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GREENHOUSE GAS POLICY QUESTIONS AND SOCIO-ECONOMIC RESEARCH IMPLICATIONS FOR FINLAND IN A NATIONAL AND INTERNATIONAL CONTEXT

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Abstract: This publication contains the proceedings of a VATT seminar held in November 1999 in Helsinki. The purpose of the seminar was to assess greenhouse gas policy questions and related socio-economic research implications for Finland. Contributions come from both policy makers and economic researchers, including contributions from Germany and the Netherlands. Issues dealt with are: permit trade, sinks, macro-economic costs and technology development, spatial-economic aspects, long term studies on sustainable economic development, and assessment of policy mixes. The introduction provides a summary of the presentations and the discussion.

Key words: climate policy, macro-economic modelling, flexible mechanisms

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Tiivistelmä: Tämä julkaisu sisältää marraskuussa 1999 pidetyn VATT-seminaarin esitelmät ja niiden yhteenvedon. Seminaarin tarkoituksena oli arvioida kasvihuonekaasupäästöjen rajoittamisen politiikkakysymyksiä ja tutkimustarpeita Suomen näkökulmasta. Seminaarin esiintyjinä oli politiikan valmisteluun osallistuvia virkamiehiä ja taloustutkijoita, viimeksi mainittuja myös Hollannista ja Saksasta. Esillä olivat seuraavat kysymykset: päästölupien kauppa, nielut, kokonaistaloudelliset kustannukset ja teknologinen kehitys, spatiaaliset taloudelliset vaikutukset, pitkän aikavälin kestävä taloudellinen kehitys ja politiikkapakettien arviointi.

Asiasanat: ilmastopolitiikka, makrotaloudellinen mallintaminen, joustavat mekanismit

Contents

1 INTRODUCTION AND SEMINAR OVERVIEW 1

1.1 Overview of presentations 1

1.2 The Ministries 2

1.3 Modelling, emission rights and sinks 3

1.4 Technology development at macro and micro level 5

1.5 Special subjects: impacts of spatial organisation and Finland's road to a sustainable economy 6

1.6 Toward implementation - Policy package assessment 7

1.7 Concluding Remarks 8

2 GREENHOUSE GAS POLICY QUESTIONS AND SOCIAL-ECONOMIC RESEARCH IMPLICATIONS FOR FINLAND IN A NATIONAL AND INTERNATIONAL CONTEXT 11

3 EMISSIONS TRADING AND ITS IMPACTS ON WORLD ECONOMIES CONTEMPLATION OF BASELINE EMISSIONS PATHS AND A CEILING ON EMISSIONS TRADING 15

3.1 Introduction 15

3.2 Previous model results 16

3.3 Model description 17

3.4 Conclusion 25

APPENDIX: MATHEMATICAL DESCRIPTION OF THE WAGE MODEL 27

4 ON THE ROLES OF ECONOMIC AND TECHNOLOGICAL MEASURES IN ECONOMIC ASSESSMENT OF FINNISH CLIMATE POLICIES 33

4.1 Introduction 33

4.2 Economic instruments and their effects 34

4.3 The role of technology in Finland 38

4.4 Evaluation of the effects of the Kyoto Protocol on the Finnish economy 41

4.5 Conclusions 42

5 TOWARDS A SUSTAINABLE FINNISH ECONOMY. RESULTS OF MIXED MATERIAL FLOWS AND ECONOMIC ANALYSIS 45

5.1 Background 45

5.2 Development of total material requirement in Finland 46

5.3 Input-output analysis of material use 50
5.4 On the structural development of the Finnish economy 53
5.5 Partitioning the economy-wide material intensity measure 56
5.6 Concluding remarks 60

6 ENERGY AND EMISSION IMPACTS OF THE ORGANISATION OF SPACE AND INFRASTRUCTURE – INVESTIGATIONS FOR THE HELSINKI REGION 61

6.1 Land Use in 2020 61
6.2 Evaluation of CO2 emissions 66

7 POLICY PACKAGE DESIGN AND TESTING 73

7.1 Dutch Policy Process on greenhouse gas emissions since Kyoto 73
7.2 Options for reduction of greenhouse gas emissions 75
7.3 Cost calculation 76
7.4 Cost results 78
7.5 Climate policy implementation plan 81
7.6 Scientific evaluation 82
7.7 Research questions 82

REFERENCES

1 Introduction and Seminar Overview

Adriaan Perrels, *Senior economist, Government Institute for Economic Research (VATT), Helsinki, Finland.*

The seminar covered 1½ day in which 11 presentations were given. The programme and participants list are added as Appendix. The seminar was organised by VATT as part of a project concerning the macro-economic implications for Finland to fulfil the Kyoto Protocol, the so-called 'Kyoto-project'. The seminar gave a valuable overview of issues and research and policy questions.

The seminar was opened by Reino Hjerppe, Director General of VATT, who stressed the importance of national and international exchange of ideas and experiences regarding Greenhouse Gas policies, given the complexity of the issue and the urgency to act. He also underlined the prospect for VATT being an institute that looks forward to a serious and long term commitment toward (economic) climate change research questions.

1.1 Overview of presentations

The seminar started with an overview by Adriaan Perrels (VATT) of issues after which the two most involved ministries (KTM – Trade and Industry; YM – Environment) presented their tasks in the planning process, the time tables and principal questions.

The overview highlighted that various policy options are still open, notably the question whether and to what extent Finland will embark in emission trading is important for the shaping of the rest of the policy mix. This also underlines the intricate connections between domestic and foreign actions. An additional complication arises if multinational companies can act independently and optimise at international scale. Even though from an international welfare point of view such leeway for multinationals can be efficient, it may lead to less fortunate developments for some member states or for the government policy of member states. The uncertainties of policy impacts are still rather large as is obvious from the wide range in cost estimates (see also remarks of Cederlöf and Kemfert). Further research efforts are needed to clarify to policy makers what to do under various conditions (scenarios and institutional settings). The co-existence of different regulatory structures (three types of tradable emission rights IET/JI/CDM, taxation/subsidies, prescriptive regulations) for steering greenhouse gas emissions is a research question that receives increasing international attention. The alleged efficiency of emission trading is not undisputed. Transaction cost are not negligible and in the case of JI and CDM even expected to be prohibitive in numerous occasions. The presentation of Matti Liski[1] highlighted some of the problems of different market organisations. For Finland the use of sinks is an important extra dimension, even more so, as it also includes forest products (presentation of Johanna Pohjola). A new issue – not elaborated on in the seminar - is emissions from international transport. This will soon require intensified research efforts, regarding air transport and, international logistics and optimal location choice. Technological development still turns out to be a difficult issue in economic modelling. Emission reduction is closely related to energy technology and indirectly to a wider range of technologies (think of the cross-cutting impacts of IT). There is a strong need for improved treatment of technological development in economic environmental modelling. It will need a combination of macro and micro (company based) knowledge. Honkatukia and Loikkanen discuss these problems. Ilmo Mäenpää introduced the concept of Total Materials Requirement in Finnish environmental modelling, while Irmeli Harmaajärvi discussed the impact of spatial organisation on the development of CO2 emission in urban areas.

