in the following step by step manner:

- The negative effects in 2010 compared to a situation without a climate policy programme amount to -0,3% to -0,6% points for GDP and -0,6% to -0,9% points for household consumption with respect to the central alternatives considered.

- The results above are based on the programme alternatives in which the energy tax is increased and at the same time the net excess revenue of taxes is given back to taxpayers, being companies and households, by means of so-called tax recycling. The most obvious ways to recycle tax is by lowering social security payments of employers and by lowering income tax of households. Also lowering of selected VAT items can be considered .

- Energy taxation *in connection with* tax recycling is an indispensable ingredient to avoid unnecessary macro-economic cost. The programme alternatives in which no taxation instruments are used result in appreciably higher cost for households (-1,0% to -1,2%). In these alternatives the exclusion of the use of the tax instrument implies an intensified use of standards and norms. Generally these tend be more expensive than the measures incited by raising taxes. Furthermore, the unchanged energy tax combined with energy saving results in loss of tax revenues, which has to be repaired by tax recouping rather than recycling.

- The differences with regard to GDP and household consumption between programme alternatives including extra nuclear capacity and those without vary from 0,1% to 0,2% points depending on the programme alternatives and the way of tax recycling. Differences of 0,1% point or less are however of doubtful significance.

- The reductions in production volume in 2010 vary between 0,1% and 0,4% for the heavy industry, between 0,15% and 0,25% for the light industry and between 0,3% and 0,6% for commercial services and agriculture depending on the programme alternative

- In case extra nuclear capacity is installed, the negative effects for the heavy industry are halved, while the benefits for the light industry are minute or negligible. Similarly for the commercial services differences between the inclusion and exclusion of extra nuclear capacity are very small (0,05% to 0,1%).

- Also for the sector effects the way of tax recycling makes a some difference, especially commercial services and some light industries benefit more, the better the purchasing power of households is repaired.

- The average cost per household after tax recycling vary between about 1200 FIM (~ € 200) and 1800 FIM (~ € 300) per year in 2010 depending on the programme alternative. The programme alternatives without tax instruments cause average cost of about 2000 FIM (~ € 340) to 2400 FIM (~ € 400) per household The central alternatives including extra nuclear capacity cause on average 270 FIM to 420 FIM (~ € 45 to ~ € 70) less cost per household. The variation of cost (the standard deviation) over households is somewhat smaller in the programme alternatives with extra nuclear capacity.

- The variation of the absolute level of costs over households depends mostly on the type of dwelling and type of heating system. For those programme alternatives that include the increase of transport fuel tax (diesel and gasoline) the variation of costs over households is substantially increased due to variation in car ownership (0, 1 or 2+ cars) and use (annual mileage).

- The variation of the burden of extra cost expressed in terms of percentage of net income depends on the one hand on the physical circumstances indicated above and on the other hand on net income level. The burden distribution at the level of household categories does not show very large deviations. There are nevertheless categories with just over 1% burden. These categories represent possibly about 9% of all households. Just like for companies larger burdens can occur for individual households.

- After 2010 the macro-economic cost rises in the programme alternatives without nuclear tend to grow more than the alternatives with extra nuclear capacity.

- As regards uncertainties in the results and the robustness of the programme alternatives the following key issues deserve mentioning:

  - the installation of an international emission permit trade system in this decade and the acknowledgement of Joint Implementation as supplementary to such a system would almost certainly lead to heavy pressures to revise the domestic programme substantially, since the regret cost of non-revision would be significant

  - the assumption used in the programme assessments that the import of electric power diminishes due to high prices in Nordpool represents a reasonably likely situation, but also the lower end of a spectrum of outcomes and consequently the possibility that competitive imports remain at significant higher levels than assumed should not be relegated as entirely irrelevant; larger availability of competitive imports would reduce the cost in the alternatives without extra nuclear capacity, but are not expected to affect the alternatives including extra nuclear

  - the assumption of the cost free and sweeping EU wide introduction of the so-called 5-litre car as a default trend is liable to serious doubt; given the EU framework Finnish policy makers may feel compelled to insert the assumption, but that cannot make up for the *analytical* judgement that it is a feeble concept; in case of significant non-achievement of the EU covenant it is not self-evident from an economic point of view whether compensatory measures should be only found within the transport sector, including possibilities to find more revenues than investment options in transport.

- Relatively simple exercises with judgement of the performance of the programme alternatives in a wider context (i.e. more criteria than purely economic ones) hint at the fact that by and large the ordering of alternatives as indicated by the economic assessment is fairly robust. Only in case of strong attachment to other than purely economic criteria a larger revision of the ranking can occur. This observation relates also to the time frame in which one wishes to judge programmes. The studied programme focuses mainly on the first commitment period of the Kyoto Protocol, the process in which Finland embarks has however a much longer time scale.

Contents

1. Introduction

As a consequence of signing the Kyoto Protocol Finland is one of the many countries that has to reduce its greenhouse gas emissions[1]. Within the European Union a so-called burden sharing approach has been followed. This resulted for Finland in an obligation that greenhouse gas emissions in 2010 should have the same level as in 1990.

In order to fulfil that commitment Finland is putting up a climate strategy. A domestic programme is an important part of the climate strategy. Within the framework of that strategy a domestic programme is defined. The strategy formulation including the programme lay-out is led by a ministerial working group, which is assisted by The ministries of Agriculture and Forestry, Environment, Trade and Industry, and Transport and Communication are putting up policy packages, while also the ministries of Finance and of Foreign Affairs are involved in the policy definition and the negotiations. Next to its own policy area of environment, building and spatial planning, the ministry of Environment is responsible for co-ordinating the measure preparations at the international level, the so-called flexible mechanisms. The ministry of Trade and Industry is responsible for the co-ordination of the so-called domestic programme, abbreviated as KIO (***K***ansallinen ***I***lmasto ***O***hjelma – National Climate Programme). The present report concerns the evaluation of macro-economic effects of that programme.

This report constitutes the final report of phase 2 of the so-called Kyoto project. It is the result of extensive model calculations and preparatory work regarding the reference development of the economy ('Baseline' or Business ad Usual - BAU). The preparatory work concerned also electricity markets, model adaptations, instrument selection and interaction, and a preview to the potentials of the flexible mechanisms (notably joint implementation). Possibly, in a third phase of policy support studies for climate policy formulation a reassessment of the dosage may take place. Both the international endorsement of (at least one of) the flexible mechanisms as well as the digestion of the domestic programme effects and variation possibilities could well lead to such a reassessment. Therefore, the study presented here can be regarded an important step in a learning process, even though as such it represents a comprehensive social-economic assessment.

The study is built around the calculations for the baseline and the climate programme packages. The calculations concern:

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[1]. A glossary with terms from climate policy, energy engineering and economics is added in Appendix 1.

- the trends and the policy impacts on these trends in the energy supply sector, giving information about primary energy use, energy conversion, end use, emissions and direct costs
- the trends and the policy impacts on these trends in the entire economy, either due to changes in the energy sector or due to policies directly intervening in the economy, the results give information about direct and indirect (induced) costs (and in some cases benefits) in the whole economy, including issues as household purchasing power and employment

The energy sector calculations are carried out by means of the EFOM model, managed by VTT Energy. The economic evaluation is largely based on calculations with KESSU, which is owned by the ministry of Finance but deployed in VATT. In addition specific calculations are made for purchasing power effects in various household types. Last but not least an overall assessment is made applying multi-criteria analysis (MCA).

The prime aim of the study is the assessment of the ministerial climate policy packages. The current government programme provides two important general guidelines with respect to macro-economic assessment of climate policy. The first is that the climate programme should as much as possible be attained against lowest social-economic cost. The second is that a balanced budget principle prevails, which implies that extra tax revenues should be recycled and a fall-back in tax revenues should be recouped. Whereas the second guideline leaves limited leeway for variation in interpretation, the first prerequisite of lowest attainable social-economic cost can still give rise to quite different rankings. Reasons for this larger room for interpretation are the different options for representing social-economic cost (see also Kemppi and Pohjola, 2000) and the time scale on which costs and benefits are judged. Both the lowest cost criterion (and its different dimensions) and the balanced budget criterion have been taken into account in the assessment.

This assessment focuses particularly on the economic consequences of the first commitment period of the Kyoto Protocol, which refers to the average emission level in the period 2008 - 2012 compared to the 1990 emission level. In the case of Finland the total of greenhouse gas emissions in 2008 - 2012 (period average, expressed in CO2 equivalents) should be the same as the 1990 level. However, some attention will also be paid to the cost development up to 2020 and possible consequences of a tighter reduction target for 2020.

The report is organised as follows. Chapter 2 explains the overall evaluation approach, gives short descriptions of the models used, and indicates also the limitations of the approach and validity of the results inter alia in comparison to other studies.

Chapter 3 gives highlights and backgrounds of the baseline (Business as Usual - BaU). Business as Usual implies that one pictures the socio-economic and technical trends from 2000 to 2025, without adding new policies while keeping existing ones unchanged. Yet, it does include the more-or-less inevitable dynamics such as economic growth, an ageing and slightly growing population, internal migration, etc.

The ministerial policy packages are explained in chapter 4. First, the consecutive instruments in each package are described. This also includes the energy saving programme and the renewable energy programme. Next, the translation of the packages into information that can be used in the models (model input) is dealt with.

Chapter 5 handles the model simulation results of the packages as produced by EFOM and KESSU respectively. In order to provide more depth in interpretation also the results of sensitivity analysis are presented.

Macro-economic impact assessment is not merely a listing of simulation results, but needs to be put in a decision context. This is done in chapter 6, which contains an overall evaluation. The overall evaluation looks to issues such as robustness of instruments and packages and trade-off possibilities. Chapter 7 is the concluding chapter. Appendices are added for more background information on assumptions and simulation results.

This is not the only assessment study regarding the ministerial climate policy packages. ETLA[2], also in co-operation with VTT Energy, has made a macro-economic assessment as well, albeit based on another type of model. SYKE has made an overall environmental impact assessment of the ministerial climate policy packages. The four institutes have been exchanging information and some activities were carried out in co-operation.

[2] . ETLA – Research Institute of the Finnish Economy; VTT – National Technical Research Centre of Finland; SYKE – Finnish Environmental Institute

2. The Evaluation System

2.1 Introduction

In ideal circumstances the evaluation starts already during the instrument identification phase of policy formulation, as has been explained in chapter 2 of the background report on instruments (Perrels, 2000). In this case the evaluation task started however after ministries had been putting up separately their (preliminary) sub-programmes. It meant factually that the research team itself composed a list of instruments and measures by scanning the various (draft) programmes and by asking for written or spoken comments or updates of programmes. All in all several types of difficulties arose, such as overlaps between programmes of different ministries, competing effectiveness of instruments, vaguely specified instruments and, intended effects with lacking or scant instrumentation. As the assessment of KIO1 and KIO2 progressed these setbacks were gradually alleviated. Eventually almost all programme elements could be assessed in the model system. The description of the instruments and measures and their translation into model input is given in chapter 4.

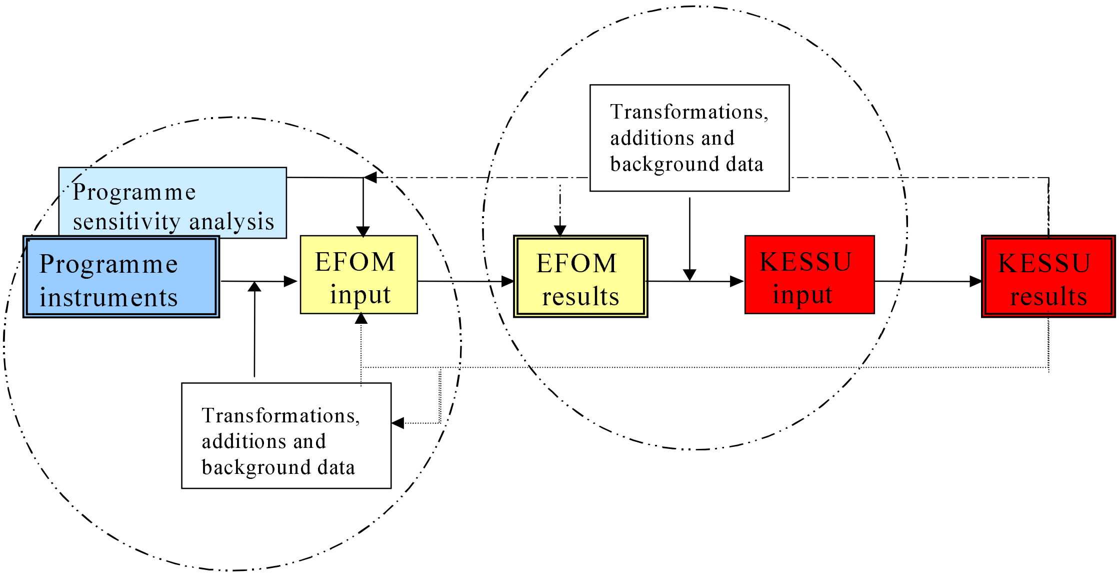

Figure 2.1 *Overview of the linked model evaluation system*

Figure 2.1 gives an overview of the information flow from the policy packages through the models. The policy programmes are first translated into EFOM input. The results from EFOM are fed into KESSU. In case of large macro-economic impacts, the production levels pictured in KESSU's output have to fed back into EFOM in order reassess the energy and emission levels. In the sensitivity analysis various plausible variations of BaU assumptions and effectiveness of instruments are tested. The circles in figure 2.1 refer to input handling of EFOM and KESSU, which is discussed in further detail in section 4.2.

2.2 EFOM

In order to obtain eligible model input for EFOM the ministerial programmes have to be translated in terms of effects on prices, energy efficiency, quantities such as car stock or building volume, and upper or lower bounds for the use of some energy resources.

EFOM is an optimisation model managed by VTT Energy. Its original design is rooted in an initiative of the European Commission to obtain a model standard for energy system modelling throughout Europe. The Finnish version has been extended and tuned to the Finnish circumstances, e.g. concerning the abundant use of district heat and the significance of the pulp&paper industry.

The model looks for the cheapest combination of energy carriers and energy technologies, given the indicated boundaries on emissions, price levels of primary and secondary energy sources, costs of energy saving technologies, the potentials of energy saving technologies, the default (Baseline) improvement of energy efficiency by type of use, the current structure and age distribution of (main) energy conversion and energy using technologies, the economic growth by sector, growth of the buildings stock, growth of the vehicle stock and annual mileage. An overview of key input figures and translation of policies into model input is given in chapter 4 and Appendix 2.

In this study a distinct number of forecast years is chosen for EFOM, being 2005, 2008, 2010, 2015 and 2020.[3] The simulations of the policies starts in 2001, but the effects are shown for the years mentioned. Also upper or lower bounds (including for example the emission reduction target) are always specified for the years mentioned

Next to energy use per fuel type per sector and emission by type of greenhouse gas, the output from EFOM concerns annualised costs per sector distinguished by:

- investment in energy conversion capacity (both utilities and heavy industry)
- extra use cost due switches in fuels and/or energy technology
- extra investments in energy efficiency
- extra energy/carbon tax levied
- extra subsidies (mostly on renewables) received

[3] . Being a simulation - optimisation model such years are called ‘study years’ in the EFOM system.

In addition the model gives also output on total incited investment by period by sector as well as the marginal cost levels for energy use and abated emissions.

The optimisation in EFOM is done on the basis of the relative prices and technical and capital restrictions for all subsequent periods. The impacts of R&D intensification on future unit-cost and technology uptake can be taken into account in EFOM, but this option has not been used given the time and resource limitations in the project. Furthermore, all a-priori announced policies (e.g. a second emission target in 2020) can be taken into account in the model. This also means that industrial investors know future demand developments. In other words the model runs with 'perfect foresight', but it cannot derive new behavioural strategies.

2.3 KESSU

KESSU cannot straightaway use the output from EFOM. The sectoral distinction in EFOM is different from the one in KESSU. Therefore, a weighing procedure is applied to reattribute the costs by sector, while there is made a distinction between actual costs due to investments and fuel switching on the one hand, and extra taxes on the other hand. The latter are to a large extent recycled by lowering social security payments and income taxes. Details on the transformation of output to input for KESSU and KESSU input in general are given in Appendix 3 and to some extent in chapter 4.

KESSU is an econometric model of the Finnish economy developed and used by the Ministry of Finance (Hetemäki and Kaski, 1992; Kaski et al, 1998)[4]. The latest version of the model (KESSU V) is deployed in VATT and at several places adapted to be able to absorb energy cost information better than in the standard KESSU. KESSU is meant for medium-term forecasts, which implies that the interpretation of results preferably focuses on forecast years that between 3 and 10 years after the year in which policy impulses start. In this study policy impulses start in 2005, which means that we focus on the results for 2008, 2010 and 2015.

Observing the medium-term purpose of the model and given that 2005 implies already five years forecasting (in the Baseline), we refrain from interpreting results beyond 2015. KESSU simulations step from year to year. Though the profit maximisation function can in principle look further ahead, the principal changes in the model refer to phenomena in the past year, the current year or the upcoming year. Therefore, perfect (long term) foresight capabilities are absent in KESSU. However, as regards investments in energy conversion and energy use technology this problem is circumvented by using the results from EFOM.

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[4] . The model version used in the study is a somewhat adapted version compared to the 1992 publication.

KESSU V has separate blocks for commercial production sectors, households, public sector and taxation and foreign trade. Important exogenous variables (i.e. can be set 'freely' by the model user) are among others:

- demand developments on export markets;
- international trade prices (import and export) such as. the oil price;
- technical development;
- public sector consumption and investment (volumes);
- demographic variables (employable population by age cohort, migration, under aged and retired population, number of households/homes).

Technical development is of the Harrod-neutral kind, implying that the capital-output ratio is constant, but may differ between sectors. This means for example that technical development that makes machinery more intelligent (and hence more productive) is difficult to represent in KESSU. For this study - focusing on energy use mainly - this is not an enormously disturbing factor. Though, strategic anticipation behaviour of firms, in which for example production augmenting innovation is merged with material and energy saving innovations, is outside the scope of this model. Labour productivity, however, can grow. Wage increases are linked to labour productivity developments by sector, but there is no automatic fixing of real wage levels. It is possible to introduce purchasing power reparation in the model. Such an intervention comes at the price of a (small) decrease of production and employment, since the higher wage cost will cause shedding of some production capacity that was just marginally productive before the reparation.

A crucial aspect in KESSU is the decision concerning the commercially optimal size of the capital stock. In each sector the optimal size of the capital stock (and consequently the sectoral production level) is reconsidered year after year. The so-called price of value added can change due to changes in prices of products and - in case of international operating sectors - changes in prices of intermediate products such as energy and materials. Product prices are derived from import and export prices for sectors engaged international trade (so-called exposed sectors), while the product prices for domestically operating sectors are determined by costs of capital, labour and other inputs. For exposed sectors an increase of the price of energy (an intermediate good) implies a decrease in the price of value added, as exporting sectors are assumed to adapt to international price levels. In turn a decrease in the price of value added is a disincentive to hire (more) labour or to invest (more). In other words the energy price rise can cause - in principal - a contraction of exposed sectors, which seek to restore the original profitability level. For non-exposed sectors a contraction will depend on the extent to which the energy costs raise product prices, which in turn will cause a reduction in demand (either of the product itself and/or of other products). The reduced production can cause a reduction in employment and hence reduce consumer demand a bit further, since social security income will be lower than the earlier wage.

In this study a prime, but in most sectors small, effect is the change in energy purchase costs. In addition the incited efficiency investments incur direct or indirect cost to sectors (but lower the original cost rise of the energy purchases), the indirect effect can be sometimes slightly more significant, but usually still rather small. Furthermore, due to the higher energy and investment cost for households also consumer demand reduces somewhat, this causes a small additional signal to reduce production. Last but not least, employees can try to seek compensation for the increased cost of living. The extra labour cost resulting from that will again reduce productions slightly. This effect is not taken into account in the simulations.

It should be noted that an important part of the price changes is set in motion by means of energy (or carbon) taxes. Given the current and expected state of the public finances, these energy taxes are preferably recycled to the tax payers (companies and households) in order to mitigate the original cost rises and thereby the negative impacts of the climate policy measures on the economy. This has been extensively and convincingly proven in the international economic literature to be a viable approach (e.g. OECD, 2000; see also the phase 1 reports of Kemppi and Pohjola, 2000; Kemppi, Perrels, and Pohjola, 2000). Next to model characteristics the chosen procedure of recycling (via income tax and/or social security payments) and the technical representation of recycling in KESSU influence the results. Therefore in section 4.1 this issue will be explained in terms of its structure and implications. The significance for the results will be discussed in section 5.2.

The policy packages, notably the taxes and subsidies, but also various support programmes and the voluntary agreements, are inciting investments. These investments may be more or less productive than the investments that were in the Baseline (BaU) investment portfolio of companies. Depending on the tightness of the capital market and the growth and profit prospects of the affected sectors a certain level of displacement of investments will occur. In the worst case the level is higher than 100%. It means that the sum of the investments incited by climate policies is smaller than the sum of the investments skipped. That will happen if the policy programme significantly affects the cost level of an industry leading to reduced growth and profit prospects. If prospects are not so bad but financing capabilities not endless (this depends on the capital market) a displacement rate somewhat under 100% occurs. For some financially healthy and well expanding sectors the displacement effect might be much smaller. Furthermore, the incited investments can coincide with other technology trends in the sector or boost product mix changes, possibly even resulting in net benefits rather than reduced costs.

The judgement of the occurrence and beneficial effects of less than total displacement depends also on the time scale considered. A temporary expansion of demand for capital could succeed, but only if the extra investments soon appear to be productive enough to make up in excess of the extra capital cost, otherwise the endeavour would ultimately go at the expense of the consumer. In all likelihood such a situation of policy incited not-totally-displacing investments can only occur if the new policies directly or indirectly imply the change of relative factor prices in a way which is better in line with relative scarcity of production factors, enabling an overall more efficient use of scarce resources in the economy.

This above considerations can be only partly taken into account in KESSU, as there is for example no capital market in KESSU. By and large KESSU reacts to this kind of cost increases by shedding off the least profitable production capacity. So, fortunate displacement rates are unlikely to occur. More offensive investment strategies, technological synergies, etc. are outside the scope of KESSU.

KESSU is apparently not a so-called closed model, meaning that there is no built in mechanism that takes care that equilibria in factor markets, foreign trade and public budget achieved. For the public budget the model has been run in such a way to check for public budget balance, while the apparently small effects for foreign trade did not need further treatment. The lacking or indeterminate equilibria on factor markets remains however a weakness that could be easily compensated.

The output from KESSU constitutes a large range of macro-economic and sector results. We focus in particular on (changes compared to Baseline of):
- Gross Domestic Product GDP (approximately same as national income)
- Private consumption
- Production volume by sector
- Exports
- Imports
- Employment

2.4 Remaining evaluation steps

The results from EFOM and KESSU give indications of the costs of the policy programmes, the distribution of the effects over sectors, and the relative efficiency of groups of instruments. This does nevertheless not mean that the answer is given by a simple subtraction of one result from the other. Even with respect to the representation of costs, several distinct aspects do count. For example in phase 1 of the Kyoto project it has been explained that welfare (represented by household consumption) is at least as important an indicator as production (represented by GDP). In addition there is the aspect of robustness of results. The sensitivity analysis provides insights to what extent the key ratings change when important input assumptions are changed. Furthermore, there are non-economic aspects to be considered in the final evaluation. SYKE is doing a study on the environmental impacts of KIO1 and KIO2. Notably, in the case of differences in health impacts, the cost implications can be significant. Last but not least it is good to realise that the model results are not to be seen as snapshots from inescapable futures, but as signals that call for further action, notably regarding strategic behaviour of companies.

By ranking the main types of instruments for various criteria, it becomes clear what seem to be most favourable and least favourable measures. To this will be added aspects as robustness and degradation risk. This ranking will be indicative, since for most instruments and measures only an interval of costs and potentials can be given.

In addition policy packages will be assessed on total social cost, overall cost efficiency, distribution effects and other factors. The multi-criteria analysis (MCA) used for this purpose also allows for testing variation in outcome, when different stakeholders attach different weights to effects. It should be born in mind that these total package assessments are indicative in nature.

2.5 Principal criteria and key variables

2.5.1 Costs and volumes

This section wraps up what has been told about purpose and output from the various models in the previous sections. Firstly, we can state that this study is focussing on *macro-economic* effects of reducing greenhouse gas emissions, henceforth the prime key variables to observe are:

1. the actually achieved emission levels
2. the development of GDP
3. the development of aggregate private consumption
4. the changes in overall employment

The above variables represent most concisely the overall production and consumption effects of the economy.

Other key macro-economic variables that give an indication of the extent to which the international position is affected and whether structural changes are enhanced are:

5. the changes in import and export volumes (and hence the trade balance)
6. production and employment effects by sector

Notably the production and employment effects are also indication of the *distribution of effects* over sectors

As regards the energy system changes and abatement effectiveness it is relevant to know to what extent the various types of fossil-free energy sources are gaining market share in the primary energy mix and what appears to be the ex-post unit cost of greenhouse gas abatement. Finally, the prices of final (delivered) energy to various types of customers are relevant to understand the price signal in relation to the relative scarcity (i.e. limited allowance to emit greenhouse gases) that climate policy is supposed to introduce in the economy. Summarising the variables are:

7. percentage shares of biomass, hydro, other renewables, and nuclear in the primary fuel mix, as well as the share of electric power;
8. the change in energy intensity per sector (in terms of units of energy per unit of value added);
9. cost per abated ton of CO_2-equivalent in selected years;
10. price changes per MWh of electricity, district heat, coal, natural gas and heating oil for industry, services and households, possibly also indicating build-up of price change (tax, operational and fuel cost, extra investments)

It is important to realise that the *cost figures as provided by EFOM are first line or direct cost directly resulting from the imposed measures and instruments*. When adding the increased tax payments to these direct or first line cost, the term *initial outlays* is used.

On the other hand the *macro-economic impacts based on KESSU give a picture after digestion of the direct costs throughout the entire economy* including effects on and from foreign markets via export and import.

So, in summary three cost levels are distinguished:

- *direct or first line cost*, denoting the initiated investment measures
- *initial outlays*, being first line cost + extra taxes paid
- *macro-economic impacts* (balance of cost and benefits)

Usually there will be a difference between the direct cost and the macro-economic impacts, while the difference can also vary over time depending on the distribution of cost over sectors and the composition of the cost. Given the character of KESSU one can expect that the macro-economic cost will be somewhat larger than the direct cost without taxation as indicated by EFOM.

2.5.2 Distribution of effects

Next to the total societal cost decision makers are usually interested in the distribution of cost and benefits in society. On the one hand there can be generic considerations of fairness, for example that no sector – including households - should carry a disproportionate share of the cost. However, it is equally possible that decision makers are particularly concerned about the impacts for specific sectors, for example because of exposure to foreign competition. For this study no operational indicators for acceptable upper or lower bounds for sectoral burdens have been specified, although the stakeholder discussion provided proxy indications for this. These proxy indications can be used in a few example exercises when a few assumptions are added.

In section 5.2.1 costs per economic sector are shown, whereas in section 5.2.2. the variation in costs for households will be discussed.

2.5.3 Uncertainty and robustness

Uncertainty refers to the possibility that the actual development of input variables deviates from their assumed values as used in the BaU scenario and/or in the policy programmes (KIO1&2).

Robustness refers to sensitivity of the policy packages to the changes in the scenario developments and/or unanticipated performance of instruments.

Variables with uncertainties that are expected to affect the performance of the policy packages are:

1. Economic growth
2. Population growth
3. Limitations in the electric power system (i.e. caps on the use of coal and nuclear, assumptions on import possibilities)
4. Technical progress (energy efficiency)
5. International competitiveness levels (relative export and import prices; foreign climate policies)
6. Real interest rates / capital opportunity cost (IRR)
7. International climate policy uncertainties

- The implementation of the flexible mechanisms (emission trade)
- Tightening targets in subsequent commitment periods

The variables mentioned under point 1, 3, 6, and 7 are taken up in the sensitivity analysis in section 5.3. Population growth (2) may be larger than assumed in the BaU scenario due to a larger migration to ease the labour market. However, the specification of a meaningful alternative including implications for housing, economic growth, etc is beyond the scope of the study.