1.2 The Ministries

The Ministry of Environment represented by Magnus Cederlöf first presented the organisation of climate policy design in Finland. He stipulated that the targeted ratification of the Kyoto Protocol in 2002 puts significant pressure on the policy design and henceforth the policy research to produce useful results. Cederlöf stressed that the calculation results of the policy research should have a high reliability, which was illustrated to be a high pitched demand in later presentations. Furthermore, not only single issue modelling but also instrument design and policy package design and testing ranks high on the wish-list of the ministry. Given the limited time and resources the use research and policy experiences from abroad is highly recommendable. For the environmental ministry it is also important to look beyond the first commitment period, i.e. further than 2010, to 2020-2025 at least. For fully integrated analysis also damage assessment should be included and that refers to a time span of at least several decades. On the basis of such integrated analysis it may be identified whether early action is both environmentally and economically a wise things to do. Magnus Cederlöf also pointed at the prevailing perception of CDM and JI as being not only climate policy instruments, but just as well development mechanisms i.e. through the transfer of technology. Another interesting issue is the possibility of beneficial side effects of greenhouse gas reduction measures or - vice versa - non-greenhouse gas measures having greenhouse gas reduction as side effect. Identification of such opportunities will enhance the co-operation of the private sector and can lower the mitigation cost to society. This feature was underlined by Torsti Loikkanen and showed up in his presentation about technological change as well. Magnus Cederlöf mentioned that a study was carried out

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[1] The presentations of Matti Liski, Johanna Pohjola, Anja Silvennoinen and Torsti Loikkanen are not included in these proceedings

right now (and should be finished by the summer of 2000), which aims at identifying concrete side effects among industrial projects.

The Ministry of Trade and Industry represented by Anja Silvennoinen started to reiterate the structure and timetable of the entire greenhouse gas policy process. The Ministry of Trade and Industry is especially responsible for measures taken in Finland, not the least regarding energy conversion and efficient end-use of energy. Anja Silvennoinen pointed out that a crucial factor in the decision making process is to have a clear understanding of the costs involved. This means that research should make clear:

- To whom the costs accrue, both first instance cost, and – if relevant – to what parties it may be handed over (roll-off effects);
- The cost to society, that is the net impact on GNP, employment, price levels, etc.
- The cost to government, that in programme cost, implications for national debt, tax load, etc.
- The cost effectiveness, that is cost per ton CO2 equivalent saved, where cost encompasses any of the previously mentioned definitions.

The Ministry of Trade and Industry wants a planning process that aims at a comprehensive assessment of options. Sector plans should be ready in 2000, while the overall national plan should be ready by 2001.

The various aspects of cost assessment as spelled out above are principal questions of KTM. Furthermore, in line with remarks of the previous speaker Anja Silvennoinen also mentioned that as much as possible joint benefits of greenhouse gas measures and otherwise motivated measures need to be identified and used to optimise the policy mix. In this respect it should not be forgotten that various Finnish industries have been successful in exporting environmental technology during the past twenty years.

1.3 Modelling, emission rights and sinks

Various model based presentations were given. The first presentation by Claudia Kemfert (IER) started with an overview of estimates for emission permit prices by the most well known world models. The differences in assumed flexibility of the production and trade patterns by world region, the uncertainties about the technological development and technology transfer and the different assumptions about the permission trade regimes (ceilings, banking, etc.) create an enormous spread in forecast permit prices. This is a serious handicap for modellers as regards conveying a message to policy makers. In the discussion it was acknowledged that clarity and transparency about these modelling exercises is an important policy research issue. Subsequently, Kemfert presented the WAGE model results for emission trade among Annex B countries, assuming different possible carbon emission trajectories. Evidently, the permit price paths differ substantially depending on the strictness of the ceiling and the gap between baseline and target emission levels. Other greenhouse gases and sinks are not included, neither is technological development endogenous. The same applies to the other world models used so far.

An important and supposedly quite robust message from the results is that emission trade constitutes a major welfare gain option to Russia and Eastern and Central European countries. The ceilings on emission trade as favoured in the European Union cause lower prices for a rationed demand, consequently, ceilings are an important cost (foregone revenues) to these countries. Yet, also for the USA, Japan and the European Union ceilings may be expected to increase the commitment cost. Furthermore, indirectly developing countries (non Annex B countries) are affected negatively as well. Problem is however, that there are still too many uncertainties to indicate to policy makers with sufficient confidence, what will be the permit price, and whether ceilings will be actually a significant extra cost to a particular country. It should be clear to policy makers that the uncertainty about the impacts of ceilings is one sided. It will not bring economic benefits, but perhaps for EU countries the cost are limited in practice. The vast amount of tradable permits available in Russia and other Eastern and Central European countries is also referred to as ‘hot air’ (i.e. representing no genuine reduction any more). The seriousness of this phenomenon is still disputed. A question related to that is the absorption capacity of the permit selling economies regarding the revenues. There might arise a situation reminiscent of the oil dollar glut in OPEC countries in the late seventies and early eighties.

As already mentioned above an important extension to (CGE) modelling is the inclusion of carbon sinks in the policy options. Johanna Pohjola (VATT) has built a CGE model which focuses on the role of carbon sinks for Finland. Johanna Pohjola started with clarifying the role of carbon sinks in the Kyoto Protocol. At the moment it is not yet known what are the exact formulations of how sinks (generally spoken changes in land use and vegetation) are to be treated in the calculation of assigned amount and baseline developments. Furthermore, next to vegetation (trees) as such also wood products are expected to be included in the calculation of (changes in) the carbon stock. There are three different ways to define changes in the carbon stock. Basically, the main differences are about the attribution of carbon stock changes in products (country of product origin or country of use). The EU favours attribution to country of origin. In countries where the forest sector is a sizeable economic sector (such as Finland, Canada and Russia) the use of sinks is an important macro-economic question and in these countries sinks can make a large difference between net and gross abatement.

With the CGE model it was tested whether sinks are economically attractive as a mitigation instrument for Finland. In the modelling exercise sequestration is regarded as a positive externality, which therefore could be justified to get a subsidy, while activities that cause release of carbon are a negative externality, hence they are liable to taxation. In this case only the taxation is applied in the simulations. If this sink stimulation policy would be carried out a GDP loss of 0.9% is calculated, while the CO2 tax level is halved compared to a gross reduction policy. Please note that in its current form the model is run with only unilateral Kyoto commitment by Finland, which results in overstatement of the losses. Furthermore, the limitation mentioned for the WAGE model applies here as well. An interesting side effect of this sink policy is the transfer of income to forest owners, which by and large coincides with an income transfer to less favoured regions of Finland. Other discussion items that were brought up, related to technological development and the trade-off between fertiliser production (which is energy intensive) and the carbon growth impact of fertiliser. The model will be used and elaborated in a project for the Finnish Academy of Sciences.

The next presentation by Matti Liski (HKKK) was meant to question the perhaps too easily accepted point of departure that large anonymous international trade in emission permits (IET) represents the most ideal, and most efficient form of emission trade compared to the project related Joint Implementation (JI) and Clean Development Mechanism (CDM). The supposition about the high efficiency is based on the idea that the transaction cost are insignificant in the case of IET. This is indeed a disputable assumption since the market for greenhouse gas emission permits barely exists so far. The entire institutional structure needed to guarantee a smooth, reliable and efficient trading process is still to be established. It should be noted that entry regulation, compliance and control and sanctions are sensitive and still unresolved discussion items in the UNFCCC.

The requirements to be met before a country (and a principal agent in that country) is allowed to participate in IET are elaborate and strict and are likely to be subject to scale economies. This means that initial cost can be high and therefore constitute a threshold. Furthermore, for selling countries – notably in Central and eastern Europe – the technology transfer and other benefits related to JI and CDM may incur a priority ‘bias’ in favour of these (bilateral) trade options. To this should be added that industries from wealthy Annex B countries will invest (and transfer technology) for a collection of good reasons and in most cases not just trading permits (see earlier remarks on swapping main and side effects and motivation). So, both at the supply and demand side there are reasons that may lead to a much better thriving of bilateral trading than expected. The existing trade for SO2 emissions is done through bilateral transactions for 93% of the traded emission volume. Another reason might be that in the framework of bilateral agreements long term contracts (certainties) can be arranged. Similar developments can for example be observed in the emerging markets for electricity trade.

1.4 Technology development at macro and micro level

Juha Honkatukia (ETLA) focused on the macro part of the double-presentation on the technology and economic modelling. He first gave an overview of exercises with a CGE model concerning the implementation of the Kyoto Protocol in Finland. He exemplified the importance of relations with other policy areas (e.g. industrial policies, education, regional policies) as well as the importance (and the still prevailing uncertainties) of the actions in other Annex I countries.

Presently technology change in most CGE models is pre-specified. At best the introduction of new (emission reducing) technologies is dependent on the achievement of certain cost levels. However, the speed of technology development (i.e. ‘learning’) is not integrated in the current models. First, tentative examples of how learning can be integrated in models have been done by Carraro et al of FEEM (Italy) based on a CGE model and in an ECN/ESI/IIASA (Netherlands/Switzerland/ international) study based on MARKAL-MACRO.

For Finland the application of the Kyoto mechanisms may also lead to increased exports of energy efficient technologies and renewable energy technologies. Within Finland the leeway is not so large given the current fuel cost levels. The conversion efficiency (primary into secondary or final energy) belongs to the global top. Furthermore, the shares of co-generation and of bio-energy are already high. If we want to be more precise, the improved specification of technology change in macro-model should not be confined to energy conversion and end-use technologies, but should look beyond that and take care of other important changes in the product mix, quality levels and the primary materials requirement resulting from this mix (see also the presentation of Mäenpää). Presently, there is going on a co-operative study between ETLA and VTT aiming at a first step in endogenising technological change (at least as regards energy conversion technologies).

Torsti Loikkanen (VTT) proceeded with technology change from a company perspective. Presently, VTT is involved in a bottom-up study in which all possible measures in the chemical, metal and pulp&paper industry are identified and assessed. This large bottom-up study demonstrates that companies have a multitude of reasons to invest and to shape their investment in a particular way. Climate policy will be only one of the reasons. Furthermore, also the ways environmental concerns are taken up into the strategy of companies has been studied. As already hinted at earlier the first lesson of this perspective is that company decisions affecting technology change can be made for a multitude of reasons, among others government policies necessitating action. Yet, even if investment decisions are incited by environmental policy such decisions will be scrutinised and as a much as possible shaped in the most profitable form for the company. Furthermore, a good part of investment decisions are taken for other reasons than greenhouse gas emissions.

1.5 Special subjects: impacts of spatial organisation and Finland’s road to a sustainable economy

Irmeli Harmaajärvi (VTT) presented an overview of results of a recent study on the energy & emission impacts of alternative spatial planning options to add new dwellings and business locations to the current Greater Helsinki area. The alternative spatial models include a Basic Model (based on current policy guidelines aiming at a controlled extension of the living and commercial areas preventing too low densities supporting the use of public transport), an Infill Model (aiming at densifying the current urban structure and stimulating the use of public transport) and a Sprawl Model (allowing decrease of urban densities by building more detached dwellings in the outskirts and allowing a growth in car use). Higher densities lead to on average smaller (new) dwellings. Since, furthermore the use of district heat can be higher in this strategy and car use is somewhat lower, total CO2 emission in Greater Helsinki area is 12% higher in the Sprawl model than in the Infill model in 2020. Projecting this outcome on all larger urban areas in Finland it indicates to be an interesting dimension.

The volume of CO2 emission saved compared to the total amount to be reduced, amounts to 3% for Greater Helsinki and perhaps ~7% for the whole Finland. So, it is a significant but not a dominant option (however logistics of goods has not been assessed, so the potential might be bigger). In the discussion the question remained open whether there are effective instruments that can incite people to choose for urban rather than peripheral housing locations. Coercion is neither desirable nor effective. Pricing and supply of plots as well as pricing and supply of transport infrastructure need careful consideration and presently at least supply of building plots constitutes a problem in the Helsinki area.

Ilmo Mäenpää (Thule Institute) presented a study focusing on the Total Materials Requirement (TMR) of Finland (http://thule.oulu.fi/ecoef/index.htm). TMR models are a tool for judging the overall eco-efficiency of a country and therefore have a wider significance than for climate change policy only. Yet, an interesting observation is that a good part of industrial energy use (and transportation energy) is closely related to mining and processing of raw material into basic materials (i.e. steel, primary aluminium, zinc, bricks, cement, glass, paper, naphta, ethene, pvc, fertiliser). So, next to measures directly aiming at energy efficiency in industrial processes and energy conversion, it can also be very effective to aim at material throughput reduction. The Finnish TMR/capita has increased by 50% from 1980 to 1996. However, the development shows ups and downs during the nineties. In various other OECD countries have the same development up to the beginning of the nineties, with the exception of the USA that shows a slight downward trend. Since 1990 Germany shows a clear downward trend. So, the interesting thing for Finland is that the large increase of light industries cannot be found back in the development of the TMR. One reason for this might be that in absolute terms the output of the heavy industry still grew significantly as well. Of the total TMR a distinction is made between domestic and imported materials. The imported part of TMR is rising while the domestic flow is slightly decreasing. As a trend and given the global challenge of climate change, this is a disquieting signal. It also stresses the importance of including fuel use of international transport in the Kyoto Protocol. Furthermore, the TMR approach seems to fit well as a bridge between the economic models and integrated models meant for damage assessment.

1.6 Toward implementation - Policy package assessment

Michiel Beeldman (ECN) gave an impression of the Dutch policy design process regarding the National Climate Policy Implementation Plan – Domestic actions. The Plan for the domestic actions starts with the assumption that 50% of the total emission reduction task of 50 Mt CO2 can be achieved through the flexible mechanisms (IET, JI and CDM). The 50% is in line with the proposal discussed within the EU. Although starting point of the policy analysis, it was already known from previous studies that, unless very low permit prices (< 10 Euro/ton CO2) exist, a substantial potential of cost-effective measures was available in the Netherlands and hence the 50% rule does not look too risky. The involvement of stakeholders is an important point in the design of the Policy Implementation Plan. Therefore the process went through several steps of consultation and research.

In order to create society wide commitment and as an idea of burden sharing, the eventually resulting ranking of selected measures deviates from the most cost effective ranking. For example, emission reduction of non-CO2 gases is much less used than would be cost effective (only 7.5Mt of the approx. 17 Mt CO2 equivalent low cost potential), whereas renewables and to some extent electricity production are over-represented . In the final assessment of the Implementation Plan by ECN and CPB (CPB is kind of Dutch VATT) in Autumn 1999 the evaluated criteria were:

Direct cost and non-financial (ECN):

- National cost (total, per ton CO2 eq.)
- End user cost (total, per ton CO2 eq.)
- Government cost (outlays) (total, per ton CO2 eq.)
- Comfort
- Timing
- Other environmental benefits or costs

National economy (CPB):

- Effects on GDP
- Public Budget
- Exports
- Imports
- Employment
- Wages
- Inflation
- Etc…

Main weaknesses are in the degree of control of the Ministry over the actual taking of measures. Especially the liberalised former utilities have objections against some of the suggested deals.

1.7 Concluding Remarks

It emerged clearly from the presentations and the discussions, that the researchers cannot give exact answers right now and supposedly neither in the near future. Nevertheless, a lot can be done to narrow down uncertainties and to try to assist policy makers to design contingent strategies. Some issues can be taken up this year through adaptations in existing models, comparative and (ex-post) evaluative studies, and some preliminary investigations in new issues. Fairly short term suggestions that could be derived from the presentations and discussions (or were explicitly mentioned there):

1. Adapting international competition scenarios by assuming actual implementation of Kyoto protocol by all OECD countries and Eastern Europe;
2. Further scanning of opportunities of sinks for Finland;
3. Initial investigation of short to medium term impacts on long distance transport due to inclusion of sea and air transport in EU strategy;
4. Initial investigation of the influence of climate change damage assessments on cost estimates and consequences for selection and timing of instruments;
5. Assessing the sensitivities of results due to:
   - significant transaction costs for flexible mechanisms (all and JI&CDM only)
   - high or low ceilings for obtainable emission permits in EU countries
   - inclusion or exclusion of sinks
   - interference between different institutional (i.e. market) conditions in and between countries, notably regarding the consequences of liberalised (and privatised) energy utilities (this issue needs to be taken up quickly, but will also require longer more thorough studies – see also point 4 below).