Obviously the limitation on nuclear power (point 3) is taken into account by distinguishing between a KIO1 and a KIO2 programme. Technical progress (point 4) can be translated in the context of this study as the cost profile of a technology over time, e.g. expressed as FIM / ton abated CO_2-equivalent in year t. In contrast to economic growth variations these kind of cost figures are not to be varied randomly, but instead there should be indications for changes in the cost profiles based on technology foresight studies or market penetration studies. As stated in section 2.2 given the time and resource limits such considerations could not be taken into account in the simulations, As regards the level of competitiveness (point 5) there are no strong indications that a deviation from the BaU will occur. Moreover if it would occur, it may have barely differentiating effects between KIO1 and KIO2, provided the deviations do not relate to climate policies in foreign countries.

2.6 Limitations with respect to the results

As has been explained in sections 2.2 and 2.3 the models – at least as they were used in this study - have their limitations, notably with regard to long term dynamics that may be set in motion or reinforced by climate policies in Finland and abroad. Studies that have experimented with the inclusion of such dynamics demonstrate that very substantial cost reductions are possible (Buonanno et al 1999; Seebregts et al 1999; IEA 2000). The consequence of these findings is that the moment of introduction of new technologies and substitution of existing technologies may start significantly earlier than expected. These studies are predominantly focusing on the acceleration of environmental performance of technology and its market introduction, not on social and cultural (societal) conditions that facilitate or obstruct change.

The KIO programmes are not explicitly designed to exploit such mechanisms, rather the approach has been pragmatic and tries to ensure that the known energy saving and emission reduction potentials are harvested timely without disturbing the current economic structure.

Notably the following economic mechanisms could not or barely taken into account (between brackets an indication whether a positive '+' or negative '-' economic effect is expected):

- export market competitiveness, e.g. due to differences in climate policies (+/-)

- new export opportunities exceeding baseline growth assumptions (+)
- dynamic investments and learning as explained above (+)
- monetary aspects and capital cost (+/-)

It was explained in section 2.3 that exporting sectors are assumed to adapt to international price levels. It is furthermore assumed that real prices are not increasing on export markets. So, neither import goods not export goods have real price changes, apart form a few energy carriers (see chapter 3). However, it is imaginable that either export prices go up, thanks to market power of some important market parties. Depending on the kind of goods this can be beneficial (e.g. in case of wood based products) or detrimental (e.g. in case of foodstuffs).
A study of Statistics Finland (2000) clarifies that the production and export of environmental technology is already a sizeable business in Finland. Export of energy efficiency technology, renewable energy technology and abatement technology amounts already to 5 billion FIM per year, while the growth prospects are very good and get only better thanks to the climate policies in Europe and elsewhere. The implications of this are not taken into account neither in the BaU scenario nor in the assessments of KIO1 and KIO2.

It should also be noted that the costs and benefits of climate change are not taken into account either. The study assumes that in the absence of policies (the BaU scenario) no adverse or beneficial effects of climate change occur at least not in economic terms. By and large this may be true for the first 15 years (and even that is not certain), but in the long run there will be effects on the economy. In fact the long run impacts, which on balance are expected to be negative, should be balanced against the short to medium term costs and benefits of policies as are assessed in the present study. From a short to medium term point of view delay in action can look attractive, for example if significant cost reductions of new technologies are expected. However, delay in action by a number of countries, would have serious ecological implications (higher temperature rises and stronger related impacts). Eventually, the whole climate policy debate can be regarded as an exercise in timing, in which non-linear abatement cost reductions have to be balanced with non-linear climate cost increases. Countries or parties can try to wait to see who moves first, but the resulting prisoners dilemma may manoeuvre us in a position in which all parties loose. More in-depth assessment studies have started only started recently (e.g. Parry et al, 2000), consequently good economic assessments are not available.

Last but not least the influence of the flexible mechanisms is not thoroughly assessed in connection to KIO1 and KIO2. Formally, they are no part of the domestic programme, but their use would significantly affect the effectiveness of domestic policy instruments. In the sensitivity analysis (section 5.3) a very simplified version of the inter-country emission trade is checked on its impacts on KIO1 and KIO2.

3. The Business as Usual Scenario

A working group in the Ministry of Trade and Industry prepared the Business-as-Usual-(BaU)-scenario for economic developments. The annual economic growth is rated at 2.3% for the period 2000 – 2020. The growth rates decrease gradually from the current quite high levels to just over 2% in 2010. A crucial assumption is however that in 2004 a larger slow down of growth rates is experienced due to tightness in the labour market[5]. This would especially affect the electronics industry. In addition to growth of value added it is worthwhile to mention that in the BaU-scenario the production of paper is assumed to increase to almost 16 million tons in 2010. Steel production is assumed to increase with 1 million ton up to 2010. The growth figures in the BaU-scenario imply that GDP in 2010 is 35% larger than in 2000 in real terms. In other words the average national wealth per capita increases with 33% between 2000 and 2010, given the small population growth. The GDP in 2020 is forecast to be 66% larger in real terms than in the year 2000.

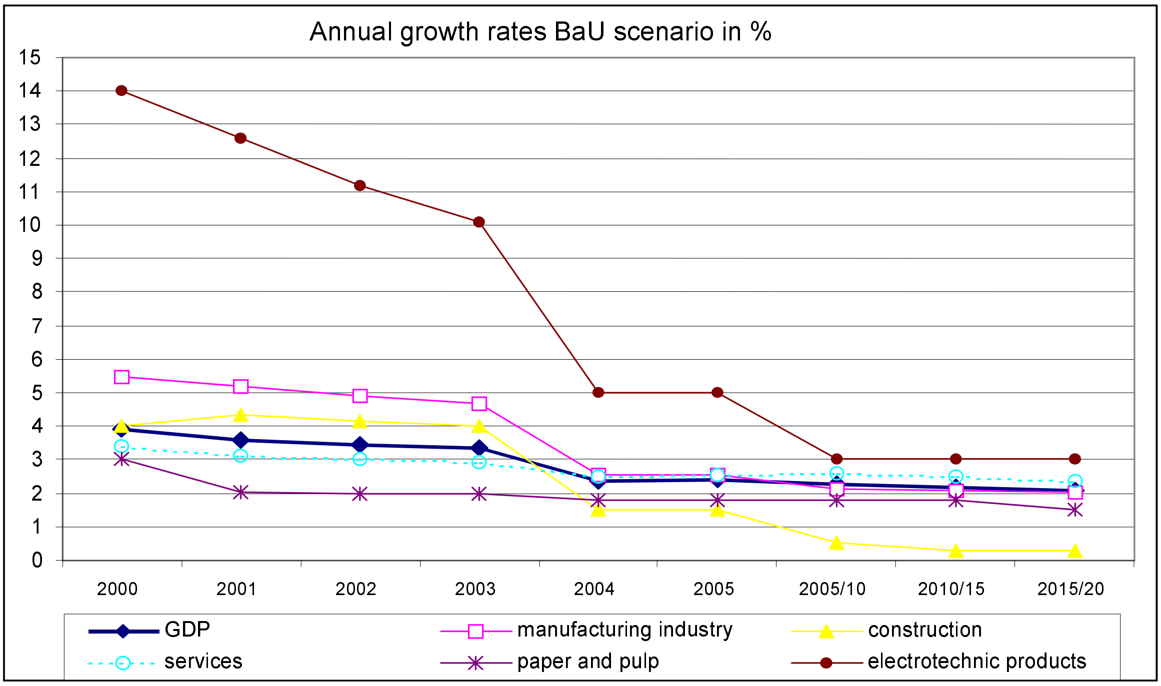

Figure 3.1 *Growth rates for main sectors and the whole economy 2000-2020 source: Ministry of Trade and Industry*

[5] . The assumed shortage in available labour force could work out differently, namely through increased competition for scarce workers between sectors. Apart from a further general reduction of growth rates due to wage increases, such a development will lead to another distribution of growth over sectors. To some extent industries could anticipate this by accelerating their productivity developments. Another 'way out' might be the increase of migration.

The development of the population in the BaU-scenario is according to the population forecast of Statistics Finland. The population increase is modest, from 5.19 million in 2000 to 5.26 million in 2010 and 5.29 million in 2020. The number of households increases from 2.27 million in 2000 to 2.41 million in 2010 and 2.43 million in 2020. A revision of these demographic forecasts would be necessary if migration would be significantly larger (see also footnote 5)

Other key assumptions in the BaU-scenario are:

- Oil price stabilises at $ 25 per barrel up to 2010 than steadily increases to $30 per barrel in 2020
- Price of natural gas is 20% higher in 2010 and 48% higher in 2020
- Electricity import declines up to 2010 and remains than at a level of 6TWh per year
- Extension of the gas grid into south-west Finland, but no connection to Western-Europe and Sweden/Norway[6]
- The introduction of the so-called 5-litre car at the latest in 2008 (5 ltr/100 km) is part of BaU, given the already signed agreement between the European Union and the European and other important car makers[7]
- The relative prices of import and export products are not changing

The speed of technological progress, notably with regard to autonomous energy efficiency improvements is assumed to continue at the pace of the recent past. More details are given in Appendix 2.

The reduction target for Finland following the formulation in the Kyoto Protocol means that the average emission levels in the period 2008-2012 should not exceed the level of 1990 as reported to the UNFCCC. After applying all assumptions as discussed above, the resulting levels of production and household consumption generate a so-called *emission gap* of 16 Megaton CO_2-equivalents (from 91.2 Megaton down to the 1990 level of 75.2 Megaton). This is the amount to be reduced in such a way that by the end of the first commitment period (2012) the commitment level as formulated in the Protocol is not exceeded.

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[6] . The problem is that the gas market situation is not independent from the developments caused by the climate programmes. In KIO1 there is more likelihood that it would pay off to get also a westward connection to the Western-European natural gas grid. In that case a contestable market situation could be created, which normally has price decreasing effect (or in this case a moderating effect on price increase).

[7] . Formally, a Voluntary Agreement has been made between the European Union and the Association of European car makers. Subsequently, the EU has made similar but somewhat more loose agreements with the non-European car makers. The agreements do not specify sanctions in case of non-attainment of the targets.

4. Description of the policy packages

4.1 Overview of instruments and their intended effects

The KIO1 and KIO2 programme alternatives are composed of sector or part-programmes from three ministries, being the Ministry of Transport and Communication (LVM, 2000), the Ministry of Trade and Industry (KTM, 2000a, 2000b, 2000c) and the Ministry of Environment (YM, 2000). The package of the Ministry of Trade and Industry consists of an energy saving programme, a renewable energy promotion programme, and a remaining set specific climate policy instruments. The policy options with respect to forestry are not included in the domestic programme, given the ongoing discussions on how to deal with sinks in forests and soils. Below follows only a summary of the packages.

Table 4.1 gives an overview of the selected instruments and the various ways they contribute to emission reduction. At the supply side of the energy system one can device instruments such as taxation and quality standards that increase the prices of carbon rich fuels, thereby making it attractive to switch to carbon free (or carbon poor) fuels. Similarly, one can try to bring down the prices of carbon free fuels, e.g. by means of subsidies on renewables. A bit special aspect is the option to reduce other greenhouse gases strongly, as in agriculture, waste processing and a few industrial processes in order to have more leeway for CO_2[8] Some of those options are quite cost effective and relatively easy to organise due to the limited number of actors. The creation of permits is typically an international option, and does not belong to the domestic programme alternatives KIO1 and KIO2. However, in principle we have to bear in mind that these options can become available and make a big difference for the ranking of instruments and the macro-economic cost level.

Given the prospect that the emission reduction policies may have to be maintained and extended for many decades, cost reduction and potential increase of renewable and energy efficiency technologies are important options for the medium and long run. Subsidies for R&D and demonstration projects have that purpose. Indirectly, the market take up of the developed technologies affects both supply and demand sides (the first two impact columns n table 4.1).

Last but not least there are the structural changes in the society, both at the production side (new processes and products) and at the consumption side (new consumption patterns guiding economic development). Indirectly such changes will for example enhance the penetration of renewable energy. A part of the

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[8] . The CO_2 emission reduction in the first commitment period (midpoint 2010) can be approximately 6% smaller, thanks to the cost-effective reduction potential of other gases. The other gases cover 15% of the greenhouse gas emissions in BaU 2010, but their share in the reduction is 20%.

innovations brought about by the climate related R&D programmes can have also generic effects on economic structure and growth of particular sectors. For example, in a recent study of Statistics Finland (2000) it is shown that the value added of energy efficiency products and services and of airborne emission abatement technologies and services constitute already an amount of 5 billion FIM, with excellent growth prospects and export shares of over 50%. The climate policies both in Finland and abroad will stimulate this sector further. As said in chapter 2 such beneficial aspects, in as far as exceeding assumed trends in the BaU-scenario, cannot be taken into account in KESSU.

Table 4.1 *The instruments of the ministerial packages and their impact classification*

Proposed instruments/measures	Sectors	Prices of energy sources *-> carbon free sources*	Costs of final energy use *-> energy saving*	Fuel switching and inter gas compensation *-> (net) emission target (-> energy sources)*	Creation of permit trade *-> (net) emission target (-> energy sources)*	Promotion of new technologies *-> carbon free sources -> energy saving*	Preference structures of consumers and industries *-> production and life styles -> carbon free sources and energy saving*
Other gases / waste	Agriculture	X					
	Waste treatment	X		XX			
	Industry			XX			
Mobile machinery	Agriculture		XX				
	Construction		XX				
	transport/warehousing		XX				
	Industry		XX				
Energy taxation + tax recycling	All sectors	XX	(XX)			(X)	(X)
Limitations on power supply options	Electric power and district heat	XX	(X)				
(coal, nuclear, import)	Heavy industry	XX	(X)				
Renewable energy + subsidies	Electric power and district heat	XX				X	
(incl. R&D subsidies)	Agriculture						X
	Construction		(X)			X	
	Services		(X)				
	Households		(X)				
New buildings e-efficiency *	Construction	(X)	XX				
	Services		XX				
	Households		XX				
e-efficiency and renovation *	Construction	(X)	XX				

	Services		XX				
	Households		XX				
Urban density	Construction	(X)	(X)				X
	Municipalities	(X)	(X)				X
(5 ltr car) + car purchase tax	Households		XX				
	Services		XX				
Economic driving behaviour *	Households		X				X
	Services		X				
	Transport services		XX				X
Promotion of public transport*	Transport services		X				(X)
	Households		X				(X)
Promotion of slow modes *	Households		X				(X)
	Municipalities		X				(X)
Motor fuel tax *	Households		XX				
	Services		XX				
Energy scans *	Industry	X	X				X
	Services		X				X
	Transport services		X				X
Research & development subsidies *	Electric power and district heat					XX	
	Industry					XX	
	Transport services					XX	
Voluntary agreements*	Industry	X	X	X	?	X	X
(includes variety of previous instr)	Services	X	X	X	?	X	X
Flexible mechanisms	Electric power and district heat	(XX)	(XX)		XX	(X)	
	Industry	(XX)	(XX)		XX	(X)	
	State	(XX)	(XX)		XX		

4.2 The policy packages as model input

The policy programmes KIO1 and KIO2 are composed of five main elements:

- Measures relating to other gases (methane, N_2O, HFC's, PFC's, SF_6). For Finland only methane and N_2O can contribute significantly to the reduction target;
- The Renewable Energy Programme (UEO), which focuses especially on the increase of biomass use;
- The Energy Saving Programme (ESO), which contains measures for the buildings, transport and industry;
- Limitations in the use of coal in KIO1 and allowance of 1 extra 1300 MW nuclear power unit in KIO2;
- The increase of the energy and electricity tax both for companies and households.

The measures for other gases more or less precede the other measures and make an important base contribution of 3,3 Megaton. In the simulations this package of measures remains unaffected by the variation in the other measures.

For the other packages it has been tried to follow as much as possible the programme specifications. However, additionally the guideline was given to apply as much as possible the same increases in energy and electricity taxation in KIO1 and KIO2. Since, the addition of a nuclear power unit in KIO2 has significant effects on the remaining emission reduction task and on the electricity price, this required some modest deviations between KIO1 and KIO2 regarding the energy saving (ESO) and renewable energy promotion (UEO) programmes. During the fine tuning of the programmes the ministries amended step by step the prescriptions as given in the default KIO programmes (see below). The taxation package functions as the 'closure' of the policy programmes, i.e. they are put in at a dosage which ensures achievement of the target. This means that despite the initial try to start with same taxation increases the ultimately selected programme alternatives have different increases of energy when comparing the versions including extra nuclear (less tax increase) with those without extra nuclear (more tax increase).

A few elements of ESO appeared to be impossible to implement sensibly in the EFOM model. The most notorious exclusion is that of the urban compacting concept, which to some extent has been assessed separately in EFOM. The likely positive effects of R&DD programmes and subsidies on lower unit abatement cost of new technologies are neither taken into account.

When the default KIO1 and KIO2 programmes had been simulated and the results assessed, the ministries responded particularly to two aspects, being:

- eliminate the overshooting of the target (which occurred notably in KIO2) by *reducing the increase* of the energy tax
- take out the increase of transport fuel tax, since the circumstances of the BaU scenario (5-litre car) make this measure very cost-inefficient and aggravate redistribution effects over households

In general it should be stressed that the treatment of the transport sector in terms of its possible responses has been relatively simple compared to assessment of other sectors. Also concerning the BaU-scenario assumption of the introduction of the 5-litre car without purchase cost effects there remain background questions to be considered[9].

The combination of reducing energy tax increases with abolished transport fuel tax increases has been applied as well. This appeared to be only relevant for KIO2. For the option without extra nuclear (KIO1) the exclusion of extra transport fuel tax did not leave any room for reduction of other energy tax increases[10]. This means that KIO1-NONLV and KIO1-NONLV* are the same. Only for the sake of parallellity the abbreviation KIO1-NONLV* is used. Finally, there is a set of alternatives in which the tax increase is abolished altogether and only other policy instruments (performance standards, voluntary agreements, mandatory regulations) are used[11].

All in all the following KIO1&2 and variations have been assessed:

1. KIO1, default KIO without extra nuclear
2. KIO2, default KIO including extra nuclear
3. KIO1-NONLV, as KIO1 without higher transport fuel tax
4. KIO2-NONLV, as KIO2 without higher transport fuel tax
5. KIO1*, as KIO1 with less extra taxation to skip overshooting of the target
6. KIO2*, as KIO2 with less extra taxation to skip overshooting of the target
7. KIO1-NONLV*, this is the same as KIO1-NONLV
8. KIO2-NONLV*, KIO2-NONLV with less extra taxation to skip overshooting of the target
9. KIO1-NONEV, KIO1 without any rise in energy taxes; intensified other

[9] . In the first place there is the implicitly assumed purchase price-neutral introduction of the 5-litre car in the BaU scenario. Secondly, in case of indeed a more or less enforced large scale introduction, there will be impacts on the second hand market, with possibly diverging effects for small and large second hand cars. Thirdly, no in depth research has been carried out on whether the 5-litre car involves a dramatic shift towards diesel. Furthermore, interaction between car ownership, (abolished) tax deductions for commuting and possible trends in city planning and public transport is assumed to have minute effects on car use and ownership.

[10] . In fact the energy tax rates in KIO1-NONLV are even slightly raised, due to elimination of transport fuel tax.

[11] . For the sake of experiment also an alternative which tries to depend as much as possible on taxes has been run. The results are reported in a separate publication (Kemppi and Lehtilä, 2001).

measures instead

10. KIO2-NONEV, is KIO2 without any rise in energy taxes; intensified other measures instead

Eventually, the ministries decided to concentrate on the alternatives 5 – 10, therefore the main text in chapter 5 will concentrate on the results of those alternatives. In Appendix 2 also results of the other alternatives are given.

For each programme alternative several ways of recycling of excess tax revenues have been assessed. The options were:

- *50/50* - half of the recyclable amount through reduced income tax (lump sum) and the other half through reduced employers payments for social security

- *100* – entirely via income tax reduction (lump sum)

- *VAT* – reduction of VAT rates (only applied by ETLA, see Forsström and Honkatukia, 2001)

In the final wrap-up of programme comparison the ministries decided to focus on the 50/50 recycling alternative. In chapter 5 the differences in results between the 50/50 and 100 options are sometimes mentioned. Appendix 2 contains results of both alternatives.

In this report the above names will be used throughout the next chapter. In the official presentation of results by the ministries (Ministry of Trade and Industry, 2001b) the options have been renamed as follows:

Final ministerial nomenclature and abbreviations in this report	**Electric power option 1**	**Electric power option 2**
Energy taxation alternative 1	KIO1*	KIO2*
Energy taxation alternative 2	KIO1-NONLV*	KIO2-NONLV*
Energy taxation alternative 3	KIO1-NONEV	KIO2-NONEV

Table 4.2 gives a qualitative overview of the EFOM input by policy instrument. It makes a distinction between price measures for energy carriers and energy efficiency and direct interventions in stocks and efficiency levels.

Eventually the involved ministries decided to separate the option of urban compacting from the domestic programme as studied here. The effect of this instrument has been assessed separately in EFOM. Full implementation according to the plan of the Ministry of the Environment would result in 0.8 MT reduction. This result involves however optimistic interpretation of the readjustment cost in the energy system (early amortisation). Moreover urban compacting leads usually to higher land prices, which is another obstacle for full implementation. Provided spatial planning regulation is adapted one-third of the estimated abatement effect could be realised. The importance of this instrument lies in the long run, when accumulated effects can become significant.

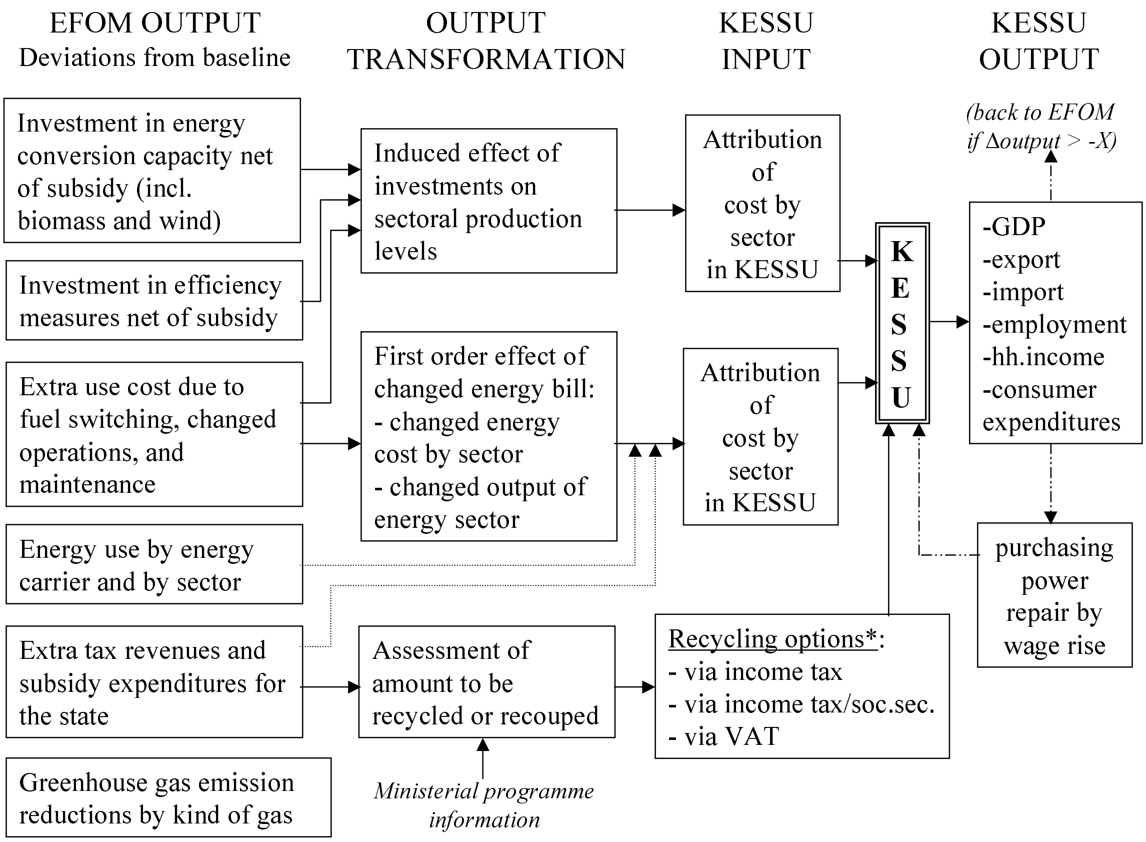
Table 4.2 *The instruments of the ministerial packages connected to EFOM input*

		EFOM INPUT	
Proposed instruments/measures	Sectors	*Price levels of energy carriers and energy saving options*	*Stocks by type of fuel, vintage and efficiency level*
Other gases / waste	Agriculture Waste treatment Industry	Subsidies for biogas investment Implementation of EU directives	Biogass from manure; information and subsidies Implementation of Methane extraction N_2O emission reduction; VA
Mobile machinery	Agriculture Construction transport/warehousing Industry		Substitution by more efficient units; demonstration of new designs
Energy taxation (including electricity tax)	All sectors One alternative with And one without extra tax on transport fuels Slightly lower levels in KIO*	Tax levels increase stepwise are in KIO1 70% up in 2010, 90% up 2015 and 110% up in 2020. In case of no extra car fuel tax the level are approx.20% lower in KIO2	
Limitations on power supply options (coal, nuclear, import)	Electric power and district heat Heavy industry		Practically barely any coal use (except cokes) in KIO1 after 2010. No extra nuclear in KIO1
Renewable energy + subsidies	Electric power and district heat Industry Any other sector	Subsidy tariffs remain at BaU level, but use increases	
New buildings e-efficiency *	Construction Services Households		New performance standards for new buildings (30% more e-efficient in 2004)
e-efficiency and renovation *	Construction Services Households	30% subsidy on energy saving renovations in KIO1, lower amounts in KIO2	New performance standards for existing buildings (15% more e-efficient in 2004)
/Urban compacting/ outside KIO assessment	Construction Municipalities	Not included model assessments	

(5 ltr car) + car purchase tax	Households Services	Car purchase tax revision implies 5 litre car is not more expensive than otherwise would be the case (there is risk of tax revenue loss see KESSU input)	Stepwise (2004-2008) introduction of 5litre car for newly bought cars is BaU trend, however on- the-road correction (5.5ltr) and rebound effect added.
Economic driving behaviour *	Households Services Transport services		In annual steps ultimately 25% of private car drivers and 50% of truck drivers reached in 2010, translated as 4% fuel consumption reduction of related cars and trucks
Promotion of public transport*	Transport services Households		Small increase in share of public transport as in LVM programme
Promotion of slow modes *	Households Municipalities	Not included in EFOM, anyhow very small impacts. Public health, congestion reduction and households cost savings may be more important.	
Motor fuel tax * (also programme alternatives without this -NONLV)	Households Services	Increase of gasoline tax with 2% per year and diesel tax with 2.3% per year,	
Limiting commuter tax deduction	households	Abolishment of deduction for commuting by car; 0,35% less car km. 0,5%more public transport km (ESO)	
Energy scans *	Industry Services Transport services	Effect included in sectoral energy saving goals As agreed in Voluntary agreements (see VA item)	
Research & development subsidies *	In principle for applications in all sectors	Impacts not implemented in this study, given absence of impact indicators (e.g. on future prices or potential of energy saving options).	
Voluntary agreements* (includes variety of previous instruments)	Industry Services Transport		Sectoral e-efficiency improvements and emission reductions as specified in VA's (see ESO table 3)

*) proposals that are usually part of a voluntary agreement

The output from EFOM gives figures on primary and final energy use per sector and energy carrier and annualised costs per sector distinguished by investments in energy conversion capacity, efficiency improvements, fuel cost and other operational cost (e.g. higher maintenance cost). Also the energy tax payments by sector are given and of course the emission levels for the main greenhouse gases. Since only the cost impacts of these expenditures have been only taken into account within the energy supply system, the total expenditures on taxes, investments, etc. is termed *initial outlays* which need to distinguished from ultimate changes in costs per sector. These initial outlays need some pretreatment before KESSU can run simulations. An overview of the transformation from EFOM output to KESSU input is given in figure 4.1.