Several issues will take a longer time, due to their complexity and/or due to the recent inclusion in the policy debate. Examples of such longer term research issues are:

1. a genuine understanding of technological development and the ability to translate technology foresight into concepts usable in economic models;
2. the implication of climate change policies for multi-national companies (MNC), with special reference to (1) the degree of autonomy of MNC in flexible mechanisms and (2) the long term changes in Europe’s logistics as regards location choice, mode choice, and route choice;
3. a better and more complete integration of climate change damage assessment into integrated (economic) modelling;
4. a thorough understanding of the eventual effectiveness for actual emission reduction of instruments in packages, including the influence of contextual aspects such market types, governance cultures, behavioural patterns, R&D policies, etc.
5. the contributions of physical approaches such as Life Cycle Analysis (LCA), which is typically a product and company related instrument and Total Materials Requirement (TMR), which is kind of physical translation of conventional (economic) National Accounts. If one would add stocks to the TMR system and picture TMR as flows to and from stocks a step-up to damage assessment would be created.

2 Greenhouse gas policy questions and social-economic research implications for Finland in a national and international context

Some remarks on the need of improved knowledge on costs for decision making in climate policy.

Magnus Cederlöf*, Senior Technical Advisor, Ministry of the Environment, Finland.*

According to the present Government's programme the Government designs and implements a national plan in order to fulfil the commitments included in the Kyoto protocol to reduce emissions of greenhouse gases. The programme states that the commitments shall be carried out without reducing economic growth and without harmful effects on the improvement in the employment situation.

The task to draw up the national climate plan has been given to a Ministerial working group chaired by Minister Tuomioja[2]. This group co-ordinates the work done by a number of sector groups which are for the time being working on sector strategies to implement the emissions reductions in the Kyoto protocol. Among the sectors covered by this work one could mention energy production, agriculture, traffic, waste management and residential heating. The starting point of this work is that each sector drafts a sector specific programme based on its own targets and development trends. The sector specific programmes are at a later stage being adjusted together in order to reach the overall reduction target.

The recent 5th Conference of Parties did not get as much attention and publicity as it might have deserved as many of the issues dealt with were quite technical in nature. One quite clear message however, was that the EU strives for ratification of the Kyoto Protocol by 2002. The discussion on the ratification should not be brought up in this connection, my only remark is that the outcome of COP5 in this regard seems to add to the need for analysis of the economic consequences of the Protocol. This need springs from the fact that the Kyoto protocol has a potential to cause profound economic implications both on the national and international level.

The Ministry of Environment is co-financing the project run by VATT with the objective to analyse the economic consequences of the Kyoto Protocol for Finland. In the present situation it is of utmost importance that these consequences could be assessed in a confident and comprehensive manner taking into account different routes available for implementation of the commitments. Economic analysis has to be undertaken and made available in the design of the implementation process. We still have to broaden and deepen the knowledge and information on the costs related to the

[2] By the time of writing Mr. Tuomioja was Minister of Trade and Industry, since March 2000 he is Minister of Foreign Affairs. Presently, Mrs. Mönkäre is Minister of Trade and Industry.

emission reduction targets. The calculations presented so far are in any case tentative and not necessarily always consistent.

The present situation with a relatively high number of countries, Annex-1 Parties, being faced with emission reduction commitments of similar level actually provides an excellent opportunity for international co-operation between researchers involved in climate change economics. I think this seminar is a good indication of such emerging co-operation and international networking. It would probably be quite useful to try to follow and get information about similar socio--economic research projects in other countries. Also some organisations such as OECD have already done calculations on the economic impact of the Kyoto commitments. When we have some results from the study by VATT it will be of great interest to analyse them in the framework of these other studies.

It is obvious that an important part of the project now run by VATT is the development and improvement of the methodology to carry out economic calculations based on models on the consequences of climate policy. The approach chosen in this project is to use two types of models in parallel and with iteration. The models are a macroeconomic model (KESSU) and an energy sector specific model (EFOM). This seems to be a promising approach as we could get relatively detailed and relevant results in a shorter time in this way compared to other options. As the results will offer a basis for the discussion and decision making during the next few years it is important to strive for as confident figures as possible.

On the other hand it is important to remember that we do not have all the cards on the table yet. It is quite realistic to assume that countries like Finland might be willing to fulfil part of the commitments by using the so called Kyoto mechanisms. The problem is however that we do not know how the rules for these mechanisms are going to be designed. A possible assumption in any case is that the Kyoto mechanisms are going to influence the implementation costs significantly for countries such as Finland with relatively high domestic marginal abatement costs. In these cases it would really make sense to fulfil part of the reduction commitments outside the national boarders by using the Kyoto mechanisms. According to the research plan the role and influence of the mechanisms shall be included in the second phase of the research project.

I would also like to stress the importance of improving the capacity and skills in carrying out this kind of analysis. The Kyoto Protocol and its commitments could be seen as only the first step taken in the direction of reducing emissions of greenhouse gases. There is probably going to be a constant and long lasting need for assessment of economic implications of different policy objectives in climate policy. It is quite clear that the contribution of the Kyoto commitments, if extended beyond the first commitment period, to stabilise C02 concentrations is going to be rather modest. Therefore it would be farsighted to make some assumptions on the required reduction targets for the time after the first commitment period and how they would affect the abatement costs.

One of the merits of the approach taken in the project we now discuss is that it contains an analysis on the potential policy instruments to be applied. The intention is to study which policy instruments are available and what would be the most cost efficient alternatives. It seems likely that a mix of different policy instruments has to be applied - no single instrument would provide an optimal solution. It is important to have these policy instrument mixes presented and discussed, the next step would be to assess the political feasibility of such policy packages.

In the case of climate policy as in the context of environmental policy in general one should be cautious in trying to strive for too aggregated results. This is certainly also the case when discussing costs from climate change abatement policies. The cost concept is a complex one and opens up for various interpretations. It is important to remember that both quantitative and qualitative results could be important. A classical methodological problem is to specify how much of an investment could be labelled as environmental protection - in this case climate change abatement - and how much is something else. Another potentially important issue is that if we use economic instruments such as carbon taxes or emissions trading, the revenue could be used to reduce the impact of such policies that distort resource allocation for the time being.

A discussion on costs and climate policy should besides abatement costs also cover costs caused by climate change. These are of course important to analyse both on a national and an international level. According to the Climate Convention, the developed nations are responsible for giving consideration to the developing country needs arising from adverse effects of climate change. The evaluation of adaptation costs is however a difficult exercise due to many uncertainties.

This discussion also has bearings on the question of benefits from climate change abatement activities. Often mentioned benefits is reduction of other emissions such as SO_2. It is also clear that an active climate change policy could provide a new opportunity for certain types of business such as export of energy technology. The evaluation of the benefits on a more general level is connected with significant uncertainties and has still to be developed. It is also important to put the discussion on costs from the Kyoto commitment in a proper context: that is to be aware of the potential future cost of failing to act now.

It is also quite clear that an optimal mix of action would not only focus on CO_2 and the energy sector. The problem connected with most model work is that it usually limits the analysis to CO_2 alone and forgets about non CO_2 gases. Actually some of the most cost efficient measures could be located to other sectors and gases such as methane emission reduction from waste management. The sector specific work on climate strategies is going to give us additional information on the possibilities for emission reductions in all relevant sectors.