*) If tax revenues would sink under the BaU levels, recouping would be needed. The second option income tax/social security payments means 50% via income tax and 50% via employers contributions to social security. The VAT alternative has not been run in KESSU, but is assessed in the ETLA simulations (Forsström and Honaktukia, 2001).

Figure 4.1 *The transformation from EFOM output to KESSU input*

The sector allocation of outlays as given by EFOM has to be rearranged, due to an other categorisation of sectors in KESSU. Furthermore, some energy system costs are directly attributed to final use sectors, notably district heating in relation to households. The input into KESSU represents a generalised cost increase. Changes in investment levels are not treated separately. Observing the balanced budget principle the amount of recyclable tax revenues is checked for both the changes in net revenues of energy and electricity taxes and changes in value added tax revenues and on the other hand corrected for extra subsidy outlays. The significance of the latter is minor though. A possible loss of purchasing power is not automatically repaired for wage earners, but in the social security system some of the cost effects are compensated automatically for households living on basic support due to a maximum cost of housing rule.

KESSU produces abundant output, but the we focus on changes in GDP, private consumption, export and import, production value per sector, investments and employment. Given the small changes compared to the size of the economy, notably for absolute employment figures, results should be interpreted with care.

5. Simulation results: energy, emissions and economic effects

5.1 The energy mix and resulting emissions

Table 5.1 shows the EFOM results regarding primary energy supply[12]. The growth of total primary energy use is in both alternatives (without and with nuclear) lower than in the BaU-scenario. Allowing for some simplification this can be regarded as the (net) contribution of energy saving. The lower electricity price in KIO2* weakens somewhat the incentives to save energy, which is the main reason for a higher primary energy use in KIO2*. Similarly the use of biomass is larger in KIO1* than in KIO2*. In the BaU-scenario the absence of extra climate policies means that coal use grows about 60% up to 2015. This carbon intensive energy carrier shows logically the largest reduction in use, due to taxation and use limitations after 2010 in KIO1*. A winner in KIO1* is natural gas, of which the use does not increase in KIO2* compared to BaU. Natural gas is the most easy substitute for coal that contains much less carbon. Since this notion is valid throughout Europe demand will rise significantly in the whole continent, and consequently a price rise of natural gas is quite likely (as assumed in BaU). The use of oil in primary terms decreases in KIO2*, but goes up slightly in KIO1* relating to a temporary increase of oil use in the district heating sector. In both KIO1 and KIO2 oil use decreases for use in building heating systems. In transport there is a substitution trend from gasoline to diesel[13].

Table 5.1 *Primary energy supply (PJ) in BaU, KIO1* and KIO2**

		BaU			KIO1			KIO2		
Sectors	2000	2005	2010	2015	2005	2010	2015	2005	2010	2015
Electricity import	32	26	20	20	26	22	22	26	20	20
Hydro & wind	49	48	48	49	49	52	57	49	52	57
Nuclear	233	233	233	231	233	233	231	233	339	350
Biomass-wood	117	128	138	151	134	150	172	135	147	167
Pulping liquors	140	146	153	158	146	153	158	146	153	158
Reaction heat	7	7	7	7	7	7	7	7	7	7
Oil	363	381	371	356	374	379	357	375	355	341
Natural gas	144	167	189	199	188	241	255	182	184	197
Peat	80	75	75	75	75	75	75	75	75	69
Coal	162	215	239	260	165	55	49	175	113	99
Other	36	35	40	43	38	62	66	36	53	59
Total	1357	1460	1513	1550	1434	1429	1448	1438	1497	1523
CO_2 free share #	44,0	41,0	40,4	40,6	42,3	45,3	46,9	42,2	49,7	51,7

[12] . Skipping the transport fuel tax increase (-NONLV) causes minor changes, most of it in oil use. The same goes for the other variants except for the options without extra taxes (NONEV), in which there is less total demand, less biomass-wood, more oil use. Figures of the alternatives are given in Appendix 2.

[13] . This finding is borrowed from the VTT transport model Liisa.

#) This share is made up of: power import, hydro&wind, nuclear, biomass, pulping liquors, reaction heat and about 25%-50% of 'other' (share grows over time).

Figure 5.1 provides an overview of the emission reductions. In order to illustrate the overshooting the original KIO1 and KIO2 are added. In terms of average emission levels for the period 2008-2012 KIO1 is fairly near the target (0.2 Megaton lower than 1990 level) and KIO2 is overshooting it by 0.7 Megaton. If no transport fuel tax is imposed KIO1-NONLV is exactly hitting the target[14] and KIO2-NONLV overshoots it by 0.3 Megaton. Evidently by definition the KIO* and KIO-NONLV* alternatives are precisely fulfilling the reduction obligation. Comparing the various alternatives, notably the central ones (-NONLV*, -*, NONEV) the differences appear to remain in a small interval of less than 1 Megaton

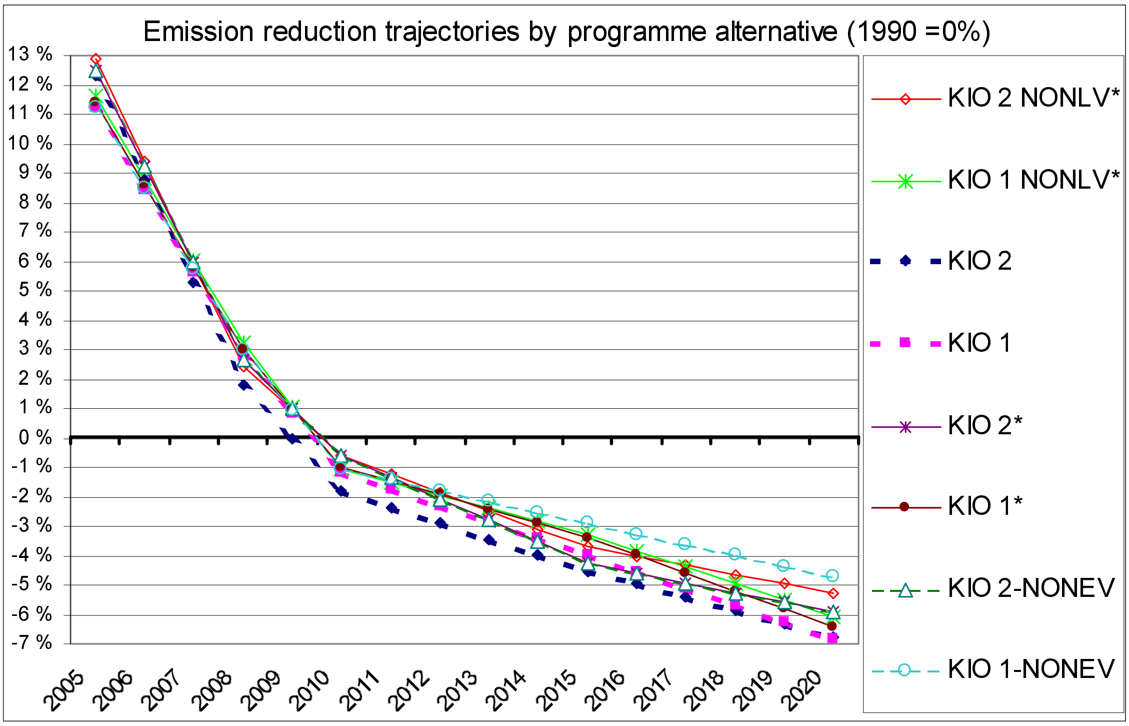


Figure 5.1 *Emission reduction trajectories for the programme alternatives*

5.2 Effects in terms of initial outlays[15]

EFOM calculates the initial outlays without effects of value added tax (VAT). By means of test runs in KESSU the impact on VAT revenues can obtained. This

[14] . This is the reason why KIO1-NONLV and KIO-NONLV* are the same (reminder: * meaning: less extra taxes to reduce the overshooting).

[15] . In this and upcoming chapters results in € are added in brackets behind the results in FIM. The Finnish markka amounts have been retained in the text in order to maintain comparability with the other publications regarding the Finnish Climate Strategy.

effect is added in the data input processing for definitive KESSU simulations. The total initial outlays ignited by the policy programmes amount in 2010 to 5.49 (0,92) billion and 7.46 (1,25) billion FIM (€) for KIO2* and KIO1* respectively. When adding the abolishment of an increase of transport fuel tax (and a bit more efforts elsewhere in KIO1-NONLV) the total initial outlays in 2010 are about 2,28 (0,38) billion FIM (€) lower in KIO2-NONLV* and 1,32 (0,22) billion FIM (€) lower in KIO1-NONLV*, compared KIO2* and KIO1*. In the NONEV variants the unchanged energy tax rates together with a reduced use of taxable energy carriers cause a loss in energy tax revenues.

Total initial outlays continue to increase after 2010 in all alternatives except the NONEV variants. Until 2010 the increments in annual outlays in KIO2-alternatives are significantly smaller than KIO1 alternatives. Subsequently, annual outlay increments decrease in both scenarios, but are larger in KIO2 than in KIO1. For the alternative without any tax increase (NONEV) the increments stay smaller in KIO2. Furthermore, it should be realised that the investment *mix* in KIO1 differs from that in KIO2, which affects the annualised cost patterns.

Table 5.2 *Initial outlays in billion FIM (1 € = 5,95 FIM)*

	KIO2*		**Taxes**	**KIO1***		**Taxes**
	2005	*2010*	*2015*	*2005*	*2010*	*2015*
Direct cost (investments)	2,13	3,59	4,22	2,63	4,20	4,76
Energy and electricity tax	0,15	1,49	1,99	0,30	2,76	3,14
Total	*2,3*	*5,1*	*6,2*	*2,9*	*7,0*	*7,9*
VAT		0,41			0,50	
Total including VAT		***5,49***			***7,46***	
	KIO2-NONLV*		**Taxes**	**KIO1-NONLV***		**Taxes**
	2005	*2010*	*2015*	*2005*	*2010*	*2015*
Direct cost (investments)	0,48	1,91	2,37	0,69	3,24	3,61
Energy and electricity tax	0,82	1,15	1,40	2,09	2,64	2,84
Total	*1,3*	*3,1*	*3,8*	*2,8*	*5,9*	*6,5*
VAT		0,15			0,26	
Total including VAT		**3,21**			**6,14**	
No tax increases –NONEV	**KIO2-NONEV**		**Taxes**	**KIO1-NONEV**		**Taxes**
	2005	*2010*	*2015*	*2005*	*2010*	*2015*
Direct cost (investments)	0,47	2,06	2,28	0,62	3,33	3,63
Energy and electricity tax	-0,18	-0,68	-0,81	-0,18	-0,77	-1,00
Total	*0,3*	*1,4*	*1,5*	*0,4*	*2,6*	*2,6*
VAT		-0,6			-0,6	
Total including VAT		***0,86***			***2,13***	

Since the predominant technical change for transport (the 5 litre car) is already included in the BaU-scenario, there are not much extra other cost besides taxation for the transport sector. It also means that the increased tax on transport fuels has fairly little effect. People can only decide to drive somewhat less, the switch to a more efficient car is already largely absorbed in the BaU-scenario. In case of no increase of transport fuel tax tariffs there occurs some tax revenue loss as the 5-litre car results in a decrease in total fuel sales. In the KESSU simulations all the extra cost for passenger car use are attributed to households. On balance the energy sector does not experience much extra cost. In KIO2 this means that an increase in investment cost is more than compensated by a decrease in fuel cost. In KIO1 the larger energy savings reduce the need for new capacity and hence higher fuel cost are compensated by lower investments, but sales also drop in KIO1. The latter means that therefore prices of delivered energy still rise in KIO1* and KIO1-NONLV and to a lesser extent in KIO2* and KIO2-NONLV*.

The purpose of energy taxation is that investments are incited that reduce energy use. In the beginning (2005) companies and households mainly pay taxes and have not yet invested much. Subsequently, investments start to increase and thereby energy use cost and tax payments are pushed down. However, since energy taxes increase stepwise there is still some growth in the total amount of taxes paid.

The alternatives KIO1* and KIO2* – in which the tax increase is reduced as far as allowed by the leeway of overshooting the emission target compared to the default KIO programmes – show that the taxes can be reduced quite substantially. It is an indication that the programme specific abatement supply curve is rather steep at that interval, meaning that large unit cost changes are needed to incite or skip a next abatement technology. It should be stressed that for the KIO alternatives the abatement supply curve is indeed programme specific. As the programmes contain quite some mandatory options (with somewhat different dosages per programme), the resulting abatement supply curve is not the default one that EFOM would use. It means that the optimisation is carried out in a biased regime. Therefore it is quite risky in this case to judge to what extent the KIO1*&2* alternatives are better than the standard KIO1&2. Furthermore, due to the tax recycling the differences in other outlays (the actual investments and the like) are more important than the amount of taxes pumped around through the economy. The way of recycling - though - will have some impact on eventual cost levels (see section 5.2).

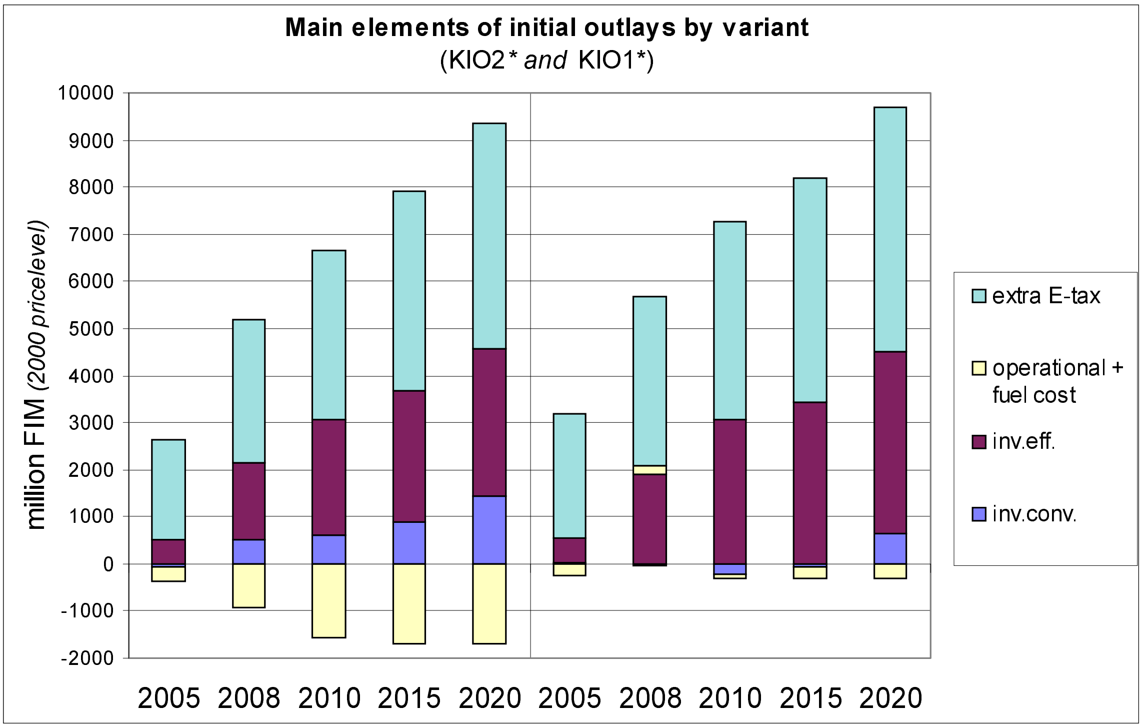


Figure 5.2a *Initial outlays by function in KIO1* and KIO2**

Legend:
1 € = 5,95 FIM

Extra E-tax:	total extra paid energy and electricity taxes
Operational + fuel cost:	extra cost due to fuel switching and other maintenance
Inv.eff.:	investments in energy efficiency
Inv.conv.	investments in energy conversion capacity (notably electricity generation and CHP/DH)

The figures 5.2a and 5.2b show the initial outlays distinguished by function. Figure 5.2a shows the results when transport fuel tax is increased, while figure 5.2b shows results when a raise in transport fuel tax is excluded. The patterns over time are largely the same, but the absolute levels differ somewhat. In all KIO2 alternatives occur extra investments in energy conversion capacity due to the construction of a nuclear power station. Whereas in all KIO1 alternatives the *net* efforts[16] are concentrated in energy efficiency investment. The cost impacts of renewables (included in conversion investment or operational & fuel cost) are on balance quite small.

[16] . At a more detailed level increases *and* decreases of investments are occurring within function categories 'operational + fuel cost' and 'investment in conversion capacity', therefore the term 'net'.

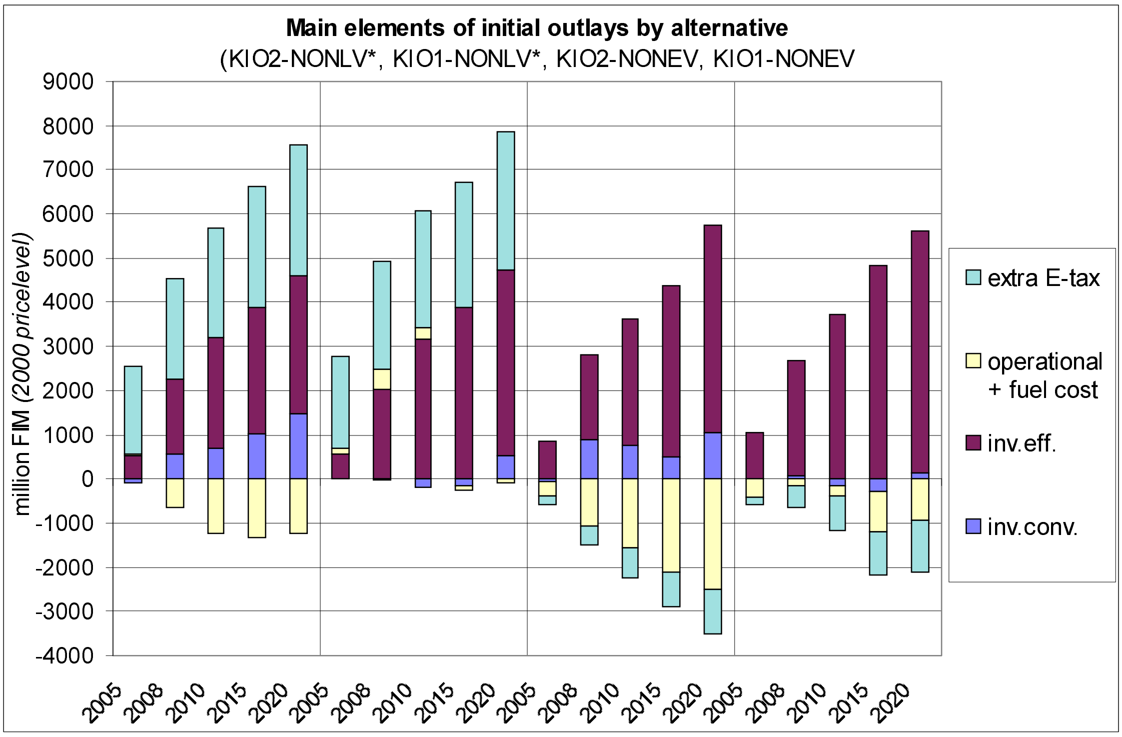


Figure 5.2b *Initial outlays by function in NONLV* and NONEV alternatives*

Though extensive discussions follow in the next section, it can already be seen that with tax recycling the net cost increases can be significantly lower than the initial outlays shown here.

The different policy programmes cause different cost distributions over sectors. Figure 5.3 provides an overview of compound outlays per sector for the entire period 2000-2020. Outlays have been discounted toward 2000 at a 5% rate. Taxes are not included given the intended recycling of energy taxes. In figure 5.3 one can see that the cost advantages of the KIO2 alternatives accrue mostly to the industry. Furthermore, it should be mentioned that the cost indications for the energy sector could be misleading since notably in KIO1 alternatives cost reduction comes along with reduction in sales.

The NONEV alternatives have some differences compared to the other programmes, for example both in the alternative with extra nuclear (KIO2-NONEV) and the one without extra nuclear (KIO1-NONEV).the energy conversion sector has less instead of more investments than in the BaU-scenario. Furthermore, notably in KIO1-NONEV services and to a lesser extent households experience significant higher initial costs than in the other alternatives.

The extra outlays for transportation in NONEV and NONLV alternatives relate to a larger influx of new technologies in the transportation sector. The differences look relatively large compared to KIO*, but one should realise that in the latter alternatives an extra amount of car fuel tax of approximately 40 billion FIM is paid in the same period. The transport sector in pictures 5.3 includes private cars.

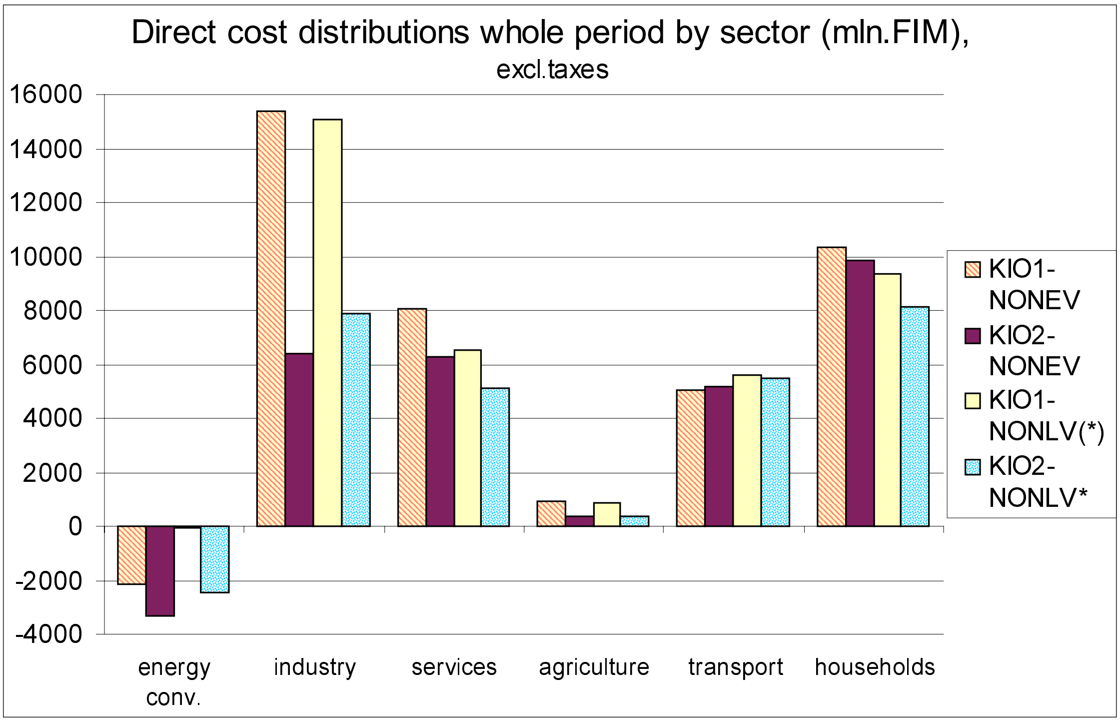


Figure 5.3a *Distribution of compound non-tax expenditures by sector 2000-2020*

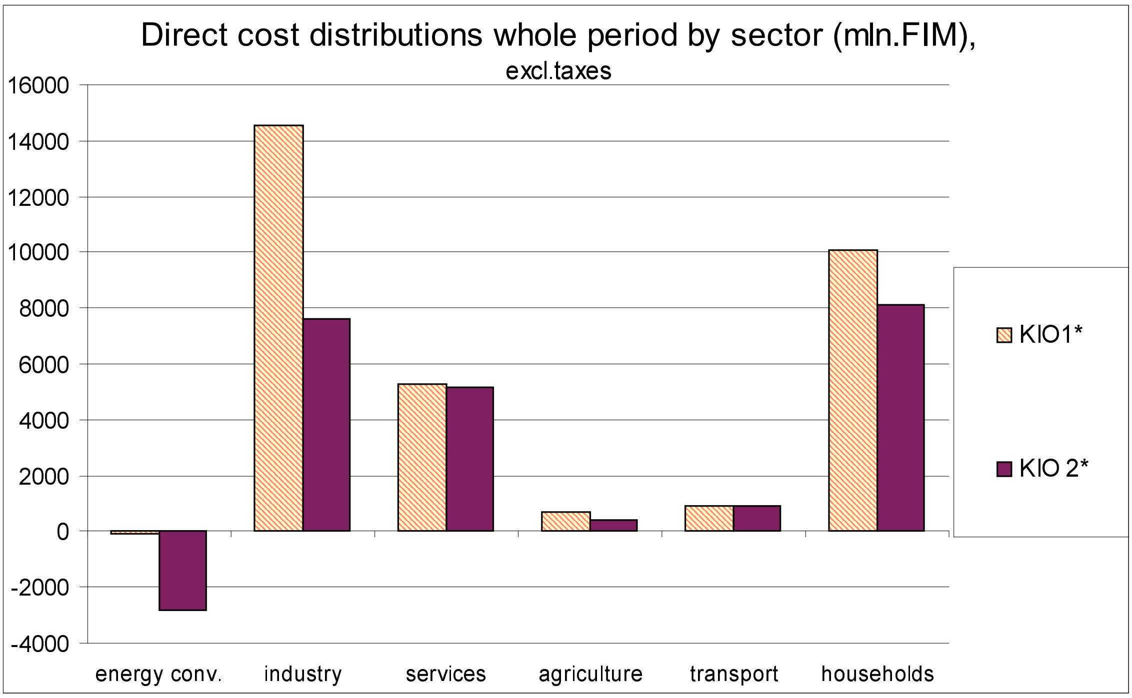


Figure 5.3b *Distribution of compound non-tax expenditures by sector 2000-2020*

5.3 KESSU results: macro-economic effects

5.3.1 Key macro-economic figures

After digestion of the effects through the whole economy and accounting for tax recycling the macro economic effects in terms of GDP are one and half to twice as large than the first line cost indicated by EFOM. Table 5.3 provides an overview of key figures. 0.1% of GDP equals approximately 1 billion FIM (~0,17 billion €) in 2010. While 0,1% of household consumption represents about 450 million FIM (~ € 76 mln.). The reason why percentage figures are to be preferred over absolute amounts is explained in 6.2.

Table 5.3 *Macro economic effects in percentage change compared to BaU-levels 2010 by main economic indicator, using mixed tax recycling (50/50)*

Indicators	**KIO1***	**KIO2***	**KIO1-NONLV***	**KIO2-NONLV***	**KIO1-NONEV**	**KIO2-NONEV**
GDP	-0,5	-0,4	-0,5	-0,3	-0,6	-0,5
Private consumption	-0,9	-0,8	-0,8	-0,6	-1,2	-1,0
Investments	-0,5	-0,4	-0,6	-0,5	-0,9	-0,7
Export	0,0	0,0	-0,1	0,0	0,1	0,1
Import	-0,2	-0,2	-0,3	-0,2	-0,3	-0,2
Employment (manyears)	-9000	-7000	-8000	-6000	-11000	-9000
Sectoral changes in production level	**KIO1***	**KIO2***	**KIO1-NONLV***	**KIO2-NONLV***	**KIO1-NONEV**	**KIO2-NONEV**
Agriculture	-0,47 %	-0,29 %	-0,47 %	-0,33 %	-0,54 %	-0,40 %
Paper and pulp	-0,40 %	-0,20 %	-0,40 %	-0,20 %	-0,30 %	-0,10 %
Basic metal	-0,20 %	-0,10 %	-0,20 %	-0,10 %	-0,10 %	0,00 %
Chemicals	-0,40 %	-0,20 %	-0,40 %	-0,30 %	-0,30 %	-0,20 %
Other industry	-0,18 %	-0,14 %	-0,23 %	-0,14 %	-0,15 %	-0,14 %
Energy sector	-1,90 %	-1,50 %	-1,90 %	-1,60 %	-2,00 %	-1,70 %
Commercial services	-0,47 %	-0,42 %	-0,38 %	-0,31 %	-0,59 %	-0,48 %
Social services	-0,50 %	-0,40 %	-0,70 %	-0,50 %	-1,10 %	-0,90 %

N.B. *In the NONEV variants tax recouping is necessary, which in this case is done via income tax only*

The results shown are based on mixed recycling, meaning that 50% of the net excess revenues[17] is returned via income tax and 50% by lowering of the social security contributions of the employers. In KIO1* use of 100% recycling through income tax means that GDP and private consumption would decrease 0.1% less (see Appendix 2). The same recycling option in KIO2* would also imply 0,1% less decrease of GDP. In other programme alternatives this effect is too small to

[17] . The decreases in production levels throughout the economy cause decreases in income tax and VAT revenues. Therefore the net available recyclable amount is smaller than the extra energy tax revenues.

become visible due to small amounts of recyclable excess tax revenues (NONLV*) or is irrelevant (NONEV). Given the problematic treatment of transport in the study (see also footnote 9) the benefits of no extra fuel tax may be underestimated. Furthermore, the transport fuel tax increase has large influence on the way the cost distribution works out over various types of households (see next section 5.3.2).