3 Emissions trading and its impacts on world economies Contemplation of baseline emissions paths and a ceiling on emissions trading

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3.1 Introduction

Climate change negotiation processes induced an international countries agreement of the Kyoto protocol abating greenhouse gases (GHG) within the commitment period by 2008 and 2012. More precisely, so called Annex B countries including among others USA, Japan and Europe committed themselves to reduce their emissions by 6 to 8 % of their baseline emissions of 1990. Beside domestic measures to mitigate GHG emissions by for example emissions taxes or standards, so called international flexible Kyoto instruments allow a reduction of emissions by project or technology transfers mitigating emissions between Annex B countries (Joint Implementation *JI*) or from developed Annex B countries to developing countries (Clean Development Mechanism *CDM*) or by emissions trading (*ET*) between Annex B countries. The analysis focus on the impacts of different emissions reductions options, i.e. to decrease emissions by domestic action or by Annex B emissions trading. Main debates are around the concrete implementation of these instruments including controversial arguments of an initial allocation of emission permits ('grandfathering'[3] or auction), early crediting and penalties of non compliance. Crucially, the concrete determination of world and regional baseline emission paths have to be co-ordinated and adjusted precisely. It is discussed controversially whether an emissions trading system induce so called "hot air" options by countries in transition with real emissions lower their committed reduction target, i.e. non binding reduction commitments. In order to avoid "hot air" trading, different kinds of emissions trading limitations are suggested. Developing countries like China and India argue in favour of a ceiling on emissions trading in order to draw industrial countries attention to their responsibility of world pollution impacts by emissions and hence bear the brunt of abatement primarily. EU 15 explain their preference of a ceiling on emissions trading by negotiation significance in order to reach a global consent.

This paper investigates the impacts of the Kyoto reduction commitments including emissions trading between Annex B countries and compares the economic outcomes of different kind of emissions trading schemes. Mainly, different emissions baseline

[3] See contribution of Honkatukia for an explanation of the term.

developments and diverse restrictions to full emissions trading, i.e. a ceiling or cap on emissions trading are compared and evaluated. Direct investment transfers between Annex B countries and from Annex B to Non-Annex B countries modelled indirectly by capital and investment transfers resulting in higher energy efficiency. This investigation is focused on different emission baseline assumptions ending in different welfare losses for developed and developing countries as well.

The structure of this paper includes first an overview of different world model results of permit prices in order to compare the model results. After a brief description of the world model an illustration and explanation is given of all model results comparing assorted emissions baseline projections and different kind of emissions trading schemes. The last section concludes, an Annex illustrates the mathematical description of the applied model.

3.2 Previous model results

In order to provide an assessment and estimation of conceivable impacts by the implementation of the Kyoto mechanisms various kind of world economic assessment models are applied by many scientists. On world level, it is important to include all relevant world regions and main energy and carbon intensive sectors. Kyoto mechanisms assessed by world models lead mainly to a favourite assessment of a full global emission trading system because of cost minimisation options by all participating countries. JI and CDM opportunities can often only be modelled by an emissions trading system between developed and developing countries neglecting direct capital transfers inducing increased energy efficiency within the host country.

Within this chapter merely a small number of model results, the permit prices due to Annex B emissions permit trading and full carbon emission trade are compared and evaluated. Model results are often distinguished in order to assess the impacts of full carbon permit trade against ceiling opportunities on a trading system.

Model construction and assumptions deviate widely, main models can be classified as Integrated Assessment models (IAM) focusing more or less on a dominant economic or policy evaluation characterisation.[4] Model results as permit prices highly depend on model construction and assumptions. exposes different model results by comparing emission permit prices of an Annex B trading system in 2010 and 2020. Main IAM models calculate a permit price within a range of 100 to 150 $\$_{1995}$ per ton of carbon in 2010 whereas main models focusing more on an economic general equilibrium like MRT or IIAM calculate a lower permit price (30 to 45 $\$_{1995}$ per ton of carbon) in order to reach the Kyoto target.

[4] An overview of IAM gives Dowlabadi (1995), IPCC (1995) or Rotmans (1998).

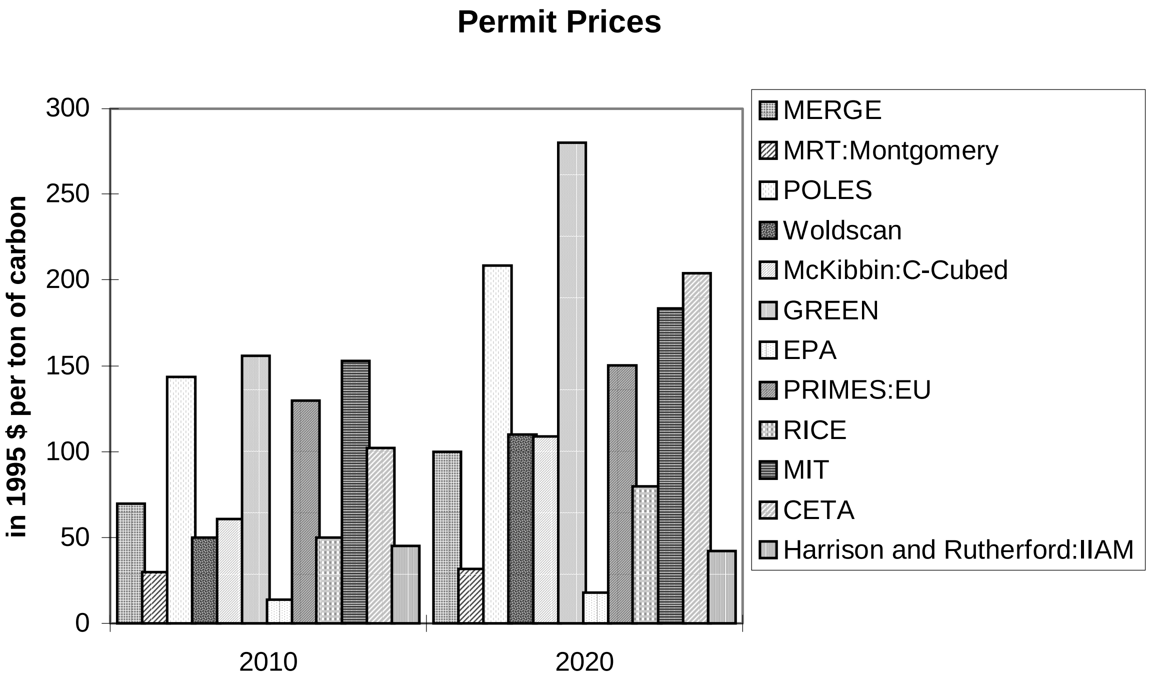

Figure 1: Permit prices in diverse model approaches[5].

3.3 Model description

In order to investigate the economic impacts of international GHG mitigation policies induced by the Kyoto protocol and climate change negotiation processes a World Applied General Equilibrium model (WAGE) is used. WAGE is an inter-temporal computable general equilibrium and multi-regional trade model for the global economy. It distinguishes 11 world regions, which are linked through bilateral sectoral trade flows, based on GTAP data[6], based on 1995.

The economic structure of each region consists of 4 production sectors, one non-energy sector and three fossil fuel sectors traded internationally for oil, gas and coal. All products are demanded by intermediate production, exports, investment and a representative consumer, market actors behave within a full competition context, i.e. they take the market price as given with the exception of OPEC countries which can influence the price of oil (non competition case for oil). Consumption and investment decisions are based on rational point expectations of future prices. The representative

[5] MERGE: Manne et. Al. (1998), POLES: Russ (1999), Wordscan: Bollen et. Al. (1999), Mackibbin (1999), GREEN: Burniaux (1998), EPA: Edmonds (1998), PRIMES: Capros (1998), RICE: Nordhaus and Yang (1996), MIT: Edmonds (1998), CETA: Peck and Teisberg (1991),MRT: Harrison and Montgomery (1999), Harrison and Rutherford (1997).

[6] GTAP = Global Trade Analysis Programme, see McDOUGALL, R.A. (1995).

agent for each region maximises lifetime utility from consumption which implicitly determines the level of savings. Firms choose investment in order to maximise the present value of their companies. [7]

ASIA	India and other Asia (Republic of Korea, Indonesia, Malaysia, Philippines, Singapore, Thailand, China, Hong Kong, Taiwan)
CHN	China
CNA	Canada, New Zealand and Australia
EU15	European Union
JPN	Japan
LSA	Latin America (Mexico, Argentina, Brazil, Chile, Rest of Latin America)
MIDE	Middle East and North Africa
REC	Russia, Eastern and Central European Countries
ROW	Other countries
SSA	Sub Saharan Africa
USA	United States of America

Table 1: World regions.