The various ways of tax recycling do not result in very big differences in macro-economic key figures, since the amount of recyclable excess tax represents up to 0,5% of the total tax revenues.

The alternatives in which the tax instrument is abolished (-NONEV) do indeed create higher macro-economic cost, as is in line with economic views on this point. The heavy industry suffers slightly less reduction of production value, but services and households (in which the abatement cost are higher on average) face significant extra cost. It is the only alternative in which the reduction of aggregate private consumption goes beyond –1%. Next to the loss of an efficient policy instrument, a second important cause for the larger reductions is the need to recoup taxes. The combined effect of no increase in any energy tax and energy savings compared to the baseline (BaU) result in reduced tax income, which is somewhat aggravated by some loss in VAT revenue as well. Given the balanced budget principle recouping is necessary by increasing another tax. In this case we have assumed that the income tax is raised somewhat. Raising VAT would presumably give similar results.

The employment consequences seem to be limited in all alternatives. It is fair to say that especially for this indicator the uncertainty range is fairly large. The differential effect between the KIO1 and KIO2 alternatives is in the order of magnitude of 1000 to 2000 person years, which in percentage terms amounts to 0,05% - 0,1% of employment.

Some background clarifications

Considering the overall picture of the results (with 50/50 recycling) it is clear that the effects on GDP are larger in the alternatives without extra nuclear capacity (KIO1 alternatives) than in the options including one extra nuclear unit (KIO2 alternatives). This can be largely attributed to larger reductions in industry and slightly in services, while households seem to be by and large equally well off in several variants. At the individual household level the difference between inclusion and exclusion of extra nuclear translates into a cost difference of about 270 FIM (€ 45) per year (KIO* alternatives) to 420 FIM (€ 70) per year (KIO-NONEV alternatives)[18]. Variation across household types is significant though

[18] . In case of recycling 100% via income tax in KIO* alternatives the difference is 190 FIM (€ 32) per year.

(see next section 5.3.2). Another difference between KIO1 and KIO2 variants is that the costs in KIO2 variants tend to grow slower over time, whereas the costs in KIO1 variants tend to increase faster in the considered period[19]. Besides a generally somewhat lower energy cost impact this effect is also attributable to the long economic lifetime of the new nuclear unit in KIO2 alternatives compared with the generally shorter economic lifetime of other investment options to which is more resorted in KIO1 alternatives. Since the input to KESSU is based on annualised cost flows there is a more mitigating influence in KIO2.

The fact that services may experience the similar percentage reductions in value added as the industry is perhaps surprising. This can be explained by distinguishing two main mechanisms through which the KIO programme works out on the economy. In the first place there are the costs caused by the incited measures (investments, fuel switching, etc.). In KIO2 alternatives the need to incite the industry to do a lot more on top of the other measures (in buildings etc.) is not so large, due to extra nuclear capacity. In KIO1 alternatives however there is more need to do so (hence the lower overall energy use) due to the absence of extra nuclear. This explains – for a start – that there are lower cost for the industry in KIO2 compared to KIO1, but that cost levels for households and services differ less between KIO1 and KIO2 alternatives (see also figures 5.3a and 5.3b).

The second mechanism concerns the public finance aspects of the programme, notably the treatment of the extra tax revenues. Given the balanced budget principle they are recycled, corrected for revenue losses in other taxes and net subsidy effects (see also footnote 16). The more money is recycled the more it counts to whom it is recycled, since the restored purchasing power will have much more stimulating effects in some sectors than in others. The amounts available for recycling vary over the programme alternatives. Generally they are larger in KIO1 alternatives compared to KIO2 alternatives. Additionally, the non increase of transport fuel tax reduces the recyclable amount and similarly the KIO* variants have less to recycle than the default KIO programmes. It appears that in the KESSU model recycled taxes cause barely extra activities in the industries if directly returned to them via social security payment cuts. As explained in section 2.3 the labour market features in KESSU are simple and consequently KESSU is not very responsive to this type of signal. It is however also true that in the industry the fixed relations between installed machinery and required labour force mean that, with small changes in relative prices of labour and in absence of clear demand stimuli, inclinations to hire extra labour are low.

All in all it means that the changes in the production levels of services end up to be fairly equal in KIO1 and KIO2 though for different reasons. In KIO2 cost

[19] . The 'considered period' is a relevant precision here, we turn back to this later in this section and also in Appendix 4.

increases are lower, which will cause marginally less production loss in services, More importantly production decreases of the industry are smaller, meaning that demand for business services remains almost unaffected. However, as the demand reduction for households is almost the same, consumer oriented services are by and large in the same situation in both programmes. In KIO1 on the other hand business oriented services will notice a bit more reduction in demand as industry shows a bit more contraction compared to the BaU scenario. This is compensated due to tax recycling which repairs a part of the consumer demand.

It should be noted that effects could be more negative, since the sector distinctions in KESSU may not reflect sufficiently the cost increases in the most energy intensive parts of for example the basic metals and paper industries. For example the results of the ETLA model[20] show indeed more distinct differences between sectors. The averaging effect following from lack of disaggregation may lead to underestimation of shedding of marginally profitable production capacity. Ultimately this would mean a bit more reduction in exports and GDP. The leeway for this effect is however limited, since energy and electricity tax payments, in as far as surpassing 3,7% of the value added of a company, are reimbursed for 85%, except if the reimbursable sum is less than 300.000 FIM.

Another point is the possibility for price discrimination in the energy markets. In as far as possible (i.e. as far as allowed by the competition authorities) energy companies will choose an attribution of the cost increases in such a way that captive customers and/or customers with low price elasticities carry a disproportionate share of the cost increase. In practice this would mean that the costs for heavy industries would be lower than calculated here (and hence less shedding of production capacity), while the costs for services and households would be higher. In this case the ultimate effect on GDP, private consumption, etc. is less easy to portray without detailed specifications of the attribution alternatives. The models used in the study have been run without price discrimination behaviour as described above. All electricity prices are increased according to the average increase of production cost.

Next to possibilities for underestimating and misallocating the costs, there are also opposite considerations that hint at the possibilities that the costs are actually lower. As indicated in section 2.3 KESSU reacts rather defensive. In reality companies may be expected to anticipate developments and thereby neutralise some of the cost increases, among others through offensive strategies that involve product mix changes. It would mean that for a part of the exports the prices could be risen slightly and consequently the buyers on foreign markets would pay a part of the costs of the KIO programme. This would be a deviation from the default assumption in the BAU scenario (see page 18, last bullet) Of course producers in other countries may sometimes be capable as well to 'export'

[20] . See Forsstöm and Honkatukia 2001.

part of their climate policy cost. So, one is preferably cautious with expecting to be better off. In this context it can be also reiterated (see section 2.6) that the growth of industries and services that are involved in renewable energy and energy saving technologies may experience a boost in activities due to climate policies throughout Europe. This causes scale effects that can reduce the unit cost of efficiency measures in the domestic programme. Another reason for a modest downward correction of the economic impacts are alternative ways to assess the investment finance cost (see also Appendix 4).

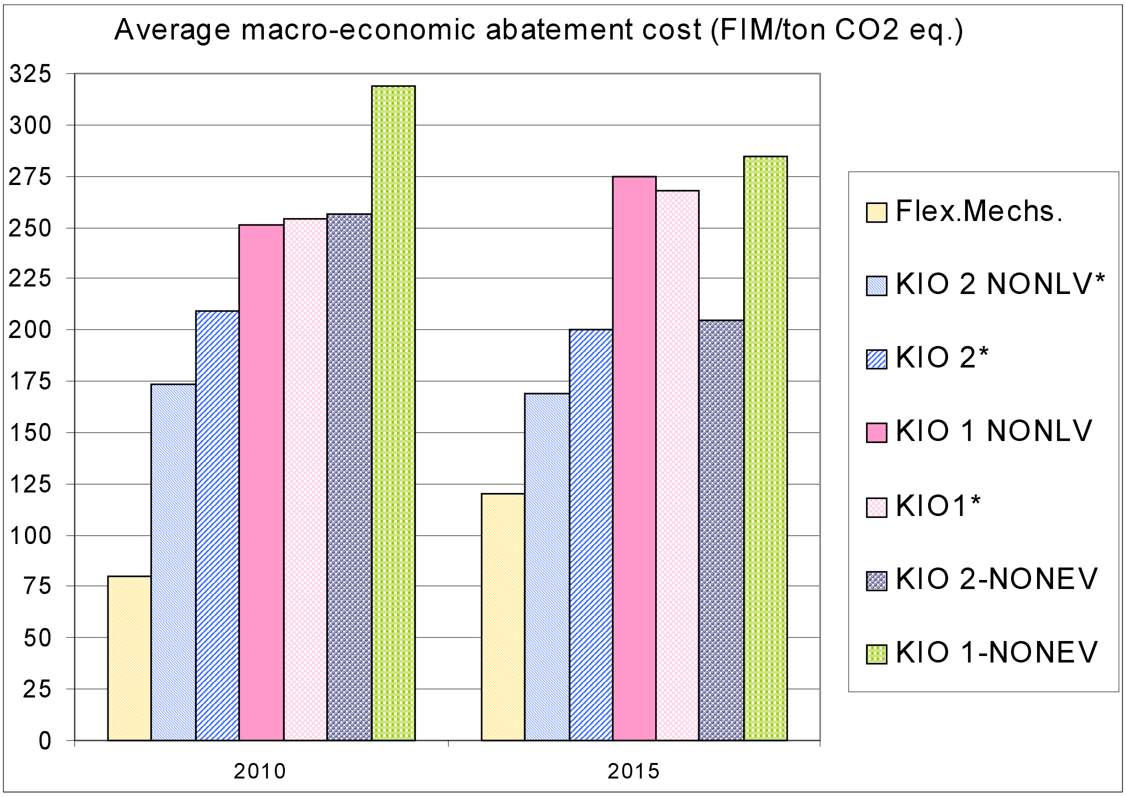


Figure 5.4 *Average macro-economic abatement cost per ton CO_2-equivalent*

The most compact way to compare the cost-efficiency of the programme is by comparing the abatement cost per ton of CO_2-equivalent. Figure 5.4 gives an overview of the macro-economic cost (GDP change) per ton in 2010 and 2015. The average macro-economic cost per ton remain about the same in KIO2 alternatives, but increase in the KIO1 alternatives. Another interesting message is that in the long run the macro-economic cost per ton in the NONEV variants start to approach the level of each of other KIO1 and KIO2 alternatives. The reasons for this relatively improving long run prospect in the NONEV variants are that tax recycling gets less important in the long run and the larger initial efforts in energy efficiency etc. start to pay off more. Please notice that the total cost (=absolute GDP change) are still increasing in all alternatives, since the total amount abated continues to grow.

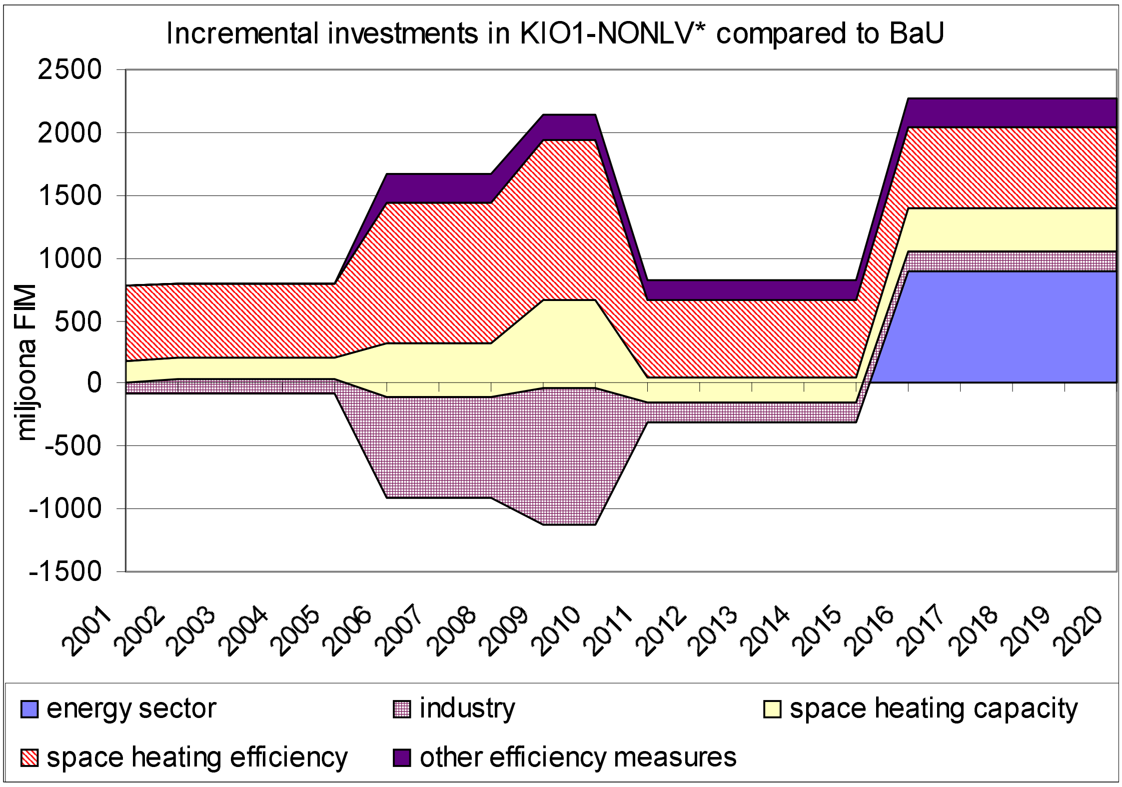


Figure 5.5a *The differential investment outlays in KIO1-NONLV* (million FIM)*

The time profile of the extra investments (or reduced investments in some cases) gives a better impression of the actual timing of the (start of) efforts. Figures 5.5a and 5.5b show these flows for KIO1-NONLV* and KIO2-NONLV* by sector and main type of purpose. In KIO1-NONLV1 there is not only *extra* investment in relation to space heating capacity and efficiency but also *reduced* investment in the energy sector up to 2015. Between 2011 and 2015 there seems to be *on balance* a slump in overall extra investments notably in KIO1-NONLV*. After 2015 extra investments increase substantially in KIO1-NONLV*. In KIO2-NONLV* there is an obvious peak in the years up to 2008 due to the realisation of a new nuclear unit. The reinforcements needed after 2015 are milder than in KIO1-NONLV*.

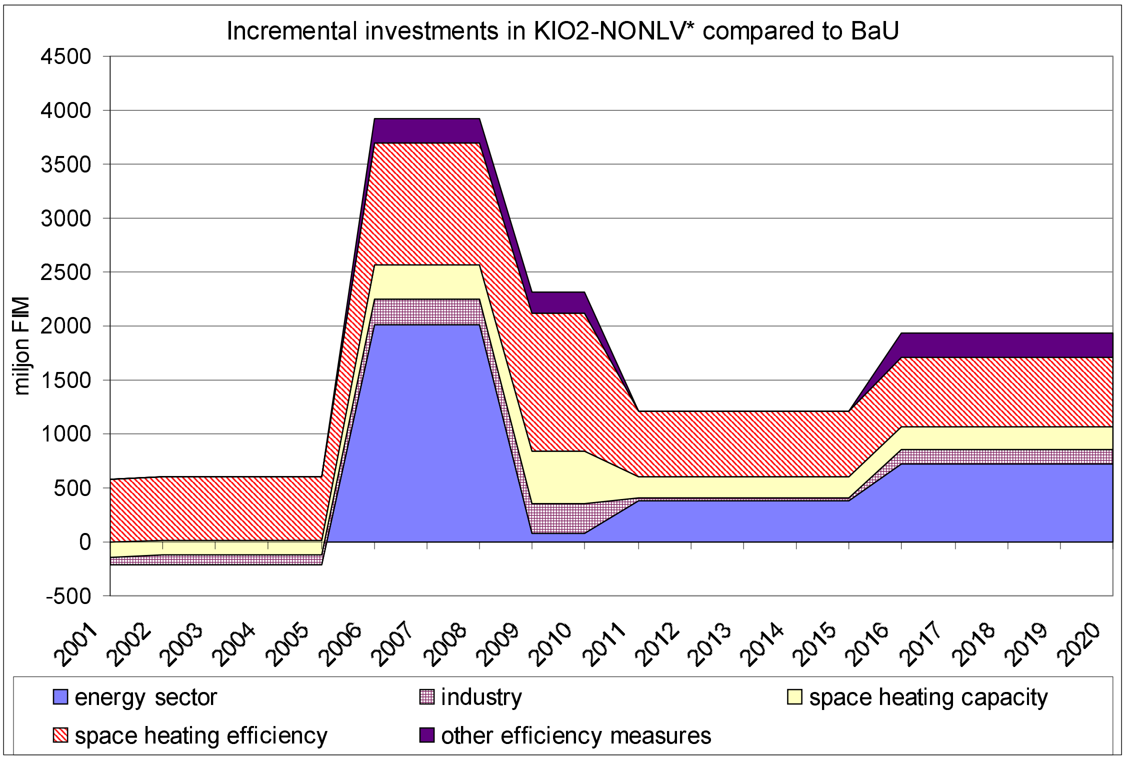


Figure 5.5b *The differential investment outlays in KIO2 (million FIM)*

5.3.2 Variation in outlays for households

Introduction

The average impacts at the level of the individual household can be easily derived from the KESSU results. For example in KIO2-NONLV* the average after recycling cost per household amount to approximately 1200 FIM (€ 200) per year, whereas for KIO1-NONLV* this figure reaches approximately 1600 FIM (€ 300).

However we want to know whether the *variation* around these averages is significant. The variation in outlays over households is to a large extent determined by the following variables:

- Dwelling type and size, and energy qualities (insulation, optimal use of daylight and sunshine)
- Heating system
- Car ownership

The first and the third variable correlate with income level, but the correlation is far from perfect. In order to obtain a good impression of the variation in effects, one needs first to calculate the cost impacts for a variety of combinations of the variables mentioned above. Subsequently, one can try to investigate how many households are fitting to each of these combinations and what there income is.

The extra expenditures of the climate policy for households consist of:

- increased energy bills (partly due to energy tax, partly due to investment outlays in the energy sector);
- increased cost of housing (due to investments in insulation and in the heating system in existing homes as well as due to higher purchase costs or rents of newly built dwellings);
- increased fuel cost for car use and other transportation;
- increased cost of other products and services

The extra expenditures of the last item can be assessed only in very generic terms. The cost increase for other products (i.e. other items than energy, housing, and transport) will be small, on average about 0.25%. For an average household in 2010 this may amount to approximately 300 FIM (€ 50) extra expenditures per year. Below first the variation in direct energy costs will be assessed, subsequently the other costs are included with some differentiation by household type. This allows us to check overall cost variations by household type for various dwelling-heating system-car use combinations.

Assessment of the variation

With the aid of small simulation model (Statistics Finland – Energy Game), in which energy use by household type and dwelling type etc. can simulated, the variation in extra costs for households have been scanned. The model calculates annual consumption in physical units on which current and future prices can be applied to obtain cost increases. The extra costs for housing due to insulation and other measures are taken from the EFOM results. The assesment of the variation focuses on household and home type combinations and variations in car ownership and use.

In the model the following variables have been used:

Variable name	Occurrence of alternatives
• Adults (Nr. of)	2
• Children (Nr. of)	0 or 2
• Dwelling type	detached or apartment
• Floor space	detached: 120m^2; apartment:75 or 80 m^2
• Building year	before or after 1975
• Heating system	electricity, district heat, heating oil and wood

The age of the building is a simple proxy for energy quality of the dwelling *given* its type and size. As regards electricity consumption for non heating purposes the number of household members and the ownership and use of several appliances has been taken into account (washing machine, dishwasher, micro-wave, cooking range, fridge and freezer, TV set and stereo, sauna, and illumination).

As regards car ownership and use there is assumed that for each of the combinations of the above mentioned categories there are five options:

- No car (of all households in 2010 between 25% and 30% will not own a car)
- Old car (that is no 5-litre car); 12000 km/year
- 5-litre car; 12000 km/year
- Old car (that is no 5-litre car); 20000 km/year
- 5-litre car; 20000 km/year

The annual distance of a Finnish car is about 19000 km. This amount is not evenly distributed. Private cars that are also professionally used have mostly a higher mileage, whereas many other households drive less than 15000 km/year. The resulting variations per combination were multiplied by the expected price increases of gasoline, electricity, district heat and heating oil. Table 5.4 shows the results for KIO1*. The results for KIO2* show largely the same spread but levels are about 100-200FIM (€ 17 - € 34) lower depending on the dwelling-car use combination.

The figures in table 5.4 show clearly that the increase of transport fuel tax causes large variations. In 1998 about 65% of all households own at least one car, while 19% of the car owning households have more than one car. Cost levels vary in an interval of about 1700 FIM (€ 286). If however the wood heating option is ignored the interval is about 1200 FIM (€ 200). As a rough approximation we can assume that the extra cost (before saving measures and recycling!) are 1400 FIM (€ 235) in KIO1 and 1250 FIM (€ 210) in KIO2.

In order to assess the overall cost effects for households we have to take into account that there are also extra housing cost and there are energy savings due to the measures taken. The extra cost related to housing are rated at approximately 280 FIM/year (€ 47) in the year 2010. (see appendix 2). For households the differences between the programme alternatives are small as a large part of the measures in the building stock is more or less prefixed.

The cost increases for public transport are rated at 100 FIM per year. Since there are also plans to stimulate public transport, cost increases due to the climate programme may be not translated into price rises or for example at least not for captive customers. Cost increases for other goods are very small in percentage terms, but given the big share in the total expenditures of households, it still constitutes an annual sum that has to be taken into account. The amounts are summarised below.

Table 5.4 *Annual cost distinguished by dwelling characteristics and car ownership and use in FIM per household, before tax recycling (1 FIM = € 0,168)*

KIO1*				12000km	12000km	20000km	20000km	2 cars	
home type	floor space	Building year	heating system	old car	5-ltr car	old car	5-ltr car	old + 5ltr	no car
Apartment	80	>1975	DH	1140	1010	1520	1300	1870	580
Apartment	80	>1975	Elec.	1190	1070	1570	1360	1920	630
Apartment	80	>1975	Oil	1140	1020	1520	1310	1870	580
Apartment	80	>1975	Wood	670	550	1050	840	1400	110
Apartment	80	<1975	DH	1260	1140	1640	1430	1990	700
Apartment	80	<1975	Elec.	1360	1230	1730	1520	2080	790
Apartment	80	<1975	Oil	1230	1100	1600	1390	1950	670
Apartment	80	<1975	Wood	670	550	1050	840	1400	110
Detached	120	>1975	DH	1140	1010	1520	1300	1870	580
Detached	120	>1975	Elec.	1310	1190	1690	1480	2040	750
Detached	120	>1975	Oil	1140	1010	1520	1300	1870	580
Detached	120	>1975	Wood	690	570	1070	860	1420	130
Detached	120	<1975	DH	1440	1310	1810	1600	2160	880
Detached	120	<1975	Elec.	1500	1380	1880	1670	2230	940
Detached	120	<1975	Oil	1290	1160	1660	1450	2010	730
Detached	120	<1975	Wood	690	570	1070	860	1420	130

Based on data of Statistics Finland concerning the distribution of the population and its net disposable income by dwelling type and car ownership, a fairly accurate picture could be calculated of the burden distribution by household type. Table 5.5 summarises the result for KIO1*. These figures are based on the population *structure* and its distribution over dwelling types in 1998. Net income levels have been corrected for economic growth up to 2010. Car ownership is kept at the 1998 level, which supposedly is 5%-7% points under the 2010 ownership rates.

In absolute terms the highest after tax cost can be found among families with employed or employable people living in detached homes. In terms of share of income the largest effects (burden) can be found among families with employed or employable people living in apartments. The reasons for this shift from one type to the other are in the first place the lower income levels of the latter group, among others also due to a higher share of unemployed. An additional reason is that car ownership among this group is still fairly near the average. So, the increase in car fuel tax still really counts for this group. All households with losses of more than 1% of purchasing power in KIO1* together represent about

9% of the studied household dwelling combinations[21]. Moreover in this exercise effects of automatic repair of excessively high housing cost, as specified in the social security system, have not been taken into account.

Table 5.5 *Cost distribution by household type and dwelling type accounting for car ownership rates by household type in 2010 (1 FIM = € 0,168)*

KIO1* after tax recycling					% loss of purchasing power		absolute costs in FIM	
home type	floor space	b.year	heating syst	Number of households	pens/stud	employed	pens/stud	Employed
Apartment	80	>1975	DH	131000	0,59 %	1,18 %	536	796
Apartment	80	>1975	elec.	3000	0,69 %	1,29 %	609	852
Apartment	80	>1975	oil	78000	0,68 %	1,27 %	533	841
Apartment	80	>1975	wood	100	0,02 %	0,64 %	19	377
Apartment	80	<1975	DH	661000	0,73 %	0,65 %	670	1070
Apartment	80	<1975	elec.	10000	0,94 %	0,76 %	773	1209
Apartment	80	<1975	oil	105000	0,77 %	0,74 %	636	1087
Apartment	80	<1975	wood	4000	0,13 %	0,38 %	94	475
Detached	120	>1975	DH	5000	0,50 %	0,78 %	910	1151
Detached	120	>1975	elec.	39000	0,77 %	0,98 %	1078	1407
Detached	120	>1975	oil	17000	0,62 %	0,83 %	947	1257
Detached	120	>1975	wood	14000	0,39 %	0,61 %	464	831
Detached	120	<1975	DH	38000	0,63 %	0,54 %	1112	1543
Detached	120	<1975	elec.	313000	1,03 %	0,67 %	1141	1667
Detached	120	<1975	oil	234000	0,76 %	0,58 %	1000	1465
Detached	120	<1975	wood	214000	0,32 %	0,46 %	295	891

5.4 Sensitivity analysis

5.4.1 Introduction and case selection

In an earlier stage of the study a range of sensitivity analyses have been carried out regarding (1) Reduction target 2020, (2) Electricity import, (3) Higher capital cost, (4) Programme flaws, and (5) Flexible mechanisms.

The effects of programme flaws were very limited (given the limited choice of obviously unsure programme parts). Also the effects of extra capital costs were fairly limited in the earlier assessment[22]. The items 3 and 4 were therefore skipped in the final round of sensitivity analysis. On the other hand the impacts of another growth path are added to the list.

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[21] . The total average cost per household of the sample above are not the same as the total average derived from KESSU results for a host of reasons. The data overview above should be only used for the purpose of illustrating the variation of cost over households.

[22] . The aspect of alternative bases for valuing finance cost of investments is dealt with in Appendix 4.

The sensitivity analyses (except the growth variant) are applied on the programme alternative without transport fuel tax and reduced extra energy taxation where possible (the NONLV* variants). Perhaps with the exception of the NONEV variants we do not expect essentially different messages when applying the sensitivity studies to all variants. The sensitivity analyses are carried with the EFOM energy systems model only. Given the earlier experiences with the main programme alternatives, there is sufficient information to infer whether the changes are likely to be significant in macro-economic sense.

Four sets of sensitivity variations are carried out. One set (-SEF) combines the effect of larger possibilities to import electricity with the availability of international emission permit trade. The next set (-SR) refers to tightening of the climate policy due to inclusion of a next target in 2020 (-15% compared to 1990 level). The third set (SREF) is combining the two previous occasions. A last set (SG) is testing the implications of a somewhat different growth curve, which leads to the same aggregate level of GDP in 2025, but differs from BaU by having higher rates before 2010 and lower rates after 2010. It means that the GDP level in 2010 is about 4% higher than in the normal BaU, while the difference is almost vanished in 2020. It also means that the reduction task increases from 16 to 18 Megaton CO_2 –equivalent in 2010, while this increase has vanished in 2020.

Table 5.6 *An overview of performed sensitivity analyses*

Item:	**Programmes and 4 sets of runs**							
	KIO 1 -SEF	**KIO 2 –SEF**	**KIO 1 -SR**	**KIO 2 -SR**	**KIO 1 SREF**	**KIO 2 SREF**	**KIO 1 -SG**	**KIO 2 -SG**
Reduction target 2020 (-15%)			X	X	X	X		
Electricity import Max 15TWh	X	X			X	X		
Alternative growth trajectory							X	**X**
Flexible mechanisms	X	X			X	X		

The alternatives with flexible mechanisms (tradable permits from Joint Implementation JI and international permit trade IET) is handled in the following way:

We assume that the Finnish state is the only trading partner outside Finland and takes part in a once-a-year auction, in which it manages to buy IET based permits. We assume 2 Megaton in 2008 and 4 Megaton in 2010. In addition project based Joint Implementation implies a gradual build-up of permits, resulting in 0,5 Megaton in 2005 and 1 Megaton in 2010. Similarly, the figures are 5+1 Megaton and 5+2 Megaton in 2015 and 2020 respectively (relevant for the variants in which there is an obligation in 2020). Both permit types (which are – once obtained – interchangeable in resale) have the same average price level of 80 FIM/ton (€ 13/ton) in 2005 and 2010 and 120 FIM/ton (€ 20/ton) in 2015 and 2020.

After the purchase there is in fact a truncated target (the original reduction – purchased permits), however instead of straightaway relaxing the emission reduction with the volume represented by the permits an approach has been followed that tries to keep the mandatory parts of the climate programme as much as possible in tact. To this end the following procedure has been followed in case the sensitivity analysis includes permit trade:

1. the increase of the energy tax can be lowered down to the point where the total energy tax revenues in 2010 and 2015 are the same as in BaU plus the permit cost in the corresponding year;

2. if criterion 1 does not prevent emission reduction of being larger than 17 Megaton, the investment efforts related to the Renewable energy programme (UEO) and the Energy saving programme (ESO) are reduced with 10% at maximum.

Appendix 2 contains graphs of the applied tax ratings in the sensitivity runs compared to the KIO-NONLV* alternatives.

5.4.2 Sensitivity analysis results

The sensitivity run with a tighter target in 2020 (SR) shows very similar results for 2010 in both programmes. Furthermore, the differences with KIO1-NONLV* are small in 2010. In 2020 the SR alternative shows larger deviations, as notably the use of renewables becomes larger compared to KIO-NONLV* programmes. Also total primary energy use is slightly lower in KIO1-SR from 2010 onwards and in KIO2-SR in 2020, implying an increase in energy saving.

The sensitivity run 'SREF' with both a tighter target and unrestricted power import potential + permit trade shows more changes also in 2010. Firstly, in KIO1 power trade seems to be beneficial indeed when available., while in KIO2 it does not have an impact. The penetration of natural gas builds up slower in KIO1-SREF as the ban on coal is abolished. Overall primary energy use is a bit higher than in KIO-NONLV*.

Table 5.7 *Primary energy supply in two sensitivity analyses and KIO-NONLV**

Sectors	KIO1 2010	KIO2 2010	KIO1-SR 2010	KIO1-SR 2020	KIO2-SR 2010	KIO2-SR 2020	KIO1-SREF 2010	KIO1-SREF 2020	KIO2-SREF 2010	KIO2-SREF 2020
Electricity import	22	20	22	22	20	22	29	38	20	20
Hydro & wind	52	52	52	66	52	66	52	66	52	66
Nuclear	233	342	234	228	347	346	233	228	332	346
Biomass-wood	155	147	151	195	147	190	141	168	126	166
Pulping liquors	153	153	153	163	153	163	153	163	153	163
Reaction heat	7	7	7	7	7	7	7	7	7	7
Oil	380	361	386	325	362	322	373	344	364	333
Natural gas	241	186	231	213	182	203	200	241	187	202
Peat	75	75	75	62	75	62	75	75	75	73
Coal	54	108	57	32	108	41	126	51	134	87
Other	62	53	61	81	54	72	54	74	52	67
Total	1434	1503	1428	1394	1506	1494	1443	1455	1501	1531
CO_2 free share #	45,5	49,7	45,5	51,8	50,0	55,6	44,5	48,6	47,7	52,4

#) This share is made up of: power import, hydro & wind, nuclear, biomass-wood, pulping liquors, reaction heat and about 50% of 'other'.

The sensitivity run with only unrestricted import potential + permit trade (SEF) has by and large the same energy supply mix as SREF.

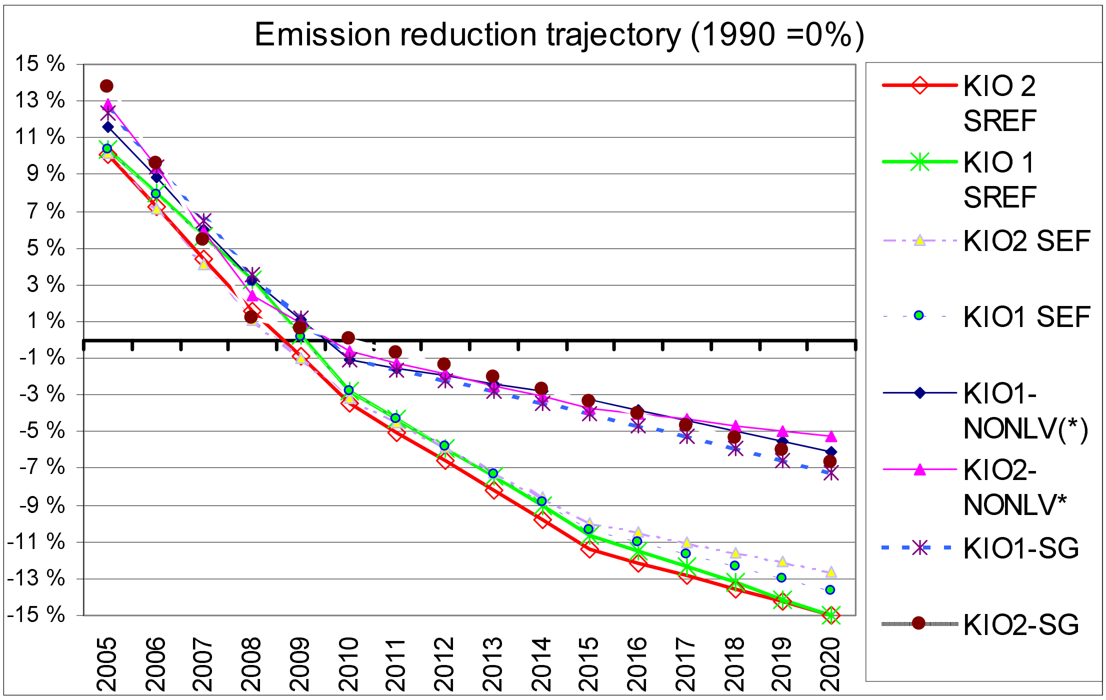

Fig 5.7 *Emission reduction trajectories in sensitivity runs and KIO1&2**

The emission reduction trajectory in SREF is largely predetermined by the targets in 2010 and 2020 and by the way the purchase of permits is added to the programme options. In SEF (more power trade potential + permit trade) only the 2010 target is applied, nevertheless also in that alternative the emissions reduce almost to the same level as in SREF given the criterion that the permit trade should not entirely crowd out domestic measures (see 5.3.1). The percentage change in SG (higher growth than BaU up to 2010, lower growth afterwards) does not exactly represent the same volume as in the others, since the gap increases between 2000 and 2010 (with a maximum of 2 Megaton extra in 2010). Given the higher growth the curve gets steeper before 2010, while it flattens strongly after 2010, notably in the variant including extra nuclear capacity.

In figures 5.8 – 5.9 the sensitivity analysis results are compared with the NONLV alternatives from which SEF and SREF are derived. The effects are generally stronger for the option without nuclear (KIO1) than with extra nuclear (KIO2), though in SREF also the option including nuclear shows more changes. In all sensitivity alternatives the initial outlays are smaller than in the KIO-NONLV* alternatives. This has two reasons. Firstly, tax rates are lower than in KIO* in SEF and SREF because of the permit trade. Secondly, in KIO1&2-SEF and in KIO1-SREF the extra investments in energy conversion and energy efficiency are smaller compared to the efforts in the NONLV* alternatives from which they are derived. In a relative sense the reductions in investments in conversion capacity in the SEF and SREF alternatives are a larger, notably in the alternative without extra nuclear.

On the basis of the results for initial outlays one can expect that in SEF and SREF impacts on GDP and household consumption in case of KIO1-SEF&SREF are a bit smaller than in KIO1*. For KIO2-SEF&SREF no remarkable changes should be anticipated compared to KIO2 *.

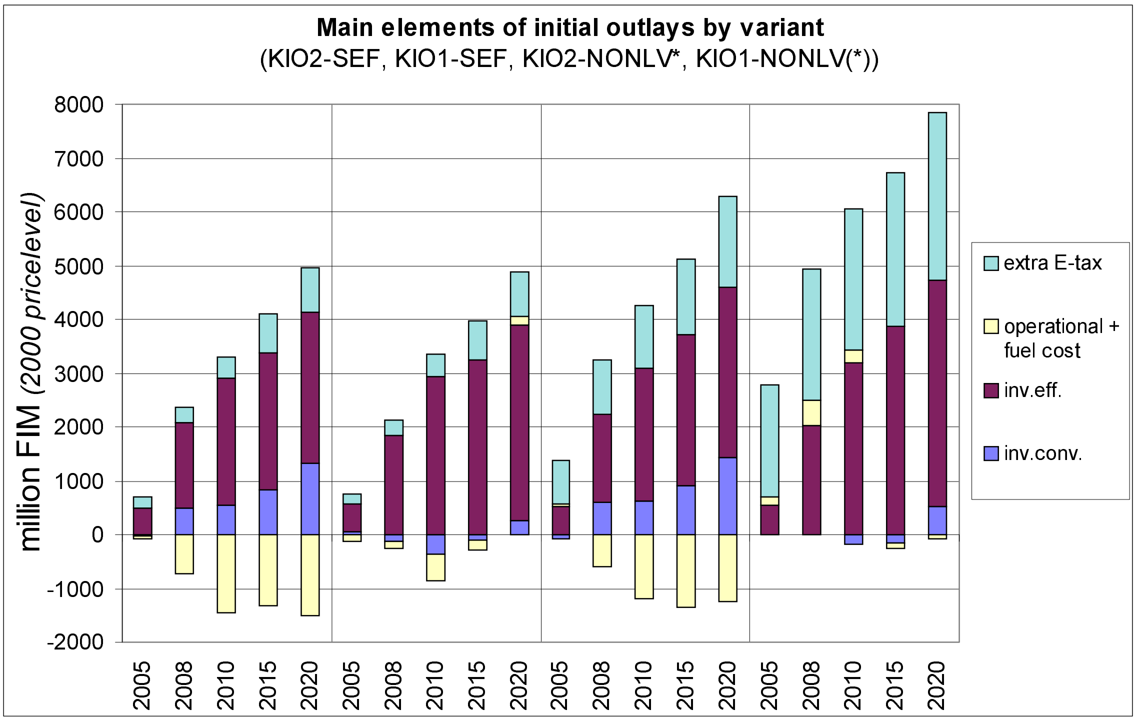

Figure 5.8 *Initial outlays by main purpose in KIO-SEF compared to KIO-NONLV*

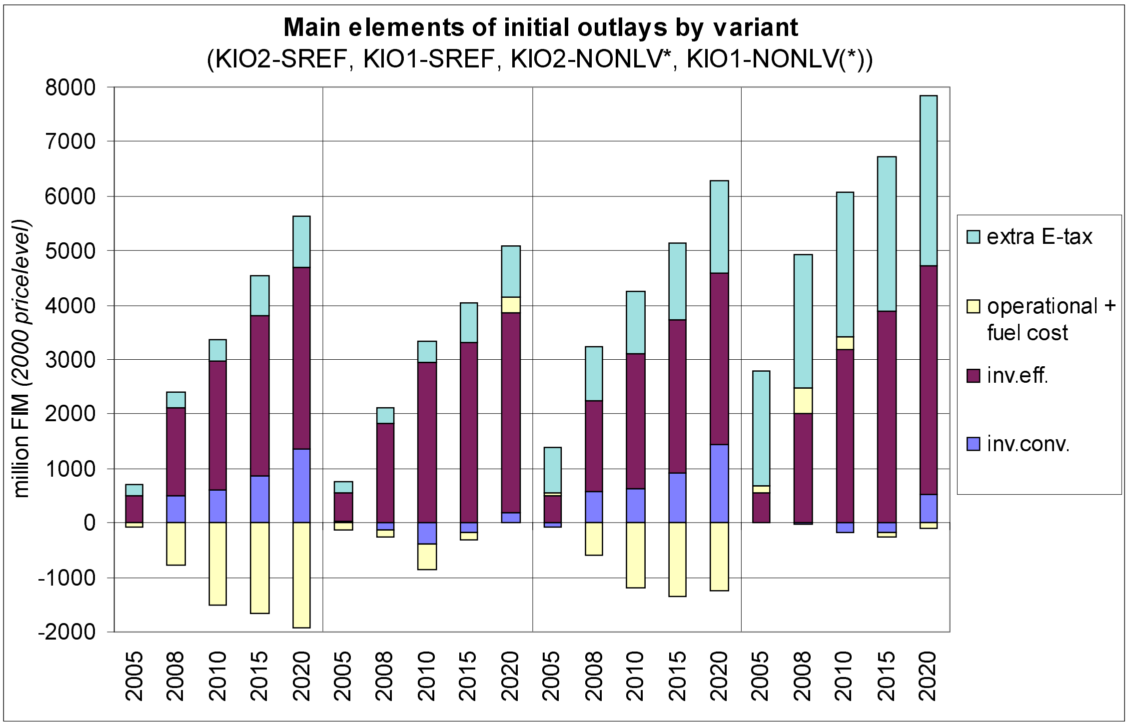

Figure 5.9 *Initial outlays by main purpose in KIO-SREF compared to KIO-NONLV**

In figure 5.10 the case of a second emission target in 2020 (SR) and the case of another distribution of growth over time (SG) are summarised. In the case of SR from 2015 onward somewhat larger impacts on GDP and households consumption can be expected. Up to that year differences between the NONLV* variants and SR are small. Apparently, only a limited amount of long term anticipation (i.e. anterior to 2015) seems beneficial, given the assumed circumstances. After 2015 costs increase rapidly, notably in KIO1-SR the volume of energy efficiency investments almost doubles compared to KIO1-NONLV*. In KIO2-SR the increase of efficiency investment is about 60% compared to KIO2-NONLV*.

In the alternative growth variant (SG) the level of total initial outlays is significantly higher in both alternatives during almost the entire the period. The higher growth up to 2010 incites more investments in conversion capacity in KIO2-SG and more efficiency investments in KIO1-SG. The higher activity levels in the economy imply also more energy tax revenues compared to the NONLV* variants (about 2,5 billion FIM (€ 0,42 billion) extra in both alternatives). Despite the higher tax levels the growth in energy efficiency investments after 2010 are not much higher than in NONLV* variants since the annual growth is lower than in the BaU-scenario, though the absolute activity levels are still higher[23].

[23] . The prices of primary energy sources have not been adapted in the alternative growth variant, even though in case of a global or at least European trend (which are the most likely causes for cyclical movements of Finnish economic growth) these prices may follow other trajectories as well.

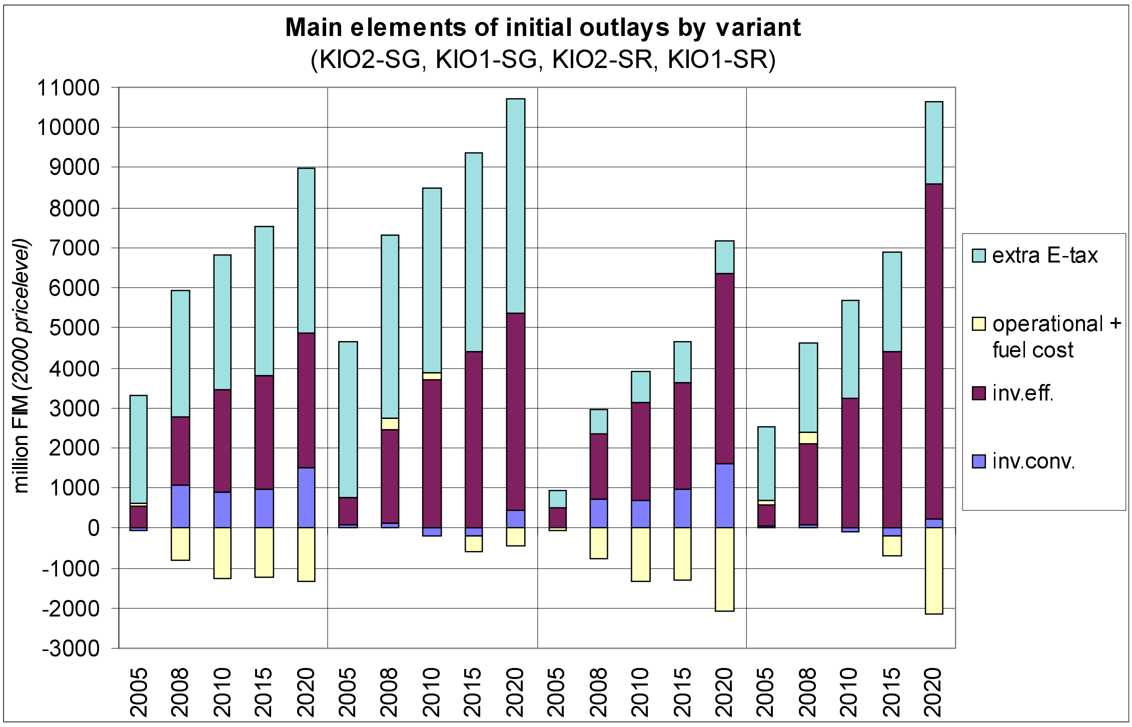

Figure 5.10. *Initial outlays by main purpose in KIO-SR and KIO-SG*

All in all we can observe that a second tighter target in 2020 will increase the cost if the extra task is only implemented through domestic measures. On the other hand the introduction of flexible mechanisms and to a lesser extent more power import potential significantly change this picture. Even in the simulations shown here, in which permit trade is not allowed to be merely a substitute for domestic action, the impacts on costs are significant especially in the longer run.

Another lesson is that given the prospect of a mandatory steady and substantial decreases of the greenhouse gas emission levels of – for a start – most OECD countries (so-called Annex 1 countries to be exact), it pays off in almost all circumstances to invest timely in RD&D efforts that get the cost of future energy efficiency options down. As other OECD countries face similar challenges there can develop a competitive but large market for energy efficiency technologies.

Despite the stylised and simplified version of permit trade used here, the sensitivity run with both permit trade *and* tighter target 2020 carries an important message and confirms findings of earlier studies. Given the prospect that a steady absolute decrease of greenhouse gas emission levels will be the guiding principle for many decades to come the so-called 'threat' that permit trade would largely substitute instead of complement domestic measures does not need to materialise. Refraining from flexible mechanisms would evidently lead to higher abatement costs. In as far as this would reduce economic growth more in the medium to long run, it would mean that it gets more difficult to mobilise sufficient resources for the needed extra R&D, while global demand for these technologies would be smaller than otherwise would be the case.

Even though in this exercise permit trade and domestic measures were put side by side with little effort for co-ordination (only a slice of more expensive mandatory domestic measures is cut out and the energy tax increase is reduced) it shows that long term cost reductions are significant (compare SR with SREF). In reality it would make sense to have more in-depth co-ordination of the domestic programme in relation to for example Joint Implementation and the Clean Development mechanism.

The exercise also demonstrates that – ex post – the economic and technological significance of the first commitment period is rather limited. From a political and process management viewpoint the first commitment period will nonetheless keep its milestone significance in the sense of getting things moving.

6. Overall package evaluation

6.1 Introduction

As has been told in section 2.4 evaluation of the simulation results of the programme alternatives is not supposed to be only a line up of the programmes according to their GDP effects or according to their costs for households. The study has not been especially geared toward extensive embedding of macro-economic performance of the programme alternatives into a comprehensive evaluation framework. Nevertheless this chapter aims to facilitate the use of the economic assessment results in an overall evaluation of pro's and con's of the programme alternatives. As regards the assessment of ancillary benefits and costs, including not purely economic and non-economic aspects, this report cannot give much clues since that was largely outside the scope of the study. The study of SYKE renders some insights in health effects and levels of other hazardous emissions. This chapter can however illustrate how ranking can be affected based on 'what-if' illustrations.

First the discussion will focus on the interpretation of the economic assessment results, and the options to put them in a perspective. To a large extent this discussion can draw on the observations already made in the preceding chapters.

Subsequently, it will be illustrated what overall assessments can include and what purpose they can serve.

6.2 Interpretation of the results – what are the figures worth ?

Character of the study - what is a significant difference ?

The character of the study, though having features of a (social-economic) cost benefit analysis, should be regarded as a macro-economic impact exercise. This means that though the impacts and differentials between programme alternatives have been indicated also in absolute terms (millions of FIM), the stress has been on percentage changes for good reasons. The way of assessment means that the economic system *as a whole* has been assessed regarding relatively small amendments on a default growth trajectory (the BaU-scenario), hence the preference to use percentage change indicators compared to a baseline. Indeed the logic of using a baseline, which represents the whole economy (indicated by GDP or by household consumption), implies that one looks to the whole 'heap' of GDP and subsequently variations in the level of the 'heap'.

Referring to the BaU-scenario and the findings for deviations in GDP, it means that the assessment indicates that:

> *when depicting the Finnish GDP development by means of an index, with index2000 = 100, the GDP index in the year 2010 amounts to 135,0 in the BaU scenario while the index in the various programme alternatives varies between 134,2 (KIO1-NONEV) and 134,6 (KIO2-NONLV*).*

For household consumption, which is the best available proxy for welfare, a similar representation in index numbers with deviations of similar magnitude can be made. Considering the programme impacts in this perspective brings us to the conclusion that the differences *in terms of macro-economic effects* are rather small. Even though they are small, that does not mean the differences are insignificant. Nevertheless one should anticipate that given the size of the differences there is less of a chance to be *a priori* decisive when put in a wider evaluation framework including non-economic and not purely economic criteria.

Does this mean that we regard differences of say 800 million FIM or 2000 million FIM as uninteresting ? *NO*, not the least, but to assess them properly, e.g. by means of genuine cost-benefit analysis, requires other assessment tools (such as. market models for the most relevant sectors), a more detailed specification of actions and a zooming in on the most important sectors (energy, heavy industry and building construction)[24].

Uncertainty and sensitivity

Firstly, there is the uncertainty due to the assumptions in the BaU-scenario, this has been partly dealt with in the sensitivity analysis, but other aspects such as future default improvements in energy efficiency, primary energy prices, and the development of the natural gas network in Finland and Northern Europe have not been reviewed on possible alternative outcomes.

Secondly, data transformation from programme descriptions into model input and the models themselves contribute to uncertainty ranges in output, KESSU contributes most to the model born uncertainty range. As means of guidance one should regard differences of 0,1% or less in the principal output (section 5.3.1) with utmost caution regarding their significance, and differences between 0,1% and 0,2% could be regarded as probably significant. This renders an additional argument in favour of embedding the macro-economic performance in a wider evaluation framework.

[24] . It is fair to say that in the various ministerial programmes a part of the measures and prescriptions has been assessed in a somewhat CBA like manner, however often at a singular basis and/or without accounting for induced market effects. The challenge is to take market effects and interaction between measures (package effects) properly into account. EFOM does take care of interaction effects in the energy system and at a very aggregate level some market effects are taken into account in KESSU, but this is far from complete.

A third aspect are developments that will be reinforced when carrying out the climate policy programme. Firstly, there is the stimulus, particularly in export markets but also domestically, of those sectors that are involved in design, building and consultancy of energy-efficient goods and renewable energy components. On the other hand foreign climate policies could cause decreases in demand of some Finnish export products or they could even involve shrewd subsidy and tax rebate programmes that would attract foreign direct investment (and consequently increase the losses in other countries including Finland).

Another kind of uncertainty is the sensitivity of the programmes toward changes in action environment. In other words, what is:

(1) the risk that due to inadequate anticipation the cost of climate policies become much higher (i.e. underestimating the tasks ahead in future commitment periods or overestimating default unit-cost decreases of new technologies);

(2) the risk that due to inadequate flexibility the programme costs turn out to be higher than would have been necessary (regretting to forego cheaper options when one is - at least temporarily - obliged to use other options).

The sensitivity exercises demonstrate that the imposition of future – ever tightening – reduction targets (which is a likely future course of events) seem to imply significant extra cost in the long run and limited extra cost in the short run. If however the portfolio of instruments is larger than assessed in this study[25], notably the use of permit trade (concerted with domestic efforts) and the use of R&D and market up-take instruments, cost increases will be much more modest, while cost in the first commitment period might even be lower than in the currently considered domestic programme. It is recommendable to be cautious with engaging in actions that imply significant loss of flexibility for a decade or longer.

Finally, there are aspects such as health costs, security of supply, etc. that have not been assessed in the macro-economic study. Anticipating on the next sections it can already be mentioned that in the environmental impacts assessment of the climate programme alternatives (SYKE, 2001) no significant differences between the alternatives occurred regarding acidifying emissions and other emissions with potential health hazards. Differences in security of supply expressed as changes in the share of imported sources in the energy supply mix can be straightaway derived from the EFOM results. This aspect will be touched upon in section 6.4.

[25] . Subsidies for R&D and to some extent for market take-up are included in the Energy Saving Programme (ESO).

In conclusion we state that four kinds of uncertainty affect the value and the interpretation of the assessment results:

1. imprecision in programme specifications and the implications for model input
2. analytical imprecision and uncertainty (input data handling, model assumptions)
3. exclusion of effects (e.g. behaviour of main export target countries)
4. sensitivity of the programme towards deviations in assumed trends of exogenous factors from their actual developments

The consequences are that:

- *the levels* of both KIO1 and KIO2 alternatives could – simultaneously – be somewhat lower or higher
- the *distinction* between KIO1 and KIO2 regarding GDP and households is generally significant, but only just
- the distinction between sector impacts – notably segments of heavy industry - might be somewhat larger than indicated in this study

6.3 Individual instruments and measures

The policy programme alternatives are made up of a collection of instruments and measures, of which a part is put in at (almost) the same dosage and another part with larger differences in dosage (see chapter 4). The measures do not have the same cost per ton abated greenhouse gas and consequently a different mix causes cost differences between the cost of programme alternatives. Furthermore, the instruments and measures influence each others' economic efficiency, which adds further to divergence or convergence of costs of different programme alternatives. Last but not least, as explained in section 5.3 the net amount of recyclable excess tax revenues influences the eventual macro-economic cost of a programme. In chapter 5 main causes of differential results were explained, based on the *given* programme alternatives. In this section single measure effects and some interaction aspects between measures will be highlighted.

Table 6.1 gives an overview of most measures included in the climate policy programme alternatives, while also the flexible mechanisms have been added. The shaded rows concern instruments and measures that address directly or indirectly energy efficiency. Energy taxation (not shaded) affects energy efficiency as well, but since taxation has such a generic impact the degree is unsure and depends on the volume and price of other options such as fuel switching. The social cost per ton abated must be seen as a reasonable upper limit in the circumstances created by the programme alternatives up to the end of the first commitment period. The actual average cost level per option will be often lower. For example, nuclear power and voluntary agreements could both have much lower unit cost than the upper limit mentioned here. Voluntary agreements in practice will overlap with impacts of taxation. Since voluntary agreements are supposed to be cheaper, their upper limit cost should always be lower than the energy tax (in terms of abatement unit cost). Also energy efficiency in new buildings is not necessarily expensive.