In each region production of the non-energy macro good is captured by an aggregate production function which characterises technology through transformation possibilities on the output side and substitution possibilities on the input side (between alternative combinations of inputs). Goods are produced for the domestic and for the export market. Production of the energy aggregate is described by a CES[8] function which reflects substitution possibilities for different fossil fuels (i.e., coal, gas, and oil) and capital, labour representing trade off effects with a constant elasticity of substitution. Fossil fuels are produced from fuel-specific resources and the non-energy macro good subject to a CES technology. Coal production in the OECD and gas production in Russia grow with energy demand at constant prices. The elasticity of substitution between the resource input and non-energy inputs is calibrated to meet a given price elasticity of supply. Exhaustion leads to rising fossil fuel prices at constant demand quantities. The carbon-free backstop technology establishes an upper bound on the world oil price, this backstop fuel is a perfect substitute for the three fossil fuels and is available in infinite supply at one price, which is calculated to be a multiple of the world oil price in the benchmark year. Demand elasticities depend on back stop technologies, by low backstop costs demand elasticities are high and vice versa.

In each region a representative household chooses to allocate lifetime income across consumption in different time periods in order to maximise lifetime utility. In each period households face the choice between current consumption and future consumption, which can be purchased via savings. The trade-off between current consumption and savings is given by a constant intertemporal elasticity of substitution.

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[7] See mathematical description in the Appendix.

[8] CES = Constant Elasticity of Substitution.

Producers invest as long as the marginal return on investment equals the marginal cost of capital formation. The rates of return are determined by an uniform and endogenous world interest rate such that the marginal productivity of a unit of investment and a unit of consumption is equalised within and across countries.

Domestic and imported varieties for the non-energy good for all buyers in the domestic market are treated as incomplete substitutes by a CES Armington aggregation function providing a constant elasticity of substitution. With respect to trade in energy, fossil fuels are treated as perfect substitutes, net trade cannot be cross-moved. International capital flows reflect borrowing and lending at the world interest rate, and are endogenous subject to an intertemporal balance of payments constraint considering no changes in net indebtedness over the entire model horizon.

Emission limits can be reached by domestic action or by trading emission permits within Annex B countries allocated initially due to regional commitment targets. Those countries meeting the Kyoto emissions reduction target stabilise their mitigated emissions at 2010 level.[9]

According to regional abatement costs countries will sell or buy emission permits. Countries facing high abatement costs above permit prices will purchase emission permits, regions with marginal abatement costs lower than the permit price will vend emission licenses. Revenues from selling permits are refunded lump-sum back to the representative consumer in the abating country. Within this context it has to be stressed that problems around the concrete implementation of the flexible mechanisms and emissions trading scheme, like on compliance, early crediting and cheating in order to influence permit prices etc. are neglected within the modelling context.

Because of the international and flexible structure WAGE is especially useful to investigate international GHG abatement policies under various key assumptions variations like the world and regional development of emissions baselines or a full versus a ceiling on emissions trading.

The quantitative results contain committed emission reduction levels for specific countries due to the Kyoto protocol mitigating greenhouse gas emissions by 5.2 % below 1990 level within the commitment period 2008 to 2012.

Following scenarios cover different assumptions about world baseline emissions level. Within the high world baseline emissions level scenario, world carbon emissions develop from 2000 by about 8 billion ton of carbon to about 12 billion tons of carbon in 2030 (see Figure 3). Key model parameters cover Armington elasticities, backstop costs and oil supply elasticities.[10] Within the Default or BAU scenario, all key parameter are adopted as demonstrated in Figure 2.

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[9] This can be called a “Kyoto forever” scenario.

[10] For model sensitivity analysis, see Kemfert (1999).

Type of elasticity	Value
Armington elasticity of substitution	1
Armington elasticity of transformation	2
Elasticity of fossil fuel supply	1 (coal), 4 (gas, oil)
Elasticity of substitution between non-energy and energy composite in production and final demand	0.25-0.5 (Annex B), 0.20-0.4 (non-Annex B)
Interfuel elasticity of substitution	0.5 (final demand) 2[a],1[b] (industry)

[a] between oil and gas, [b]between coal and the oil-gas aggregate

Figure 2: Overview of key parameter.

Figure 3 demonstrates the development of the miscellaneous world baseline emissions levels.

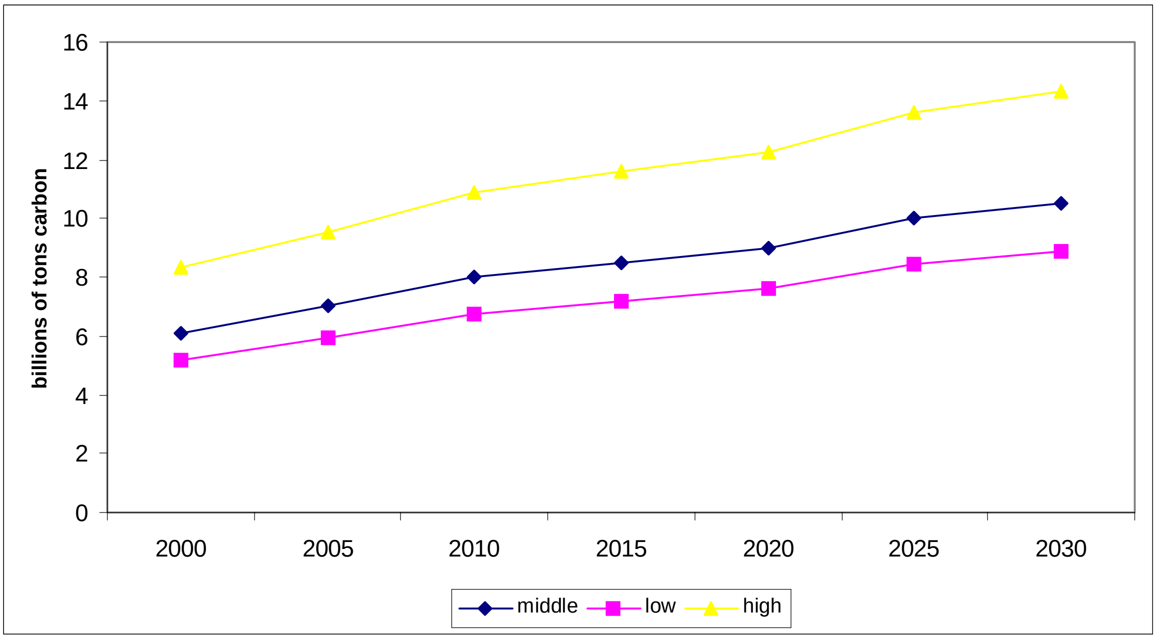

Figure 3: World Carbon emissions paths.

Countries and regions can either meet their individual reduction targets by domestic action only or Annex B countries can trade their emissions permits due to their starting commitment emissions reduction aim. Table 2 gives the commitments for the developed countries / regions as represented in the analytical framework. Regional economic growth rates correspond to MERGE growth rate.[11] Countries in transition like Russia are represented by declining economic growth rates, i.e. these countries can sell emissions permits allocated initially by the Kyoto protocol. Table 2 demonstrates the quantified emissions limits committed within the Kyoto protocol of December 1997.

[11] See Manne, Mendelsohn and Richels (1995).

Country or Region	Label	Commitments (Percentage of 1990 Base Year Greenhouse Gas Emissions)
Canada, New Zealand, Australia[a]	CAN	99
European Union	EU15	92
Russia, Eastern and Central European Countries[b]	REC	98.3
Japan	JPN	94
United States of America	USA	93

Table 2: Quantified Emissions Limits under the Kyoto Protocol.

a The reduction commitments of Canada (94), New Zealand (100) and Australia (108) are weighted based on the individual 1990 emission levels.

b The effective reduction rate for REC is derived from the individual commitments of countries belonging to the REC region.