All in all it means that though the midpoint cost levels differ, most instruments represent potentials that at least partly are already exploitable against modest costs. In the *given circumstances* transport fuel tax and a part of urban compacting can be regarded as expensive options. Urban compacting is not necessarily always expensive, but it depends on the impacts on the energy system and on land use prices. Furthermore, it has other interesting side benefits and it has long lasting structural benefits, as is indicated in table 6.1. The limitation on coal may be not very expensive from a single measure point of view, but the model exercises clarified it is strictly spoken not an indispensable measure. Dropping the measure would lower the cost slightly in KIO1 alternatives. Moreover, exclusion of the measure would relieve the public authorities from possible obligations regarding compensation of sunk cost of coal power capacity.

Adoption speed encompasses both preparatory work (e.g. regarding legislation) and the actual speed with which the instrument causes abatement measures to be implemented. In some cases, e.g. in case of permit trade, the preparatory work can be extensive with even risks for further delays and diluting effects. In other cases, e.g. in case of eco-driving and new buildings there is practically a feasible upper limit (cohort effect) that determines the maximum speed of adoption.

The degradation risk can either refer to the fact that the measure may not have lasting effects or that the attractiveness of the measure could be seriously affected by changes in the economic or physical environment. An example of the first type of degradation is the behavioural dependence of eco-driving (it would require refreshment courses after e.g. 3 years). An example of the second type is taxation, if prices of primary sources (oil, natural gas, import power) would be decreasing, it would require active decision making to increase the tax levels in order to restore the original abatement effect. Degradation risks can be alleviated by means of adequate monitoring and through introduction of automatic update or compensation systems (e.g. dynamic benchmarks for building performance and energy import price compensation for energy/carbon taxation).

Side effects point mainly in the same direction. Permit trade can mean that domestic levels of other hazardous emissions are higher. Extensive use of felling refuse in relation to boosting the use of renewables might affect bio-diversity in forests. Large scale wind turbine parks usually ignite discussions about what is an attractive landscape.

Table 6.1 *Overview of effects of instruments and measures*

Instruments & measures	*reduction potential*	social cost/ton (FIM)	*Adoption speed*	*nr. of players*	*Degradation Risk*	*side effects* Emissions & health	Land use, nature
Mobile machinery	+	<50	++	large	+	+	0
Eco driving	+	<50	++	large	+++	+	0
Waste/other gases	+++	<80	+++	medium	+	+	+
More nuclear power	+++	<100	++[1]	small	0/+	+[2]	0
Flexible mechanisms	+++	<120	++[1]	medium/ small	+	0/-	0
Renewable energy promotion	+++	<150	++	medium	+	?	?
Energy taxation (& tax recycling)	++/+++[3]	<250	+++	large	++	+[3]	0
Voluntary agreements (saving etc)	++	<250	++	medium	++	+	0
New buildings e-eff standards	++	<300	++	large	+	+	0
e-efficiency in renovation	++	<450	+	large	+	+	0
Coal power off after 2010	+	**<50 ?**	+	small	0	+/++	0
Urban compacting	+	<600	+	medium	?	+	+
Transport fuel tax	+	<800	+++	large	++	+	0

Legend: + low; ++ medium; +++ high; ? unclear/mixed

1) Flexible mechanisms and nuclear power are options that require extensive preparatory work, but once installed they deliver results quickly

2) In terms of other emissions, e.g. acidifying and small particles, and their related health risks nuclear power rates well. Yet, other risks of the nuclear power fuel cycle, such as leakage of radiation and proliferation, are still subject to national and international debate. This study has not assessed those aspects and consequently makes not any statement on these issues.

3) Observing that taxation of carbon containing fuels translates somehow in using less of them implies that GHG emission and some other emissions reduce, but it depends on the extent to which other mandatory measures are already specified what remains as effect of taxation.

The number of players is relevant for the organisational and administrative form that the instrument or measure will need, and consequently whether the public authorities and other policy implementors are facing significant extra organisation costs and risks for failing process control (which often incurs cost to reduce such a risk). If the number of players is large, as with taxation, it is essential to keep the regulations simple in order to keep the cost down. Complicated tax rules do not only cause extra cost for public authorities but also for many tax payers. Yet, in principle taxation can be efficient, notably if it can be absorbed easily in existing structures. Relatively the highest cost can occur when the number of players gets ‘medium’ (say from about forty up to a few hundred) as this will require an intricate mixture between standardisation, regulation and negotiation[26]. So, the regulation and negotiation process has to be thought through very well, prior to starting it. Proper institutional shaping and clear authorisation in the negotiation process helps.

As regards the interaction effects between the listed measures the most important ones are:

- the degree to which measures for buildings and industry are imposed as obligatory in relation to the remaining effectiveness of an energy or carbon tax
- the cost increasing effect of nuclear power on energy saving, as it makes electricity cheaper compared to a programme without extra nuclear capacity (the pay-back time of an energy-efficiency investment goes up)[27]
- a special case is the BaU-assumption of the zero-cost and massive introduction of the 5-litre car which affects the effectiveness transport fuel tax (which is already less efficient than energy tax given the current already high tax levels)

All in all the observation is that the *selection* of instruments and measures looks by and large plausible, with perhaps one or two exceptions. However, the current dosage of the various instruments and measures may well be sub-optimal *when judged from a purely economic point of view*.

6.4 Package evaluation

In its most ideal form all the criteria mentioned in section 6.3 would be used in overall package evaluations by means of MCA. The composition of the policy packages is however such that they don't distinguish much on most of the non-economic criteria (e.g. health and other hazardous emissions according to SYKE, 2001). In all programmes almost all instruments are present, therefore only in case of big differences in dosage the programmes could significantly differ from each other. The NONEV alternatives supposedly rate a bit better on low degradation risk and perhaps on side effects, but that can not be proven with the current information available.

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[26] . This may look strange, observing the popularity and alleged advantages of voluntary agreements (see Perrels, 2000), but this partly explains why voluntary agreements are often low profile and with limited ambitions. In that case a deal can be struck quickly, hence low negotiation cost, but also limited delivery. Extensive and ambitious voluntary agreements can also be efficient, but that requires efficient negotiating shapes and in that case the advantage is obtained by creating quasi-markets within sectors.

[27] . The cost impact on energy efficiency would become less problematic, n case more than one nuclear power unit would be allowed to be constructed (e.g in the next decade).

The overall package evaluation draws on the economic and energy data produced in this study, whereas the selection of additional criteria is based on the discussions during the hearing and survey held on 30 November 2000 (see Appendix 5). As a generic notion this has been translated into indicators that, next to the macro-economic indicators from KESSU, represent elements of transition towards sustainable production, efficiency of the abatement, and burden sharing aspects regarding heavy industry and households. The following set of criteria is used:

- GDP effect (change in GDP compared to BaU)
- Abatement unit cost
- Household consumption effect (change in household consumption compared to BaU)
- Production effect heavy industry (change in production value by sector compared to BaU)
- Household cost standard deviation (the standard deviation by household-dwelling type combination)
- Employment (change in employment volume compared to BaU)
- Share of renewables (in primary energy mix)
- Energy saving impact (difference between primary energy supply in 2010 and 2000)
- Dependence on imports version A (change in import share of primary mix; import includes oil, natural gas, coal, and import power)
- Dependence on imports version B (as A, but here import also includes nuclear, as the fuel cycle is entirely of foreign origin, but dependency is less instantaneous than oil and gas)
- Economic efficiency of energy-efficiency investment

The rating of the effects is done in such a way that the units represent amounts of value (FIM) of the same order of magnitude. Next to an average MCA score alternative sets of weights have been specified for stylised stakeholders that have for example strong priorities on macro-economic effects and efficiency for businesses or conversely strong priorities towards the progress in the share of renewables or care strongly for the cost level of households and the distribution of cost over households.

The MCA ratings represent judgements of stylised individual stakeholders, which to some extent can be identified with typical social-economic groups. It should be stressed that the actual positions of the different kinds of stakeholders are more diverse and refined than the ‘types’ used here. In that sense it should also be realised that exercise is *not* designed to translate the results into recognisable stakeholder positions, but rather it shows what seem to be remaining factors that are relatively influential on the ranking given that the macro-economic results fixed (known). A second interpretation would be what happens to the ranking if the priority sets of stakeholders changes.

The evaluation formula in this case is a simple additive utility function. Details are given in Appendix 6. Table 6.2 gives an overview of the weights for different types of priority sets, which can be identified with focussing in the first place on effects on business, households' purchasing power and transition toward sustainability in respectively. All these elements have their place in the real discussion, but in reality the diversity in shades of grey will be much larger.

Table 6.2 *Weighing alternatives for priority setting of criteria*

Criteria	**Alternative weight sets**		
	Macro-economics & business	Household purchasing power	Sustainability indicators
GDP effect	0,40	0,20	0,15
Abatement unit cost	0,06	0,02	0,00
Household consumption effect	0,10	0,28	0,20
Production effect heavy industry	0,25	0,03	0,01
Household cost Standard deviation	0,00	0,12	0,07
Employment	0,03	0,20	0,20
Share of renewables	0,03	0,03	0,12
Energy saving impact	0,03	0,05	0,12
Dependence on imports version A	0,04	0,02	0,03
Dependence on imports version B	0,04	0,02	0,03
Economic efficiency of energy-efficiency investment	0,06	0,05	0,10

Four sets of weights have been used, being an average (each of the above weight sets counts for 33,3%) and three alternatives in which one stakeholder type is dominating for 90% and the other two each for 5%. Table 6.3 shows the rankings for the different sets of weights for the year 2010. Details on the exact scores are given in Appendix 6. There are two alternatives with respect to the interpretation of energy imports. Option A regards nuclear energy as domestic source, option B does not.

The addition of other non-economic criteria generally tends influence the ranking to some extent in favour of KIO1 alternatives. If economic considerations, either commercially or with respect to household purchasing power prevail, KIO2 alternatives show a relative increase in attractiveness. If the transition towards a sustainable production system is seen as first priority the KIO1 alternatives gain in attractiveness. Notwithstanding the occurring changes in ranking there remains also a lot of the same ordering left as indicated by the economic assessment study described in the previous chapters. The ranking as indicated by the economic assessment is robust in the sense that the NONLV alternatives continue to precede all other alternatives in a large majority of cases, while the NONEV alternatives are virtually always ranking lowest. Please, note that only the six core alternatives have been assessed on ranking.

Table 6.3 *Ranking by MCA variants and according to KESSU 2010 GDP results, the lower the position the better the rating*

Rank	Equal weights WA	Business WA	KESSU	Household WA	Sustainability WA
6	KIO1-NONEV	KIO1-NONEV	**KIO1-NONEV**	KIO1-NONEV	KIO2-NONEV
5	KIO2-NONEV	KIO1*	**KIO1***	KIO2-NONEV	KIO1-NONEV
4	KIO1*	KIO2-NONEV	**KIO2-NONEV**	KIO1*	KIO2*
3	KIO2*	KIO1-NONLV*	**KIO1-NONLV***	KIO2*	KIO1*
2	KIO1-NONLV*	KIO2*	**KIO2***	KIO1-NONLV*	KIO2-NONLV*
1	KIO2-NONLV*	KIO2-NONLV*	**KIO2-NONLV***	KIO2-NONLV*	KIO1-NONLV*

Rank	Equal weights WB	Business WB	KESSU	Household WB	Sustainability WB
6	KIO1-NONEV	KIO1-NONEV	**KIO1-NONEV**	KIO1-NONEV	KIO1-NONEV
5	KIO2-NONEV	KIO2-NONEV	**KIO1***	KIO2-NONEV	KIO2-NONEV
4	KIO1*	KIO1*	**KIO2-NONEV**	KIO1*	KIO2*
3	KIO2*	KIO2*	**KIO1-NONLV***	KIO2*	KIO2-NONLV*
2	KIO2-NONLV*	KIO1-NONLV*	**KIO2***	KIO1-NONLV*	KIO1*
1	KIO1-NONLV*	KIO2-NONLV*	**KIO2-NONLV***	KIO2-NONLV*	KIO1-NONLV*

Compared to a purely economic assessment it seems that energy import dependence[28], and also its interpretation, are rather influential on the ranking. Energy saving and other sustainability indicators are supposedly less influential or less distinctive. Once the goals are achieved one can argue that the way how that happens is of secondary importance (this consideration has been taking into account when specifying the function and the weight sets). Only if one attaches high values to an apparent progress towards sustainable production as such, it starts to count a bit more.

Observing that the results form the energy-economic assessment of the programme alternatives are given, the significance of the *interpretation* of the results increases. Given the indications presented here, the understanding of import dependence (security of supply) and the perception of transition towards a sustainable economy could be important items. As regards setting priorities a lowering of priorities regarding security of supply would diminish the relevance of that issue. Also the weights attached to household costs and purchasing power effects may be unpredictable among different stakeholders.

[28] . In principle import dependence can be translated in economic terms if one would cast it in the form of a risk analysis, i.e. what premium is one prepared to pay for a diminished risk of non-delivery and what would be the expected costs of non-delivery (import obstructions or changing foreign supplier).

7. Concluding remarks

The main conclusions of the study can be summarised in the following step by step manner:

- The negative effects in 2010 compared to a situation without a climate policy programme amount to -0,3% to -0,6% points for GDP and -0,6% to -0,9% points for household consumption with respect to the central alternatives considered.

- The results above are based on the programme alternatives in which the energy tax is increased and at the same time the net excess revenue of taxes is given back to taxpayers, being companies and households, by means of so-called tax recycling. The most obvious ways to recycle tax is by lowering social security payments of employers and by lowering income tax of households. Also lowering of selected VAT items can be considered.

- Energy taxation *in connection with* tax recycling is an indispensable ingredient to avoid unnecessary macro-economic cost. The programme alternatives in which no taxation instruments are used result in appreciably higher cost for households (-1,0% to -1,2%).

- The differences with regard to GDP and household consumption between programme alternatives including extra nuclear capacity and those without vary from 0,1% to 0,2% points depending on the programme alternatives and the way of tax recycling. Differences of 0,1% point or less are however of doubtful significance.

- The reductions in production volume in 2010 vary between 0,1% and 0,4% for the heavy industry, between 0,15% and 0,25% for the light industry and between 0,3% and 0,6% for commercial services and agriculture depending on the programme alternative.

- In case extra nuclear capacity is installed the negative effects for the heavy industry are halved, while the benefits for the light industry are minute or negligible. Similarly for the commercial services differences between the inclusion and exclusion of extra nuclear capacity are very small (0,05% to 0,1%).

- Also for the sector effects the way of tax recycling makes a some difference, especially commercial services and some light industries benefit more, the better the purchasing power of households is repaired.

- The average cost per household after tax recycling vary between about 1200 FIM (~ € 200) and 1800 FIM (~ € 300) per year in 2010 depending on the programme alternative. The programme alternatives without energy tax increases results in average cost per household of 2000 FIM (~€ 340) to 2400 FIM (~ € 400) per year. The central alternatives including extra nuclear capacity cause on average 270 FIM to 420 FIM (~€ 45 to ~ € 70) less cost per household. The variation of cost (the standard deviation) over households is somewhat smaller in the programme alternatives with extra nuclear capacity.

- The variation of the absolute level of costs over households depends mostly on the type of dwelling and type of heating system. For those programme alternatives that include the increase of transport fuel tax (diesel and gasoline) the variation of costs over households is substantially increased due to variation in car ownership (0, 1 or 2+ cars) and use (annual mileage).

- The variation of the burden of extra cost expressed in terms of percentage of net income depends on the one hand on the physical circumstances indicated above and on the other hand on net income level. The burden distribution at the level of household categories does not show very large deviations. There are nevertheless categories with just over 1% burden. These categories represent possibly about 9% of all households. Just like for companies larger burdens can occur for individual households.

- After 2010 the macro-economic cost rises in the programme alternatives without nuclear tend to grow more than the alternatives with extra nuclear capacity.

- As regards uncertainties in the results and the robustness of the programme alternatives the following key issues deserve mentioning:

  - the installation of an international emission permit trade system in this decade and the acknowledgement of Joint Implementation as supplementary to such a system would almost certainly lead to heavy pressures to revise the domestic programme substantially, since the regret cost of non-revision would be significant

  - the assumption used in the programme assessments that the import of electric power diminishes due to high prices in Nordpool represents a reasonably likely situation, but also the lower end of a spectrum of outcomes and consequently the possibility that competitive imports remain at significant higher levels than assumed should not be relegated as entirely irrelevant; larger availability of competitive imports would reduce the cost in the alternatives without extra nuclear capacity, but are not expected to affect the alternatives including extra nuclear

- the assumption of the cost free and sweeping EU wide introduction of the so-called 5-litre car as a default trend is liable to serious doubt; given the EU framework Finnish policy makers may feel compelled to insert the assumption, but that cannot make up for the *analytical* judgement that it is a feeble concept; in case of significant non-achievement of the EU covenant it is not self-evident from an economic point of view whether compensatory measures should be only found within the transport sector, including possibilities to find more revenues than investment options in transport.

- Relatively simple exercises with judgement of the performance of the programme alternatives in a wider context (i.e. more criteria than purely economic ones) hint at the fact that by and large the ordering of alternatives as indicated by the economic assessment is fairly robust. Only in case of strong attachment to other than purely economic criteria a larger revision of the ranking can occur. This observation relates also to the time frame in which one wishes to judge programmes. The studied programme focuses mainly on the first commitment period of the Kyoto Protocol, the process in which Finland embarks has however a much longer time scale.

Recommendations

- It is recommendable to try to introduce some automatic reparation or updating mechanisms in some of the instruments that are part of the climate programme, for example the level of energy tax could be attached to the price level of imported energy sources, notably oil and gas (a fall in oil prices would be compensated by a raise in energy tax to keep end use prices constant).

- In case of implementation of international permit trade systems it is recommendable to co-ordinate the domestic and international instruments very well, notably in relation to Joint Implementation and the Clean Development Mechanism concerted instrument use can contribute simultaneously to regaining some of the reduced economic growth and reducing cost for some domestic measures.

- Observing that the net cost increases for households are generally spoken not prohibitive, while possible inequitable impacts for particular households will depend on local physical and social-economic circumstances, it seems recommendable to facilitate such pockets of inequity at the local (municipal) level and not by national arrangements.

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Appendix 1 – Glossary

<u>Units:</u>

1 Finnish markka (FIM) = 0,168 €

Kilo (k)	1000	Mega (M)	1000.000
Giga (G)	1000.000.000	Tera (T)	1000.000.000.000
Peta (P)	1000.000.000.000.000	Exa (E)	1000.000.000.000.000.000

	TOE	MWh	GigaJoule
TOE	1	11,630	41,868
MWh	0,0856	1	3,6
GigaJoule	0,0239	0,2778	1

<u>Climate jargon</u>

Climate policy: can consist of any instrument or measure explicitly meant to reduce the greenhouse gases as defined by the UNFCCC; the so-called Annex B countries in the Kyoto protocol – including Finland – have obliged themselves to produce a comprehensive set of policies and measures to reduce greenhouse gas emissions; an import distinction is between so-called *mitigation* and *adaptation* policies

Mitigation: refers to measures that aim at reduction of emissions and at mitigation of the effects of emissions

Adaptation: refers to measures that should assist countries, regions and sectors to adapt to the consequences of climate change, such as sea level rise

UNFCCC: stands for United Nations Framework Convention for Climate Change, which started with the conference in Rio de Janeiro in 1992; countries can become party to the Convention (not every country is party yet), in addition NGO's and IGO's, such as Friends of the Earth and the International Chamber of Commerce, can obtain an observer status.

Kyoto Protocol: is the agreement reached in Kyoto in 1997 in which a timetable for starting with concrete policy actions and for achieving reduction targets was agreed on; the so-

	called first commitment period runs from 2008 to 2012; for example the European Union, the USA and Japan agreed on 8%, 7% and 6% reductions respectively as average for the first commitment period compared to 1990 levels; the USA presently (March 2001) shows signs of unwillingness to fulfil the commitment in its current form
Annex B/Annex 1:	are the countries mentioned in Annex B of the Protocol For whom reduction limits are specified for the first commitment period, and at the same time belong to group that – in principle – is allowed to trade emission rights among each other.
Flexible mechanisms:	in the Kyoto Protocol three so-called flexible Mechanisms are mentioned, being international emission trade (IET), joint implementation (JI) and the clean development mechanism (CDM); JI and CDM are project based, while IET will allow for large scale exchange of permits via an trading institution (comparable to a stock exchange); permit transfers and trade will anyhow require strict rules and monitoring systems
Emission gap:	is the difference between the emission level a country is expected to reach without (further) measures and the level it should reach according to its obligation following from the Kyoto protocol; for example in the case of Finland the gap is presently rated at 16 Megaton CO2 equivalent for the year 2010 (91.2 – 75.2); in recent years most member countries of the EU have seen their emission levels rising, which implies there is less time left to still reduce the entire gap; notable exceptions are the UK and Germany, while Finland at least experienced very little growth of its emission level since 1990

<u>Economic and policy jargon</u>

Production factors	labour, capital (machinery, tools, buildings, etc.), energy and materials, and land; in some new models knowledge is regarded as a separate production factor
Factor productivity	can refer to any of the above mentioned factors in relation to output; climate policy and in a wider sense sustainable development mean that the energy and material productivity have to go up very considerably (e.g. think of the concepts ‘Factor 4’ and ‘Factor 10’)
Relative prices	the relative price of a production factor not only depends on its real market price, but also on its productivity; this

	is a very important element in wage negotiations; with respect to energy saving it means in fact that energy per unit of output for which it is used gets cheaper; large energy savings for applications that concern production or consumption activities with large amounts of latent demand can result in substantial 'rebound' effects, implying that effectively realised 'cheapness' of energy incites much more demand (car use and illumination are two examples).
Real wages	are wages corrected for changes in consumer price index
Fixed real wages	refers to an assumption in economic modelling that any increase of the price index is compensated in the wages; at an economy wide level this normally means wage rises go beyond increases of labour productivity, which leads to shedding of production and loss of jobs; fixed real wages are not used in the KESSU simulations
Opportunity cost	is a concept in which cost are rated at the value of the income that is foregone by investing in one alternative instead of other ones; return on capital (ROC) is commonly used indicator for this; in case of judging a list of investment alternatives a benchmark ROC is used, e.g. based recent past performance or on a target rate; once an investment is done the actual way it is financed counts for what are the actual cost to the economy, not a benchmark ROC
Unit cost	is cost per unit of product and in this study also per unit of abated emissions
Marginal cost	is the (unit)cost to produce (or abate) the last unit needed to satisfy demand; in this report marginal cost is often used in connection to alternative ways (fuel switching, energy saving, etc.) to achieve sufficient emission abatement, one can systematically rank the options and derive a marginal abatement cost curve from that list; thanks to for example R&D abatement options can get cheaper over time, implying that the ranking and the shape of the curve change.
Direct cost	the cost that are directly (in first instance) caused by the policy measures applied, e.g. buying new machinery or buying cleaner but more expensive fuels
Induced cost	this refers to the effect that the companies that are first affected by policy measures will as much as possible adapt their product prices in order to accommodate the higher (direct) cost, the buyers of the products are facing higher cost as well, which means they will buy less,

	maybe substitute inputs, and/or increase their product prices; in this way the direct cost induce cost elsewhere in the economy.
Technical progress	in economics this can refer either to cost reducing effects or to creation of new functions/possibilities; in reality also combinations of the effects occur; in economic modelling the stress has been more on cost aspects than on new functions, because the latter phenomenon is far more difficult to model; in this study the issue of hardly included ancillary benefits (and costs) relate to this point
GDP	gross domestic product, simply said the sum of: all wages, income from capital, and the balance of export and import
Welfare and GDP	although in daily speech welfare is often equalised with GDP, they are not the same in economic theory, since welfare is a much broader concept than GDP; welfare usually encompasses also the value attached to free (non-labour) time as well as flows of non-priced services, such as from nature; the problem is that economic activities can harm nature, which may mean that with growing economic activity the GDP goes up but the welfare goes down since the service flow from nature got smaller due to damages.
Balanced budget	the concept that annual expenses of the state (or all public authorities, depending on the country) equal its annual revenues; in practice the definition is liable to some arbitrariness, since for example the targets set for the national debt and tax burdens significantly influence the leeway for achieving balance
Tax recycling	when a specific policy causes excess tax revenues (in a balanced budget context) these will be given back (recycled) to the tax payers by reducing other taxes or social security payments
Voluntary agreement	refers to an agreement between a government and a sector to achieve a set of goals, such as a specified improvement in energy efficiency, or an absolute amount of saved energy or an absolute amount of abated emissions; usually industries prefer intensity indicator based goals (relative) instead of absolute goals; as the latter is mostly more risky, though this also depends on the level of aggregation for which the goals is formulated; for example goals for a whole sector combined with other flexible financing and trade-off arrangements within a sector reduces the risk; another

	issue is how voluntary the agreement should be, the more the public authorities risk in terms of money or broad public support, the more will they be eager that sectors comply and consequently the more guarantees are to be put in the agreement; gradually also the idea of EU wide voluntary agreements wins ground, the agreement with the car industry regarding the so-called 5-litre car is an example; for ever more household appliances minimum standards are introduced; the standardisation in policy requirements means an important cost saving; yet, compliance enforcement will be even more difficult at this level
Price discrimination	means that firms ask different prices from different kind of customers for virtually the same product; in the case of electricity small consumers pay more per kWh than large consumers because per kWh there is more capital used (e.g. more network and lower utilisation rates), however on top of those real cost differentials companies have leeway to allocate for example cost rises more to customers that are less price sensitive in order to minimise loss of sales; the extent to which price discrimination is used depends also on the criteria of the competition of authority.

<u>Energy jargon</u>

Primary energy	concerns the energy sources such as oil, natural gas, renewables (incl. hydro), uranium and imported electricity prior to conversion steps such electricity generation and refinery
Delivered energy	is the total of energy carriers delivered to non-energy sectors, this includes energy carriers obtained from conversion such electricity; a part of the delivered energy may be used within a non-energy sector for conversion, e.g. wood biomass for industrial CHP Delivered energy = primary energy – energy lost in conversion in energy sector
Final energy	is the energy which is actually used for processes and services Final energy = delivered energy – conversion losses in non-energy sectors
Useful energy	is the part of the final energy which is effectively used for the function for which it is meant; improving energy efficiency means that one increases the amount of useful

	energy obtained from an unchanged amount of final energy
Fossil fuels	are mined fuels that contain carbon, i.e. oil, natural gas, coal, oil shale; peat is categorised separately as a slowly renewing fuel
CO_2-free fuels	are energy sources that do not contain carbon, such as wind, hydro and solar energy, and nuclear; burning biomass causes CO_2-emissions, but since the regeneration of biomass is short enough to capture its own CO2 emissions it is regarded CO_2-free in the UNFCCC context
Renewables	comprise all energy sources that are based on natural regeneration capabilities, i.e. either based on natural flows (wind, sunlight, rivers) or on renewable vegetation
Security of supply	refers to the policy that aims at a supply mix which is less likely to be very sensitive to obstructions in supply chains, it involves a spread over different kinds of primary energy, spread of the imports over various countries or even a strive for a minimum amount of endogenous production
Conversion capacity	is in this report referring to the installed electric power generation capacity both of utilities and manufacturing industries
Back-pressure	is the traditional way of generating electricity by means of fossil fuels in case of separate electricity production, the conversion efficiency is approximately 40%.
Combined cycle	is nowadays more or less the standard for state-of- the-art thermal electricity generation, notably based on natural gas, the conversion efficiency for gas based plants can be around 55%
Combined heat & power (CHP)	has a long tradition in Finland in district heat systems and in the paper and pulp industry; in stead of just releasing the heat as in back-pressure, it is as much as possible used for other purposes, like process heat (industry) and space heating in the context of district heat systems (homes and offices)
Energy market liberalisation	is a restructuring process taking place in most OECD countries to change the market structure of the energy utilities; it concerns mostly electricity and natural gas, but as a side effect also district heat is affected; the idea is to abolish generation and distribution monopolies and create – even international – competition among

generators and allow buyers to choose their supplier (one way or the other forcing distribution companies to be more competitive and client oriented); the variations in liberalisation models are large, as is the number of the pitfalls.