At the domestic policy level governments are free to choose the policy instrument (e.g. emission taxes, command and control measures, voluntary agreements) in order to meet their emission reduction target.

Model calculations as a comparison of welfare implications due to an emissions reduction implementation demonstrated in Table 2 against a scenario without any constraints (business as usual BAU) exhibit negative welfare implications to developed and developing countries. Energy prices decrease because of energy demand decline. Energy exporting countries are suffering as well due to negative trade spill-over effects.[12] If the impacts on global and regional welfare are measured as the Hicksian Equivalent (EV; i.e. the percentage Hicksian equivalent in lifetime income) of world regions in comparison to the BAU scenario, negative welfare implications happen to develop also for developing countries because of international spill-over effects. The welfare losses concern even the developing countries like China and India. Although increasing production and investment within energy intensive sectors inducing carbon leakage can be detected. These results are not in line with other MRT model outcomes. For example, *Bernstein and Montgomery (1999)* observe positive welfare impacts to developing countries by meeting the Kyoto emissions reduction targets.

Within the present analysis negative welfare implications occur also for developing countries like China and India because increasing production effects due to a comparative advantage within energy intensive sectors can be offset by negative economic effects due to decreasing energy prices and negative trade spill-over effects by Annex B countries. Globally, Annex B countries are more dominant economically influencing non Annex B countries negatively by trade spill-over influences.

The initial permit allocation is defined by the Kyoto protocol, the revenue is lump- sum transferred back to the individual economies. Annex B emissions permits trading offers the opportunity for participating countries to sell and buy permits due to their reduction targets and marginal abatement costs. As expected within a general equilibrium modelling framework, global welfare is improved by Annex B permit trading revealing

[12] See Kemfert (1999)

permit trading as a Pareto - improving policy measure (i.e. no individual agent loses, while the economy as a whole wins).

A comparison of a trade versus no trade scenario demonstrates that all countries can benefit by Annex B permit trading, mainly countries in transition as REC because of the “hot air” effect previously described. Emissions permit trading makes better off all Annex B countries as well as non Annex B or developing countries because of international trade spill-over effects. Annex B countries facing high emissions reduction targets and high domestic marginal abatement like Japan and USA costs will certainly benefits by Annex B emissions permit trading. Essentially, USA and EU 15 will trade permits within a full trade scenario because of their high share on total carbon emissions. Assuming a modest development of world emissions, USA, Canada, Japan and EU 15 will buy emissions permits because of their marginal abatements costs higher than the permit price, main sellers of emission permits will be Russia and other Eastern European countries (REC) because of their non limiting reduction targets.

	Trade / no trade	Change
Japan	0,13	++
China	0,04	+
USA	0,11	++
SSA	0,06	+
ROW	0,03	+
CNA	0,09	++
EU15	0,06	+
REC	0,87	+++
LSA	0,08	+
ASIA	0,04	+
MIDE	0,32	++

Table 3: HEV Comparison of Annex B permit trade: trade versus no trade.

World economic implications by Kyoto mechanisms will substantially depend on a suitable definition of the emissions baseline projection path and the concrete implementation of an emissions trading scheme. International negotiations processes expose controversy debates on an emissions reduction option by domestic action or by international Kyoto mechanisms like emissions trading. More precisely, domestic action or domestic measures in order to reduce emissions are encouraged by a limitation of emissions permit trading. Under equity aspects, international welfare implications should be harmonised and equalised by a degraded option to purchase or sell emissions permits through a ceiling on emissions trade. Various ceiling options of a contribution by emissions trading are currently discussed.[13]

Within this study, two different options of emissions baseline development paths (see Figure 3) are assumed, a *ceiling* notified further as *cap* on emissions trading is

[13] See OECD (1999 a and b).

introduced as percentage term of Assigned Amount (AA). A *low cap* on emissions trading (ET) signifies that 10 percent of the AA of emissions have to be reduced by domestic action, i.e. 90 percent of AA can be traded. A *high cap* on emissions trade means 80 percent of AA emissions are abated by domestic action. In order to illustrate the different impacts of emissions baseline developments as well as cap on emissions trading assumptions following scenarios are compared:

LC	Mid Emissions level and Low Cap on ET
HC	Mid emissions level, High Cap on ET
HCHE	High Emissions level, High Cap on ET
LCHE	High Emission level, Low Cap on ET
LCLE	Low Emissions level, Low Cap on trade

Table 4: Scenario definition.

Table 5 demonstrates the Hicksian Equivalent variation as comparison to a full emissions trading scenario with moderate emissions development assumptions. Not surprisingly, a ceiling on emission permit trading induce negative global economic implications, mainly to the countries in transition of Eastern Europe and Russia as well as in Annex B countries. Due to high emission baseline projections these effects are much higher than in a low emissions case. Additionally, a cap on emissions trading induce negative implications to developing countries because of international negative trade spill-over effects exhibited by terms of trade developments overcompensating the positive economic effects due to Annex B emissions trading. Highest economic losses in terms of GDP and terms of trade contraction occur within high assumptions about baseline emissions development because of higher abatement targets by Annex B countries leading to negative spill-over effects even for developing countries. Within Annex B permit trading, Russia will be the main permit seller resulting in lower investment behaviour because of a full economic subsistence through permit trade, a protection of Annex B emissions trading leads to an increase of investment in Russia.

Assumptions about low emissions baseline projections affects in the first place economies with high emissions levels allowing less mitigation leeway but also lowers the opportunities for developing countries to grow compared to a case with high economic expansion. In comparison to a full emission trade scenario with a moderate emission baseline development Annex B countries can benefit by welfare increases because of less efforts meeting the reduction target. EU 15 can increase welfare significantly because of higher options to be a net seller of permits.[14] In total, the negative effects by a ceiling on emissions trading are affecting the economies in transition most negatively resulting in additional negative impacts for developing countries. EU 15, as the main advocate of a ceiling on emissions trading, can benefit by an emissions trading system and will suffer by committing their reduction targets

[14] In a bottom-up analysis for Europe, countries with huge economic potentials like Germany and France sell emissions permits whereas Italy or Denmark purchase emissions permits, see Ybema et al. (1999).

through mainly domestic action (*HC*). Other Annex B economies like USA or Canada will suffer by a cap on emissions trading because of high domestic marginal reduction costs and hence limited options of an efficient application of domestic emissions reduction measures.

	LC	HC	HCHE	LCHE	LCLE
Japan	-0,19	-0,27	-0,32	-0,28	0,04
China	-0,13	-0,46	-0,54	-0,29	-0,13
USA	-0,31	*-0,55*	*-0,99*	-0,48	0,05
SSA	-0,05	-0,38	-0,46	-0,06	-0,05
ROW	-0,05	-0,15	-0,19	-0,12	-0,04
CNA	-0,09	-0,39	-1,04	-0,34	0,01
EU15	-0,13	-0,86	-0,58	-0,46	0,09
REC	-0,47	*-4,41*	*-5,07*	*-0,78*	*0,27*
LSA	-0,05	-0,08	-0,1	-0,16	-0,05
ASIA	-0,05	-0,09	-0,11	-0,10	-0,09
MIDE	-0,60	-0,65	-0,78	-0,32	-0,23

Table 5: Welfare Impacts of a ceiling on trade in Hicksian EV in comparison to Annex B ET scenario.