<u>Modelling, simulation and scenarios</u>

Scenario	is a description of key future developments that will happen largely independent of the policy programmes planned; a Business as Usual (BaU) scenario means a scenario in which current policies will continue but nothing new is introduced, while also the key developments are usually taking a kind of 'middle of the road' course
Baseline	is the trajectory that variables in the assessment models follow when using the BaU scenario assumptions
Programme	is the set of instruments and measures which is considered to be installed; the programme is assessed in terms of its impact on the BaU scenario model results; in this study there are various programme alternatives, meaning that the collection of instruments and measures is largely the same (except for use of nuclear and energy tax), but the dosage of the instruments and measures varies across alternatives
Instrument	also called policy instrument, represent all kinds of incentives that a state or a local public authority can install that should cause change in behaviour of companies and households (in this case meant to reduce greenhouse gas emissions); taxes, subsidies, and information campaigns are examples of instruments
Measure	is an action of a public authority or of a company that directly implies a change as such (of greenhouse gas emissions in this case)
Sensitivity analysis	A model calculation in which deviations from various key baseline assumptions are tested regarding their impacts on key results

Appendix 2 – Input data and results

Primary energy supply mix (in Petajoule)

Units = PJ		BaU			KIO1-NONLV			KIO2-NONLV		
Sectors	2000	2005	2010	2015	2005	2010	2015	2005	2010	2015
Electricity import	32	26	20	20	26	22	22	26	20	20
Hydro & wind	49	48	48	49	49	52	57	49	52	57
Nuclear	233	233	233	231	233	233	231	233	345	350
Biomass-wood	117	128	138	151	136	155	172	137	147	167
Pulping liquors	140	146	153	158	146	153	158	146	153	158
Reaction heat	7	7	7	7	7	7	7	7	7	7
Oil	363	381	371	356	376	380	357	380	359	341
Natural gas	144	167	189	199	192	241	255	182	188	206
Peat	80	75	75	75	75	75	75	75	75	73
Coal	162	215	239	260	165	54	49	175	103	92
Other	36	35	40	43	38	62	66	36	53	58
Total	1357	1460	1513	1550	1443	1434	1448	1445	1503	1529
CO_2 free share	44,0	41,0	40,4	40,6	42,3	45,3	46,9	42,2	49,7	51,7

Units = PJ		BaU			KIO1-NONLV*			KIO2-NONLV*		
Sectors	2000	2005	2010	2015	2005	2010	2015	2005	2010	2015
Electricity import	32	26	20	20	26	22	22	26	20	20
Hydro & wind	49	48	48	49	49	52	57	49	52	57
Nuclear	233	233	233	231	233	233	231	233	342	350
Biomass-wood	117	128	138	151	136	155	172	135	147	168
Pulping liquors	140	146	153	158	146	153	158	146	153	158
Reaction heat	7	7	7	7	7	7	7	7	7	7
Oil	363	381	371	356	376	380	357	382	361	347
Natural gas	144	167	189	199	192	241	255	182	186	198
Peat	80	75	75	75	75	75	75	75	75	70
Coal	162	215	239	260	165	54	49	175	108	96
Other	36	35	40	43	38	62	66	36	53	59
Total	1357	1460	1513	1550	1443	1434	1448	1445	1503	1529
CO_2 free share	44,0	41,0	40,4	40,6	42,3	45,3	46,9	42,2	49,7	51,7

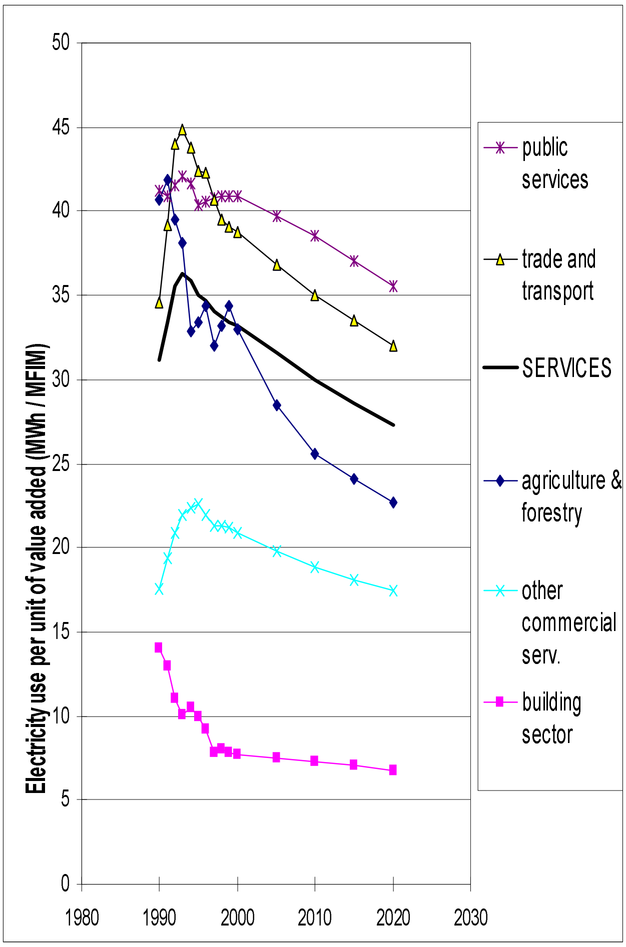
Units = PJ		BaU			**KIO1-NONEV**			**KIO2-NONEV**		
Sectors	2000	2005	2010	2015	2005	2010	2015	2005	2010	2015
Electricity import	32	26	20	20	26	22	22	26	20	20
Hydro & wind	49	48	48	49	49	54	62	49	54	57
Nuclear	233	233	233	231	233	233	231	233	346	350
Biomass-wood	117	128	138	151	122	140	143	126	124	127
Pulping liquors	140	146	153	158	146	153	158	146	153	158
Reaction heat	7	7	7	7	7	7	7	7	7	7
Oil	363	381	371	356	382	388	368	382	371	358
Natural gas	144	167	189	199	194	236	247	182	182	198
Peat	80	75	75	75	75	75	75	75	75	75
Coal	162	215	239	260	155	53	49	175	105	99
Other	36	35	40	43	35	59	64	35	56	59
Total	1357	1460	1513	1550	1423	1419	1425	1435	1493	1508
CO_2 free share	44,0	41,0	40,4	40,6	42,3	45,3	46,9	42,2	49,7	51,7

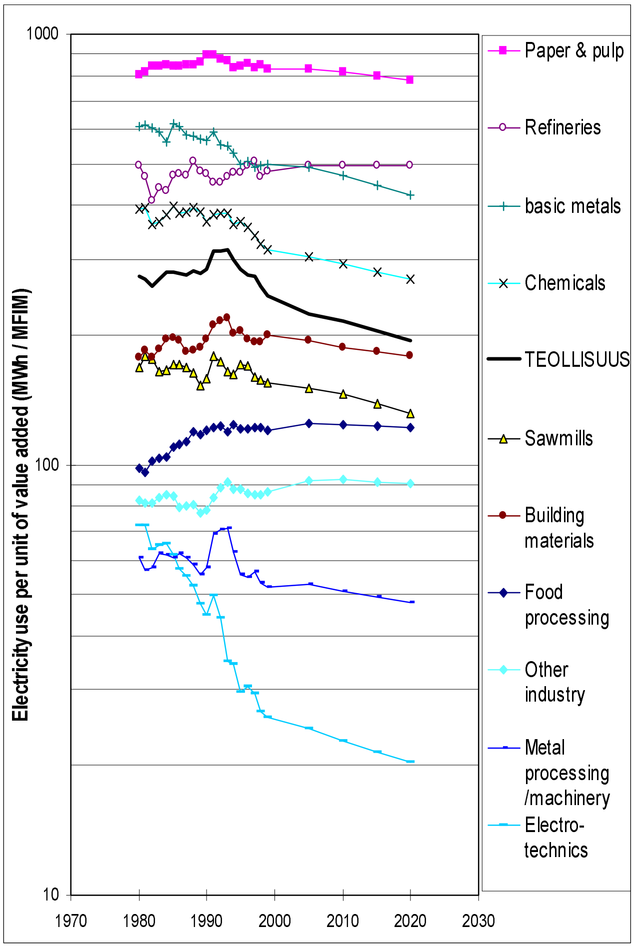
Units = PJ		BaU			**KIO1**			**KIO2**		
Sectors	2000	2005	2010	2015	2005	2010	2015	2005	2010	2015
Electricity import	32	26	20	20	26	22	22	26	20	20
Hydro & wind	49	48	48	49	49	52	57	49	52	57
Nuclear	233	233	233	231	233	233	231	233	345	350
Biomass-wood	117	128	138	151	136	150	172	137	147	167
Pulping liquors	140	146	153	158	146	153	158	146	153	158
Reaction heat	7	7	7	7	7	7	7	7	7	7
Oil	363	381	371	356	370	378	351	374	353	335
Natural gas	144	167	189	199	191	241	255	182	188	206
Peat	80	75	75	75	75	75	75	75	75	73
Coal	162	215	239	260	165	54	49	175	103	92
Other	36	35	40	43	38	62	66	36	53	58
Total	1357	1460	1513	1550	1436	1427	1442	1439	1496	1522
CO_2 free share #	44,0	41,0	40,4	40,6	42,3	45,3	46,9	42,2	49,7	51,7

Energy efficiency trends in baseline EFOM

	Annual rates 2000 - 2010 in BaU						
	Industry	*unit*	buildings	*unit*	households	*unit*	pass cars
Heat	-2,2 %	Energy /VA	-0,4 %	kWh/m3	-		-
Electric power	-1,6 %	Energy /VA	-1%	kWh/VA *	0,0 %	kWh/hh	-
Motor fuel (ltr/100km)	-		-	*) services	-		-1,9 %

Figure 2A.1 & 2: *Energy efficiency trends observed and in study period (source VTT-Energy)*





Electricity import prices

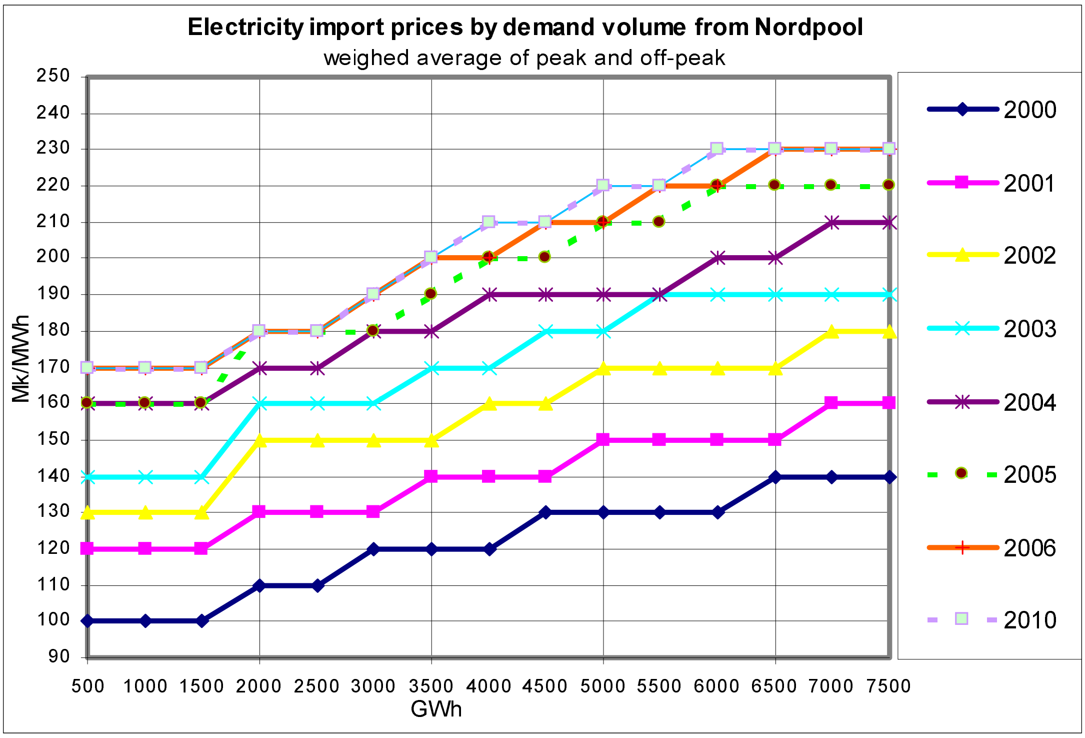


Figure 2A.3

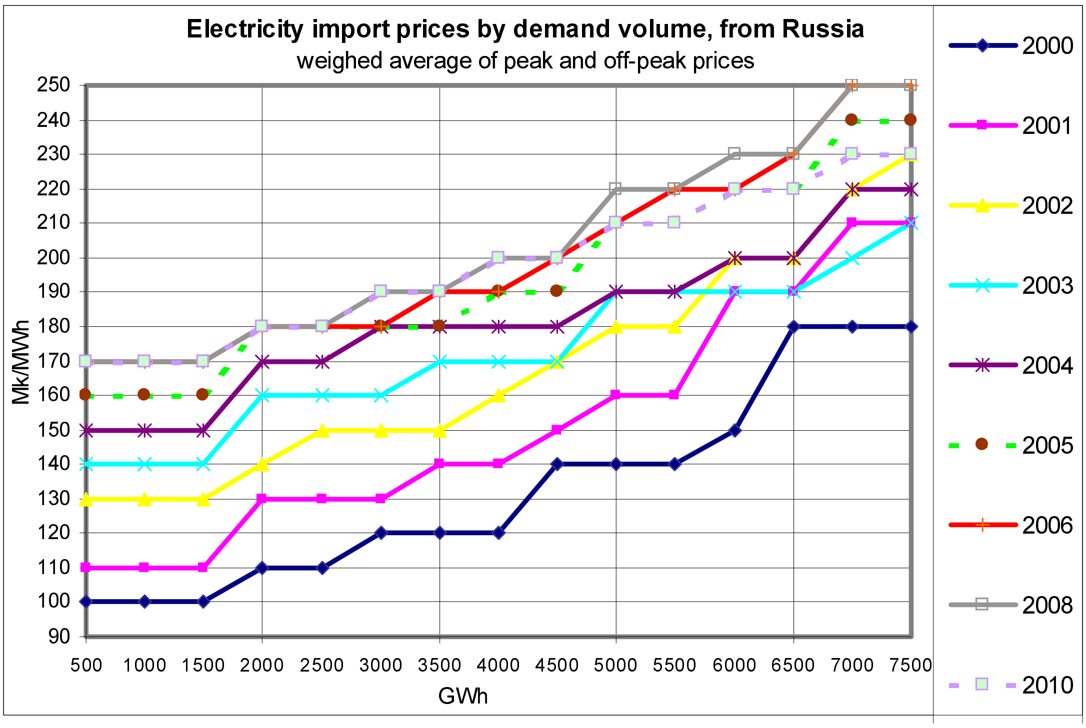


Figure 2A.4

Initial outlays in billion FIM (price level 2000)

Default KIO1 and KIO2	**KIO2 Taxes**			**KIO1 Taxes**		
	2005	*2010*	*2015*	*2005*	*2010*	*2015*
Energy sector	0,15	0,09	0,01	0,07	0,12	0,08
Industry	0,76	1,22	1,48	0,77	1,23	1,43
Services	0,45	0,62	0,72	0,45	0,62	0,68
Households	0,69	0,91	0,94	0,69	0,90	0,89
Transport	1,38	2,21	2,53	1,38	2,21	2,53
Total	3,43	5,05	5,68	3,37	5,08	5,61
	Other outlays			**Other outlays**		
Energy sector	-0,13	-0,35	-0,15	0,01	0,05	-0,23
Industry	0,23	0,58	0,85	0,30	1,30	1,50
Services	0,11	0,43	0,52	0,11	0,43	0,77
Households	0,18	0,72	0,75	0,21	0,77	0,97
Transport	-0,26	0,23	0,23	-0,28	0,26	0,24
Total	0,13	1,61	2,21	0,36	2,83	3,26
Total taxes + other outlays	***3,6***	***6,7***	***7,9***	***3,7***	***7,9***	***8,9***

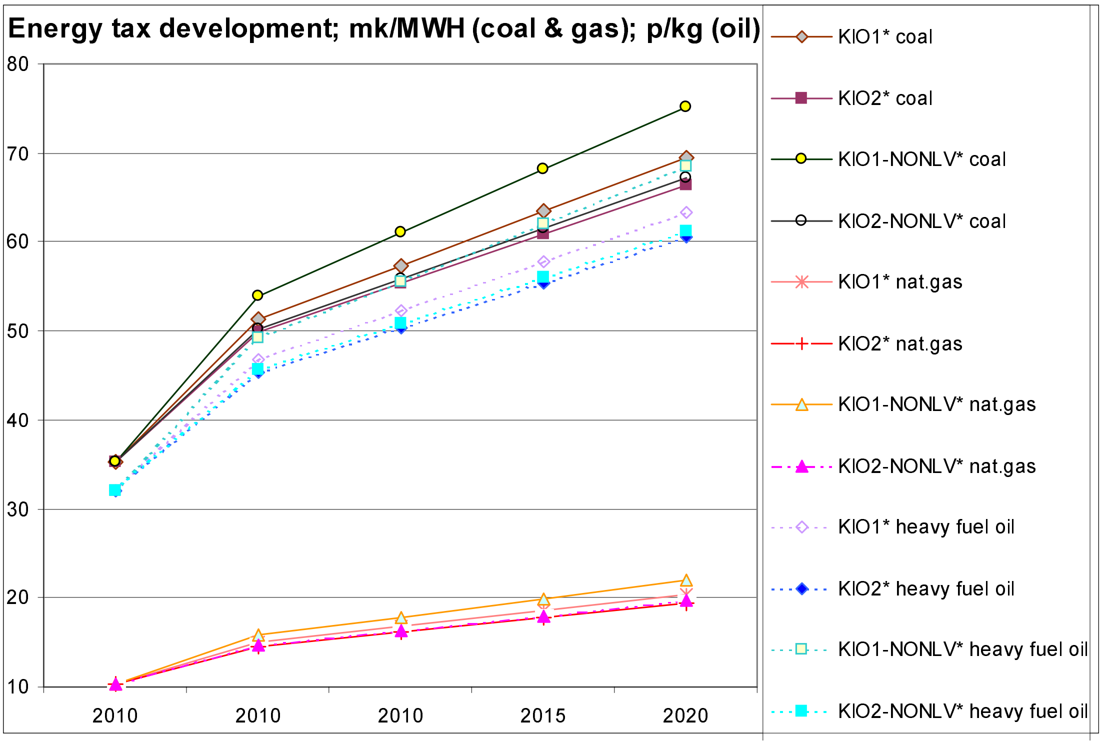
	KIO2*		**Taxes**	**KIO1***		**Taxes**
	2005	*2010*	*2015*	*2005*	*2010*	*2015*
Energy sector	0,05	0,04	-0,02	0,06	0,08	0,01
Industry	0,16	0,52	0,75	0,41	0,78	0,99
Services	0,23	0,35	0,42	0,32	0,46	0,54
Households	0,33	0,51	0,58	0,48	0,68	0,71
Transport	1,36	2,18	2,49	1,37	2,19	2,51
Total	*2,13*	*3,59*	*4,22*	*2,63*	*4,20*	*4,76*
	Other outlays			**Other outlays**		
Energy sector	-0,13	-0,35	-0,36	0,00	-0,04	-0,24
Industry	0,26	0,52	0,74	0,25	1,25	1,52
Services	0,11	0,43	0,52	0,12	0,43	0,54
Households	0,17	0,67	0,86	0,21	0,85	1,10
Transport	-0,27	0,23	0,22	-0,29	0,25	0,23
Total	*0,15*	*1,49*	*1,99*	*0,30*	*2,76*	*3,14*
Total taxes + other outlays	***2,3***	***5,1***	***6,2***	***2,9***	***7,0***	***7,9***

	KIO2-NONLV*		**Taxes**	**KIO1-NONLV***		**Taxes**
	2005	*2010*	*2015*	*2005*	*2010*	*2015*
Energy sector	0,05	0,03	-0,03	0,08	0,14	0,10
Industry	0,23	0,59	0,82	0,84	1,28	1,52
Services	0,25	0,38	0,45	0,48	0,65	0,72
Households	0,37	0,55	0,62	0,73	0,95	0,94
Transport	-0,07	-0,41	-0,47	-0,05	-0,38	-0,43
Total	0,82	1,15	1,40	2,09	2,64	2,84

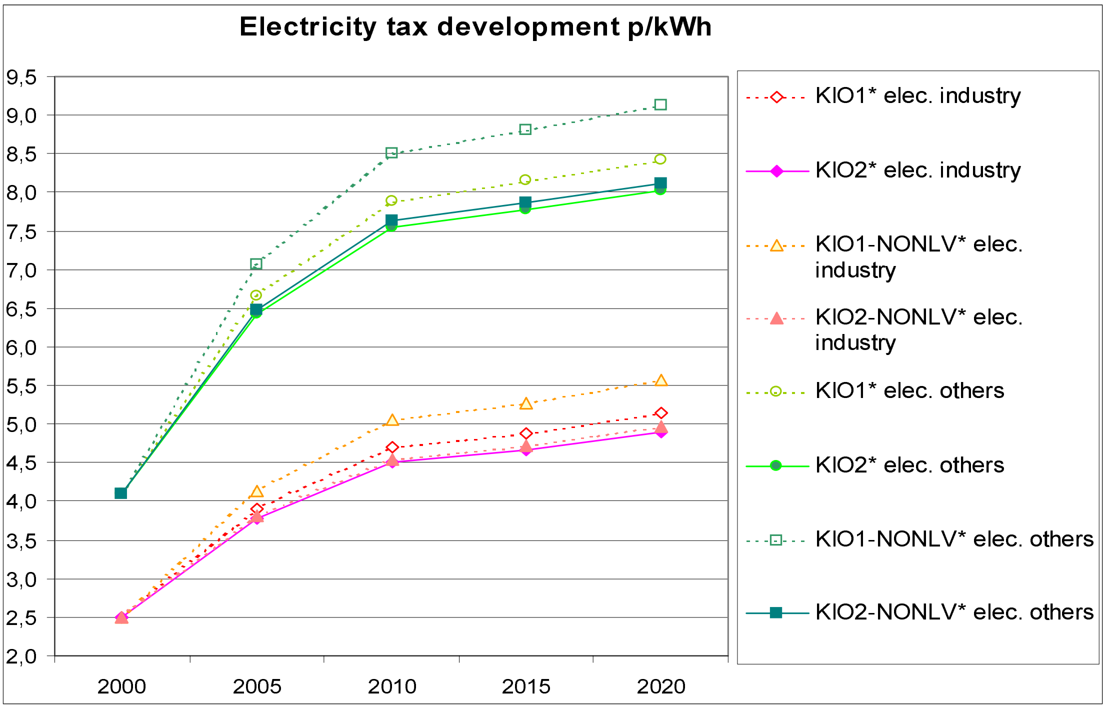
	Other outlays			Other outlays		
Energy sector	-0,13	-0,30	-0,35	0,02	0,07	-0,25
Industry	0,26	0,52	0,77	0,30	1,36	1,52
Services	0,11	0,43	0,52	0,11	0,43	0,77
Households	0,17	0,68	0,86	0,21	0,77	0,97
Transport	0,06	0,58	0,57	0,05	0,62	0,60
Total	0,48	1,91	2,37	0,69	3,24	3,61
Total taxes + other outlays	***1,3***	***3,1***	***3,8***	***2,8***	***5,9***	***6,5***
No tax increases –NONEV	**KIO2-NONEV**		**Taxes**	**KIO1-NONEV**		**Taxes**
	2005	*2010*	*2015*	*2005*	*2010*	*2015*
Energy sector	-0,04	-0,10	-0,13	-0,04	-0,16	-0,22
Industry	-0,04	-0,11	-0,13	-0,04	-0,12	-0,21
Services	0,00	-0,03	-0,03	0,00	-0,04	-0,05
Households	0,00	0,01	0,00	0,00	0,00	-0,01
Transport	-0,10	-0,44	-0,52	-0,10	-0,44	-0,52
Total	-0,18	-0,68	-0,81	-0,18	-0,77	-1,00
	Other outlays			**Other outlays**		
Energy sector	-0,14	-0,08	-0,50	0,00	-0,15	-0,38
Industry	0,26	0,36	0,60	0,30	1,49	1,55
Services	0,12	0,48	0,63	0,12	0,62	0,83
Households	0,19	0,74	1,00	0,18	0,82	1,10
Transport	0,05	0,56	0,55	0,03	0,55	0,54
Total	*0,47*	*2,06*	*2,28*	*0,62*	*3,33*	*3,63*
Total taxes + other outlays	***0,3***	***1,4***	***1,5***	***0,4***	***2,6***	***2,6***

	KIO2-NONLV		**Taxes**	**KIO1-NONLV**		**Taxes**
	2005	*2010*	*2015*	*2005*	*2010*	*2015*
Energy sector	0,15	0,09	0,01	0,08	0,14	0,10
Industry	0,76	1,22	1,48	0,84	1,28	1,52
Services	0,45	0,62	0,72	0,48	0,65	0,72
Households	0,69	0,91	0,94	0,73	0,95	0,94
Transport	-0,05	-0,38	-0,44	-0,05	-0,38	-0,43
Total	2,00	2,47	2,71	2,09	2,64	2,84
	Other outlays			**Other outlays**		
Energy sector	-0,13	-0,35	-0,15	0,02	0,07	-0,25
Industry	0,23	0,58	0,85	0,30	1,36	1,52
Services	0,11	0,43	0,52	0,11	0,43	0,77
Households	0,18	0,72	0,75	0,21	0,77	0,97
Transport	0,07	0,58	0,59	0,05	0,62	0,60
Total	0,47	1,96	2,56	0,69	3,24	3,61
Total taxes + other outlays	***2,5***	***4,4***	***5,3***	***2,8***	***5,9***	***6,5***

Taxation – energy tax rate increases compared to Baseline



Kuvio2A.5



Kuvio2A.6

Macro Economic results for 2010

Indicators	KIO1* 100%inc	KIO2* 100%inc	KIO1 50/50	KIO2 50/50	KIO1 100%inc	KIO2 100%inc
GDP	-0,4	-0,4	-0,5	-0,3	-0,4	-0,3
Private consumption	-0,8	-0,7	-0,8	-0,6	-0,6	-0,6
Investments	-0,5	-0,4	-0,6	-0,4	-0,6	-0,5
Export	-0,1	0,0	-0,1	0,0	-0,2	-0,1
Import	-0,2	-0,1	-0,3	-0,2	-0,3	-0,2
Employment	-8000	-7000	-9000	-6000	-8000	-6000

Cost per household

Table 2A.4 *Investment outlays and other programme induced expenditures per household in FIM/year (derived from EFOM)*

Year	KIO1	KIO2	KIO1*	KIO2*	KIO1-NONLV	KIO2-NONLV
2005	70	70	70	60	70	70
2008	180	190	170	180	180	190
2010	280	280	280	260	290	280
2015	400	360	380	340	400	370
2020	440	440	430	400	444	440

Table 2A.5 *Extra cost for expenditures other than housing, energy and private car*

Extra cost of other goods 2010	KIO1*	KIO1-NONLV KIO1-NONEV	KIO2-NONLV* KIO2*
Employed	400	370	300
Pensioner/ student	230	210	170

Appendix 3 – Input treatment in KESSU

From the energy systems model EFOM two straight and one implied set of data are transferred to KESSU input:

1. direct cost by sector (investments in conversion and efficiency, extra operational cost)
2. net tax payments by sector (the balance of energy taxes and energy subsidies)
3. the impact on value added tax receipts (which is calculated separately based on EFOM output)

Furthermore amendments are made with respect to the interaction between applicable amount of recyclable tax in relation to a proper attribution of costs to sectors. For example, for those sectors for which the recycling as such cannot be represented adequately in the model, the direct costs are lowered. The amendment concerns a few percent of the total direct cost. Another amendment is a slight generic reduction of the recyclable amount as a kind of prevention to underestimated subsidy cost. Also in this case the reduction concerns a very small sum compared to the total energy tax revenue.

The EFOM model distinguishes three energy production (conversion) sectors, being:

- separate electricity generation (hydro, wind, nuclear, gas combined cycle, back-pressure coal)
- combined heat power in district heating
- industrial combined heat and power

Apart from the three energy sectors the model distinguishes paper&pulp, basic metal, chemicals, other industries, services, building construction, agriculture and forestry, households, passenger transport and goods transport. For services and households there is distinction between space heating and other energy use (mainly electricity).

First line cost effects for non-energy sectors

The direct costs per sector in EFOM, other than the cost of the energy sector, can be fairly straightforwardly transferred to the corresponding sectors in KESSU. In the case of services, KESSU contains more sub-sectors of one EFOM sector. The sector costs are attributed to these sub-sectors on the basis of their share in gross production value of the whole sector. The attribution of direct costs to sub-sectors of the other industry is based on their share in electricity consumption of the whole sector (in 1998). Obviously, the costs of the heavy industry sectors can be just be used as such in the identically defined sectors in KESSU.

Cost effects in the energy sector and their induced effects

In principle the changes in energy production costs could be transferred to the (less disaggregated) energy sector in KESSU as sector costs. This would imply that in KESSU the prices of distributed electricity and heat are adapted exogenously and the resulting cost rises are handed over the power and heat purchasing sectors via the input-output table.

This procedure has not been used though, since the insufficient disaggregation of the energy sector in KESSU risks substantial imprecision of the attribution of induced cost effects across sectors. A second issue is the handling of energy efficiency investments, which need to be attributed to the right sectors. For both issues a solution has been devised, in which both the efficiency investments and the costs in the energy sector are directly attributed to (energy using) sectors.

A part of the costs of district heat systems and of industrial CHP can be relatively easy attributed to the sectors in accordance with their heat consumption (as indicated by EFOM). The attribution of electricity costs is however a bit more complicated, since electricity is generated both separately and in conjunction with heat (the latter with differences again between industrial CHP and district heat). The cost increases of district heat need to be divided between electricity and heat output (sales). As point of departure for the cost attribution the energy volumes in value terms are used. To this end we assume that the value of electricity per unit of energy is twice that of heat.

A proper modelling of the electricity market was outside the scope of this study, consequently simplified solutions had to be used. The extra cost in electricity production can be attributed to use sectors in different ways. One of the attribution methods attempts to emulate an electric power market behaviour, in which the attribution of cost is independent of the source of power production[29]. This means that the attributable cost depend to a large extent on the amounts of electricity used. In that case the cost distribution is reminiscent of a carbon tax cost distribution, which would mean that the industry carries a fairly large share of the cost. Other attribution approaches produce results, that emulate situations in which the risen energy production cost (including energy taxes) are transferred relatively less to industry and more to services and households in comparison to the previously mentioned approach. Eventually, the averages of the cost change impacts per sector resulting from different attribution approaches as described above are used for the actual KESSU input. Please note that the input concerns *changes in cost levels* not absolute cost levels.

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[29] . In the power market the price depends on the relative scarcity by time of day, not directly on production cost. If wholesale power market prices are low, some types of sources just don't produce.

With the aid of the model results and aforementioned assumptions the *average* rise in production cost of electricity and heat can be evaluated. This implies also that in the model the electricity price rises for any kind of customer are based on the average rise of electric power production cost. In reality this may not be the case. Electricity prices for end users could rise according to the rise of marginal cost of production instead of the rise of average production cost[30]. The extent to which changes in end use prices will follow marginal cost patterns rather than average cost depends on the accounting and pricing system of power companies and on the variation in price sensitivity between customer types[31]. The modelling of customer type specific price effects in a marginal cost pricing system is complicated and beyond the assignment of the present study. Therefore, average cost increases as explained above have been assumed.

The amount of electricity import does not depend on the cost price levels within Finland, but is as exogenous variable predetermined in the BaU scenario[32].

The necessity to insert a 'shock' into KESSU

From the EFOM model intermediate results are obtained for the years 2005, 2008, 2010, 2015 and 2020. The KESSU model calculates technically up to 2020, but for the result interpretation we do not look beyond 2015, given the increasing uncertainties that are already present in the baseline development (BaU). The direct costs and extra energy tax payments as calculated by EFOM for the years 2005, 2008 and 2010 are not transferred to the corresponding years in KESSU, instead the average of the results from these three years is transferred to KESSU for the period 2005-2010. After 2010 the tax payments are put into KESSU according to the EFOM output. Likewise the net recyclable amounts of excess tax revenues are derived from those figures without multi-year averaging. However, up to 2010 the tax payments and hence the derivation of the net recyclable amount of excess tax revenues is based on averaging over the years 2005-2008-2010. The KESSU model tends to respond slowly to input changes (compared to a baseline, BaU in this case). The typical remedy for this is the so-called insertion of a 'shock' in order to obtain more sensible results. Notably for

30 . Marginal production cost are the cost of the last (most expensive) unit needed to meet demand, hence marginal cost rises are always higher than increases of average cost.

31 . In Finland electricity generators own power distribution companies and have direct access to (large) customers, though also independent distribution (municipal) companies (still) exist. Yet, the prevailing organisational model is of generators that by and large control the sales chain, and consequently have room to choose a pricing policy that improves profit margins. This usually involves attribution of cost increases as much as possible to customers with low price sensitivity (i.e. services and households). It is however unlikely that the electricity market authority will allow attribution of cost increases in a way that practically means a violation of costing and accounting principles of a power company used so far.

32 . In some of the sensitivity analyses electricity import is not predetermined and those cases it does depend on production cost levels in Finland and expected tightness (and cost levels) of the Nordpool power market. That assessment of import volume has been done by VTT Energy by means of another specific power market model. Results were inserted into EFOM.

the later part of the considered period (2010-2015) a reliable representation of how the economy reacts is obtained in this way.

Direct energy cost effects are attributed to sectors in KESSU according to their volume of energy consumption. The type of generation unit from which purchased electricity is obtained affects to some extent the degree of sectoral energy cost increases.

The linkage of EFOM to KESSU is not necessarily a one way data transfer from EFOM to KESSU. If the economic effects of the policy programme are substantial and consequently the production levels and hence energy demand levels are significantly lower than in the baseline (BaU), the new adapted production levels would be fed back to EFOM to calculate the energy mix, extra cost and tax payments again. However, in practice it appeared to be mostly not necessary to run more iterations.

Attribution of energy tax payments, labour market

The attribution of energy tax payments and subsidies is decided upon when transferring the data from one model to the other (from EFOM to KESSU that is). The attribution of energy tax payments and subsidies is done by adapting the prices of delivered energy by sector and type of energy carrier in such a way that the resulting cost rise corresponds with the extra costs as calculated in EFOM (with a difference before and after 2010 as regards averaging).

KESSU does not contain a proper labour market module, which meant that the handling of tax recycling could not be done as is common in macro-economic models containing a labour market module. Since the sectoral direct costs + tax payments are transferred from EFOM to KESSU, the tax recycling could in principle already be taken into account at that point, by correcting the sectoral cost input to KESSU commensurate to a an estimated sectoral amount of recycled tax. In that case the attribution of the recycled amounts to sectors is based on the distribution of labour cost and social security payments over sectors. A second attribution alternative to reduce in the KESSU model the social security payments by sector and/or household income tax payments. The latter alternative is used.

The treatment in KESSU is notable for its very limited significance for labour demand (and not any for labour supply). In this respect the model differs from many other macro-economic models in which the effective price of labour is affected (by tax recycling via income tax and social security payments) and hence supply and demand of labour adapt accordingly (depending on the elasticities used).

Net energy tax payments (including VAT effects) are put into KESSU straightaway as sectoral cost. KESSU does not distinguish energy tax nor electricity tax. Transport fuel tax are a separate item in KESSU, and therefore changes in those payments according to EFOM can simply be moved to the corresponding tax variable in KESSU.

Appraisal of recyclable net excess tax revenue

For the assessment of the recyclable amount of *net* excess tax revenues it has to be taken into account that the various cost increases cause a contraction of the economy, which causes also a contraction in revenues of other taxes (e.g. income tax and VAT). As a consequence the original amount of extra energy taxes from EFOM is larger than the net excess tax revenue, since a part of the extra energy tax is used to make up for the reductions in other tax revenues. To find this right amount of net recyclable tax KESSU is run at least two times to be able to correct the input values for income tax and social security payments in such a way that the public budget is in balance again.

Energy cost effects, product prices and production levels

The transfer of direct cost from EFOM to KESSU is based on the concept of unit-cost. The direct cost effects as calculated in EFOM increase the unit-cost of products and services. The rise of unit-cost in the industry raises the so-called price of value added, which implies a reduction in profitability. The reduction in profitability affects sector levels of production, investment, and employment and indirectly induces contraction effects in other sectors. In KESSU unit cost increases in service sectors translate themselves in higher sales prices, while in turn higher sales prices would increase household income thanks to a margin marking up effect that trickles down into annual income of company owners. The latter effect is however evicted, being an artefact rather than a real world effect. The sales price increase causes a reduction of demand which is taken into account.

The energy price rises for households is rated at such a level that its impact on total extra energy cost per household is the same as the extra energy cost as indicated by EFOM.

Caution for sweeping interpretations on cost development

The development of cost over time as resulting from the KESSU simulations have to be considered with care given the averaging of the input from EFOM. Over time a part of the macro-economic effects gradually subsides, while another part accumulates. All in all it is recommendable to focus on the differences with BaU for the years 2010 and 2015, or even the averaged differences of these two years.

Appendix 4 – Assessment of capital cost valuation impacts

In the EFOM-KESSU system as we have been using in this study the selection of investment options in the EFOM model is based on interest ratings that correspond to empirically tested appropriate levels of internal rate of return (IRR). As a consequence these interest rates can be quite high.

In the commercial sectors this can be the case if the required rates on return on investment are commensurate to the selection criteria on the capital market and the return on investments that are reported by competing companies. Another complementary reason for a high IRR criterion is the non-core character of energy investments in many sectors. This is perceived as a risk that requires a premium to be accepted. The IRR can often be 15% - 20%, whereas for core investments the criterion will often vary between 12% - 15%.

For households a high IRR can be applied if there are empirical indications that households have a high time preference rate. For items such as for example energy saving lamps it has been frequently demonstrated that households indeed have a time preference rate. In other words households tend to distrust that one can earn the higher purchaser price of the lamp back within 6 to 8 years for lamps that are used for many hours per year. The – implicitly – used IRR can be 20%-25%.

The IRR is a selection benchmark and also indicates the level of performance of capital productivity to which the company aspires to strive or which it wishes to maintain. The IRR however does not represent the actual financing cost in case the investment would be selected. The current modelling structure does not allow however to use a second figure for actual finance cost (including opportunity cost considerations, see below). So, either the IRR ratings as indicated above are used or an interest rate of say 5%.

The financing cost depends on the way the investment is financed. If it is entirely done by a (bank) loan than the loan's percentage can be applied, ignoring indirect effects of the total capital structure of a company (which among others put a limit on the use of non-equity capital). Such way of financing would mean an interest rate of for example 8%, made up from: real interest rate (e.g. 4%) + inflation (e.g. 2%) + a project/sector specific risk premium (2%). If however an investment is entirely financed from internal means of a company, than it has to compete fully with the alternative opportunities for investment in a company. In that case the opportunity cost principle is fully applicable. The opportunity cost are the foregone benefits of the project(s) not implemented due to the selection of other projects. So, the opportunity cost are lower than the IRR criterion, since projects achieving that are selected anyhow. The opportunity cost are at least as high as the currently reported return on capital employed (ROC). Otherwise the ambition to move the ROC toward the IRR would frustrated. The opportunity cost will in fact be at the level of the IRR of the project just not chosen. In the heavy industry it will mean that the opportunity cost rating 12%-15%. The electricity sector in Europe is generally not performing terribly well in terms of ROC. The ratings hover around 10% (with the ambition to go up though).

For public investments often a real interest rate of 5% is used. Though in European countries common or even prescribed rates vary between 4% and 10%. In case of a social cost benefit analysis of a publicly financed project such a rate.

Even though the present study has public finance aspects it is not a social cost benefit analysis, but rather a simulation of what happens throughout the economy. Therefore preferably opportunity cost principles would have been applied when calculating actual investment finance cost, with a possibility to assume different degrees of the use of loans by sector. All in all it means that the current interest rates used for the various kind of investments are too high for households and real estate and too low for large scale energy utility investments (assuming that currently the large majority of the electricity generation companies applies private company like investment criteria).

It has been decided to use the usual ratings of the EFOM model throughout the study. Major modelling difficulties would arise, if the distinction as explained above would have been used. As an approximation of the – possibly – required correction VATT used the annualised investments by sector from EFOM and applied the philosophy as explained above. The ratings are listed below. For the electricity sector the current fairly low ROC ratings have been used.

Sectors	**ROC***	**EFOM**
Electricity generation	9 %	5 %
District Heating	9 %	5 %
Industrial CHP	13 %	5 %
Dwelling heating	10 %	7 %
Services heating	10 %	7 %
e-efficiency paper	13 %	13 %
e-efficiency chemicals	13 %	14 %
e-efficiency metal	13 %	14 %
e-efficiency other industry	20 %	20 %
e-efficiency dwelling-heating	10 %	25 %
e-efficiency services-heating	10 %	25 %
e-efficiency households appliances	10 %	25 %
e-efficiency services-appliances	20 %	25 %

For the two sets of alternatives that achieve the most favourable outcomes in the study the corrected sets of initial outlays are shown below in figures 4A1 and

4A2. It means direct cost reductions both in KIO1 and KIO2 alternatives. The reductions are larger in KIO1 than in KIO2 alternatives. Maximum corrections occur in 2010 with about –670 million FIM for KIO1 alternatives and about –390 million FIM for KIO2 alternatives. Since these corrections relate purely to the direct investment cost and not to taxes, it also means that the macro economic results improve modestly. Applying a multiplier of 1,5 as indicated in section 5.2, it would mean that the GDP effect gets 0,1% less negative in KIO1 and 0,06% less negative in KIO2.

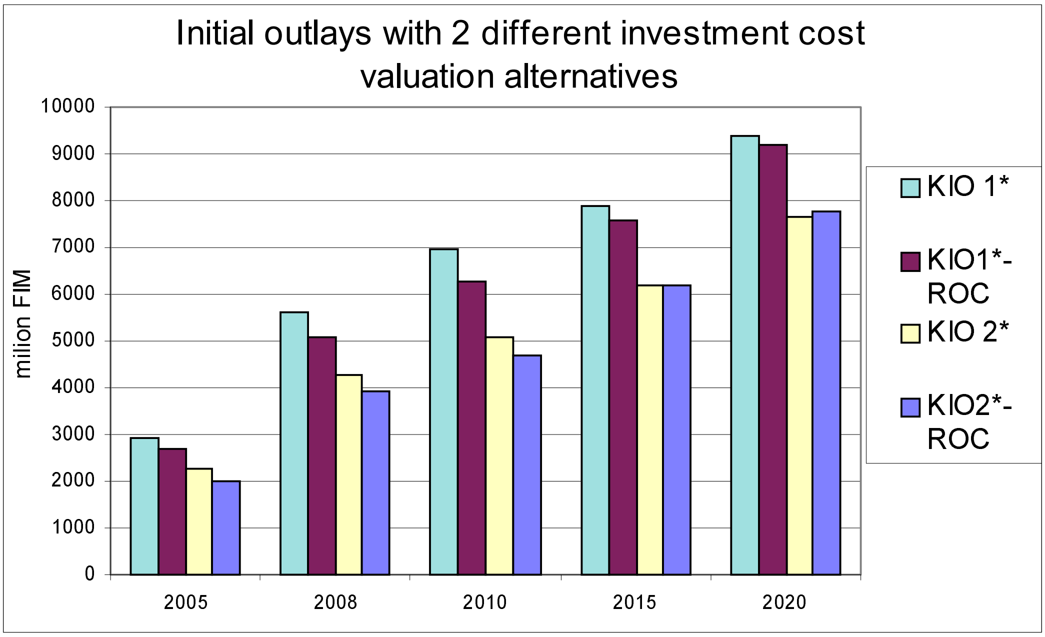

Figure A4.1

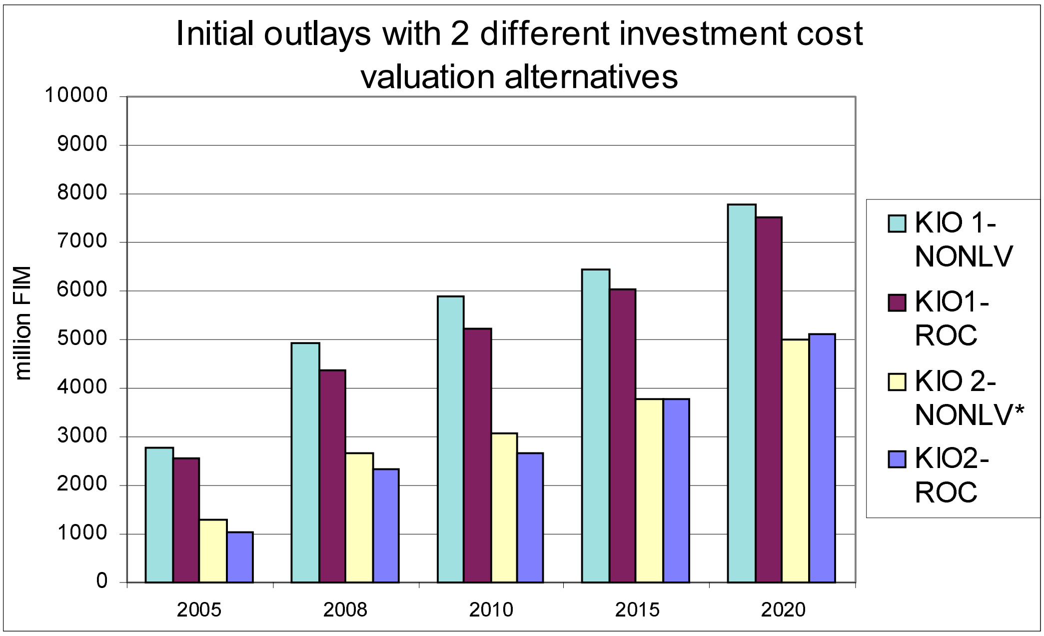

Figure 4A.2

Appendix 5 – Survey on stakeholder preferences

Implementing greenhouse gas reductions in Finland – workshop on evaluation of applicable policy instruments

A summary of the assessment of the working groups and concluding discussions[33]

Working group 1

What sectors should be addressed by the climate policy measures?

- All sectors need to be included
- All instruments that actually can be applied should be used
- Distribution effects across sectors, household types and regions should be assessed separately
- Cost distribution effects can not be included in a meaningful way in this phase

What are the important qualities of instruments when making a selection?

- Certainty, implementability and lasting effects
- Ensuring that energy remains available at prices not harmful to (international) competitiveness

What objectives are to be aimed at in particular next to GHG emission reductions as such?

- Health and safety
- Technology development
- Security of energy supply
- Global solidarity
- Implementability of instruments and general democratic points of departure
- Not overlooking 'megatrends'

Working group 2

Discussion on What sectors should be addressed by the climate policy measures?

- What exactly constitutes cost effectiveness and what criteria can be applied here

[33] . Translated from a Finnish summary made by Marja Hiltunen (Finnish Environment Institute)

- Structural change of the consumption structure is an important criterion for various factors. Changes in production and consumption structure are two distinct matters
- To what extent other than technical-economic criteria merit to be taken into account and if so, can these criteria be operationalised (e.g. quality of life aspects) ?
- Global equity has been put forward in various occasions (e.g. COP6) as an important criterion.

<u>How to allocate the policy instruments over different sectors ?</u>

- Proposition 1: The direct cost are preferably allocated over sectors in way that corresponds as closely as possible with the emission volumes of the sectors. The reduction task of a sector could be diminished, if the original cost burden reaches unreasonable levels.
- Proposition 2: The households could be considered for taking a somewhat larger share in the cost burden than their corresponding share in emissions, as a result of which the consumption structure might change a bit more. This proposition would also include compensatory measures for low income households to prevent unreasonable loss of purchasing power.

<u>What objectives are to be aimed at in particular next to GHG emission reductions as such?</u>

- Sustainable consumption
- Global equity
- Social sustainability and preservation/improvement of the quality of life
- Emphasising long term views
- Minimising other environmental effects

General concluding discussion – issues raised

- Should climate policy be based on market based and voluntariness preferring policy approaches or on strong societal guidance (e.g. regarding making industry less energy intensive)
- Does it pay off to be a pioneer in energy policy ? What risks and what opportunities does it bring ? ”Incremental politics” feels more secure, but on the other hand also too conservative (nothing risked, nothing gained) politics can lead eventually to expensive situations.
- Is it sensible to start with cheap and unsure measures and invoke more expansive but more surely effective measures in case results are below expectations ?

- Should we take the notion into account that the present measures are only first steps, whereas later steps can be expected to be tougher ?
- What is the impact of energy price level on the motivation to save energy of consumers and thereby affecting the structure of consumption in general ?
- What is the role of the Climate Programme – pragmatic or visionary ? For example, the Climate Programme time table has been quite tight, which probably relates to scant time resources of the involved officials (as cause and consequence). Yet, sooner rather than later we will need anyhow resources for a deeper and more visionary analysis of the problems our challenge for the future. Through what platforms and interest groups can visions on climate policies be (further) developed?

Appendix 6 – Background of the MCA analysis and main results

The MCA is based on a straightforward additive utility function with 10 arguments. For 1 argument (energy import dependence) two alternative inputs exist, depending on the interpretation of what is regarded as imported energy.

The function is specified as follows:

the result R_n of programme alternative n can be described as:

$R_n = \sum_i \{f_i(C_{ni})\}$

i = 1 .. 10

n = 1..6 (whereas 1 represents KIO1-NONLV* up to 6 representing KIO2-NONEV)

	Criterion (C_{ni})	Function (f_i)
C_1	GDP effect	$+1.\ C_1$
C_2	Abatement unit cost	$-\sqrt{C_2}$
C_3	Household consumption effect }	$+1.\ C_3 \cdot \sqrt{C_4}$
C_4	Household cost standard deviation }	
C_5	Production effect heavy industry	$+1.\ C_5$
C_6	Employment	$-1 / 1.5^{C_6/100}$
C_7	Share of renewables	$+1.\ C_7$
C_8	Energy saving impact	$+1.\ C_8$
C_{9A}	Dependence on imports A	$+1.\ C_{9A}$
C_{9B}	Dependence on imports B	$+1.\ C_{9B}$
C_{10}	efficiency of e-efficiency investment	$-\sqrt{C_{10}}$

Programme alternative	Criterion	Criterion source value	Scaling factor	Input value
1	GDP effect	-4200	0,01	-21,0
KIO1-NONLV*	Abatement unit cost	251	0,10	25,1
	HH Consumption effect	-1600	0,01	-16,0
	Production effect heavy industry	-0,42	10,00	-4,2
	Household cost St.Dev	280	0,01	2,8
	Employment	-8000	0,01	-80,0
	Share of renewables	26,2 %	100,00	26,2
	Energy saving impact	-5 %	-100,00	5,25
	Dependence on imports A	-6 %	-100,00	5,5
	Dependence on imports B	-5 %	-100,00	4,7
	efficiency of e-efficiency inv.	542	0,10	54,2

2	GDP effect	-2900	0,01	-14,5
KIO2-NONLV*	Abatement unit cost	173	0,10	17,3
	HH Consumption effect	-1200	0,01	-12,0
	Production effect heavy industry	-0,27	10,00	-2,7
	Household cost St.Dev	225	0,01	2,3
	Employment	-6000	0,01	-60,0
	Share of renewables	24,3 %	100,00	24,3
	Energy saving impact	-0,70 %	-100,00	0,70
	Dependence on imports A	-9 %	-100,00	9,3
	Dependence on imports B	-2 %	-100,00	2,0
	efficiency of e-efficiency inv.	3171	0,10	317,1
3	GDP effect	-4300	0,01	-21,5
KIO1*	Abatement unit cost	254	0,10	25,4
	HH Consumption effect	-1800	0,01	-18,0
	Production effect heavy industry	-0,62	10,00	-6,2
	Household cost St.Dev	360	0,01	3,6
	Employment	-9000	0,01	-90,0
	Share of renewables	25,9 %	100,00	25,9
	Energy saving impact	-6 %	-100,00	5,61
	Dependence on imports A	-5 %	-100,00	5,4
	Dependence on imports B	-4 %	-100,00	4,5
	efficiency of e-efficiency inv.	491	0,10	49,1
4	GDP effect	-3500	0,01	-17,5
KIO2*	Abatement unit cost	209	0,10	20,9
	HH Consumption effect	-1500	0,01	-15,0
	Production effect heavy industry	-0,27	10,00	-2,7
	Household cost St.Dev	300	0,01	3,0
	Employment	-7000	0,01	-70,0
	Share of renewables	24,4 %	100,00	24,4
	Energy saving impact	-1,14 %	-100,00	1,14
	Dependence on imports A	-9 %	-100,00	9,3
	Dependence on imports B	-2 %	-100,00	2,1
	efficiency of e-efficiency inv.	1941	0,10	194,1
5	GDP effect	-5400	0,01	-27,0
KIO1-NONEV	Abatement unit cost	319	0,10	31,9
	HH Consumption effect	-2400	0,01	-24,0
	Production effect heavy industry	-0,38	10,00	-3,8
	Household cost St.Dev	300	0,01	3,0
	Employment	-11000	0,01	-110,0
	Share of renewables	25,5 %	100,00	25,5
	Energy saving impact	-6,2 %	-100,00	6,2
	Dependence on imports A	-5,0 %	-100,00	5,0
	Dependence on imports B	-3,9 %	-100,00	3,9
	efficiency of e-efficiency inv.	529	0,10	52,9

6	GDP effect	-4200	0,01	-21,0
KIO2-NONEV	Abatement unit cost	257	0,10	25,7
	HH Consumption effect	-2000	0,01	-20,0
	Production effect heavy industry	-0,23	10,00	-2,3
	Household cost St.Dev	250	0,01	2,5
	Employment	-9000	0,01	-90,0
	Share of renewables	23,1 %	100,00	23,1
	Energy saving impact	-1,4 %	-100,00	1,4
	Dependence on imports A	-8,7 %	-100,00	8,7
	Dependence on imports B	-1,0 %	-100,00	1,0
	efficiency of e-efficiency inv.	1718	0,10	171,8

MCA scores

Equal weights

Programme	weighed total A	weighed total B
KIO1-NONLV	-28,8	-29,6
KIO1*	-38,4	-39,3
KIO2*	-31,1	-38,3
KIO2-NONLV*	-24,1	-31,4
KIO1-NONEV	-50,2	-51,2
KIO2-NONEV	-41,3	-49,0

Strong industrial/commercial weights

Programme	weighed total A	weighed total B
KIO1-NONLV	-37,9	-39,1
KIO1*	-44,9	-46,0
KIO2*	-32,7	-42,0
KIO2-NONLV*	-29,7	-39,1
KIO1-NONEV	-51,0	-52,3
KIO2-NONEV	-39,8	-49,8

Strong household purchasing power weights

Programme	weighed total A	weighed total B
KIO1-NONLV*	-57,5	-58,1
KIO1*	-72,0	-72,6
KIO2*	-59,3	-64,4
KIO2-NONLV*	-45,5	-50,7
KIO1-NONEV	-90,2	-90,9
KIO2-NONEV	-73,2	-78,8

Strong sustainability weights

Programme	weighed total A	weighed total B
KIO1-NONLV*	7,1	6,2
KIO1*	-1,3	-2,2
KIO2*	-3,2	-10,4
KIO2-NONLV*	2,1	-5,2
KIO1-NONEV	-13,3	-14,3
KIO2-NONEV	-13,4	-21,1

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