A reduction of carbon emissions in Annex B countries might be offset by increased emissions in non Annex B countries like China and India through a migration of energy intensive sectors. This effect is named as carbon leakage impact. Global and regional carbon leakage effects resulting in higher emissions in countries without binding emission reduction targets appear primarily in the prohibited trade scenario and with a high cap on emissions trading. Main emissions leakages emerge within the high emissions scenario, full Annex B emissions trading avoid high leakage rates. Looking at regional leakage rates, China will be mainly affected negatively by high leakage potentials because of assumed economic growth options, the comparative advantage of their energy intensive sectors and migration relevances. Earlier studies about the effects of international permit trading found often huge capital flows because of fluctuations in real exchange rates and large transfer of wealth. Although financial capital is perfectly mobile within this model context these effects these effects cannot be detected. Within the full trade scenario, Russia and other Eastern European countries will be the main seller of emissions permits resulting in high capital increases and vice versa to capital outflows by purchasers of emission permits like USA and Europe.

An introduction of a ceiling on emission permit trading leads to lower permit prices because of less permit demand in comparison to a nearly full trade scenario. The overall permit price reaches 20 US $ per ton of carbon in 2010 meeting the Kyoto target in the high emission baseline case (LCHE). After meeting the Kyoto target permit prices are decreasing because of declining demand. Full trade or a low cap on emissions trading leads to higher permit prices, vice versa induce a cap on trade lowest permit prices. These results are in line with calculations by for example Bernstein and Montgomery (1999) (MRT) and Edmonds (1998) (EPA) (see Figure 1).

HC	CHN	SSA	ROW	LSA	ASIA	MIDE	Total
2010	0.7597	0.1136	0.5795	0.2514	0.4619	0.2225	2.3886
2015	0.4593	0.0682	0.3486	0.1502	0.2804	0.1342	1.4409
2020	0.4591	0.0679	0.3486	0.1492	0.2820	0.1341	1.4408
2025	0.4574	0.0677	0.3480	0.1483	0.2827	0.1342	1.4383
2030	0.4528	0.0669	0.3452	0.1464	0.2810	0.1335	1.4258

Table 6: Global and regional emission leagake in Bil. ton of carbon within HC scenario.

HCHE	CHN	SSA	ROW	LSA	ASIA	MIDE	Total
2010	0.8990	0.1345	0.6858	0.2976	0.5466	0.2633	2.8268
2015	0.5435	0.0807	0.4126	0.1777	0.3319	0.1588	1.7052
2020	0.5433	0.0803	0.4125	0.1766	0.3337	0.1587	1.7051
2025	0.5413	0.0801	0.4119	0.1755	0.3346	0.1588	1.7021
2030	0.5359	0.0792	0.4085	0.1732	0.3326	0.1580	1.6874

Table 7: Global and regional emission leagake in Bil. ton of carbon within HCHE scenario.

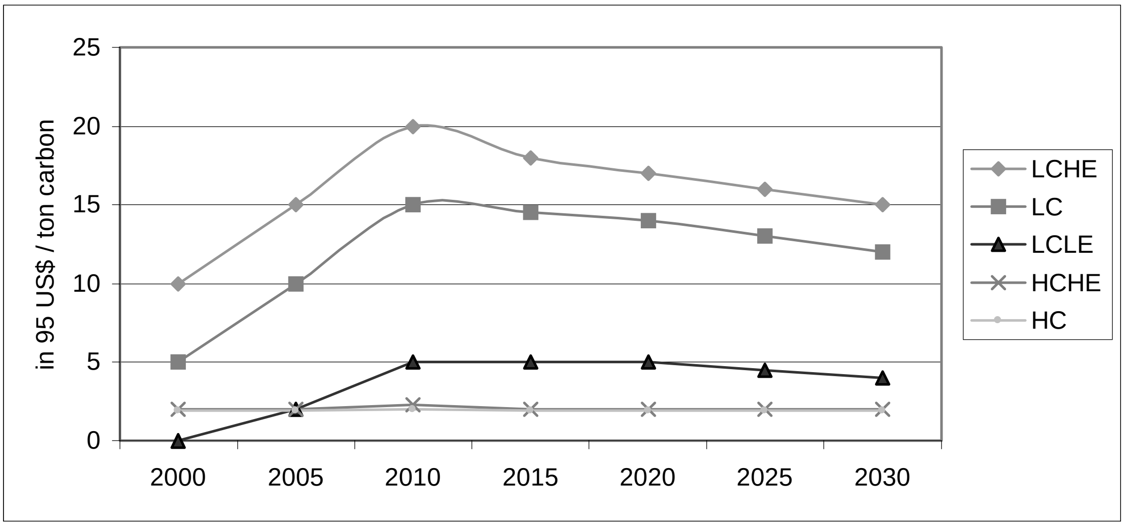

Figure 4: Annex B Permit Prices.

3.4 Conclusion

World economic implications by Kyoto mechanisms will substantially depend on a suitable definition of the emissions baseline projection path and the concrete implementation of an emissions trading scheme. International negotiations processes reveal dissimilar debates about emissions reduction options by domestic action or by international Kyoto mechanisms like emissions trading. Countries will trade emission permits due to their marginal abatement cost differentials. Regions facing high marginal abatement costs possess huge incentives to buy emissions permits. Countries with declining emissions because of substantial economic decline like Russia can sell large quantities of their emissions permits, entitled as “hot air” effect.

Carbon emission mitigation targets due to the Kyoto protocol induce not only negative economic impacts to industrialised and developed countries with high emission levels and emissions reduction target, but likewise have negative impacts on developing countries. International energy use decreases induced by productivity improvements and resulting in international energy price cutbacks. Within the Kyoto protocol emissions permits can be traded due to the initial allocation of signed emissions abatement targets between Annex B countries, model calculation reveal a substantial increase of welfare by meeting the emissions reduction target allowing permit trading. Regionally, countries in transition like Eastern Europe and Russia increase welfare significantly by facing the “hot air” effect. Because of high marginal abatement costs, USA, Japan and EU15 benefit as well by an Annex B trading system, these effects are highest within low baseline emissions assumptions because of lower efforts to meet the targets. A ceiling on emission permit trading induce global negative economic implications, the “hot air” effect can only be weakened by huge welfare losses.

Acknowledgements

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Appendix:
Mathematical description of the WAGE model

WAGE is a dynamic model and characterised by zero profit conditions, market equilibrium, income restrictions and trade relations (Armington).

The CES production structure follows the concept of ETA-MACRO combining nested capital and labour at lower level. Energy is treated as a substitute of a capital labour composite determining together with material inputs the overall output (see Figure 5).

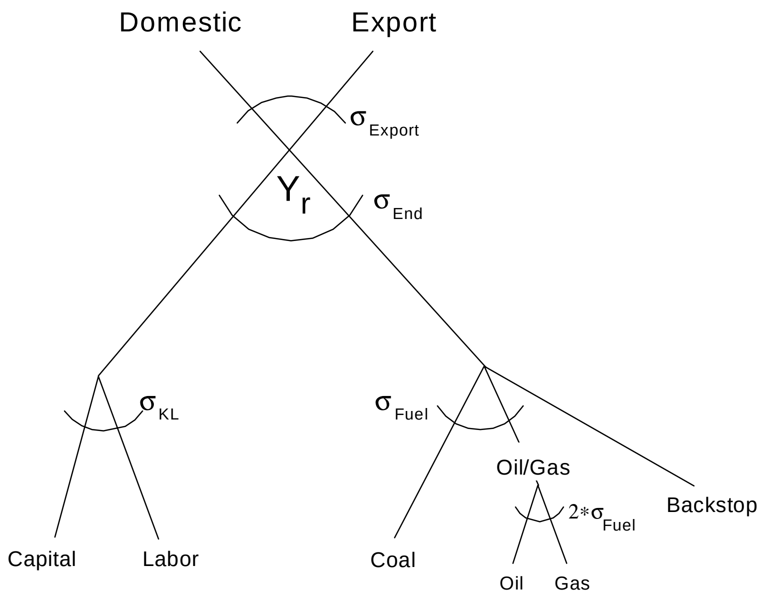

Figure 5: Production Structure.

The representative producer of sector j ascertains the *profit function*

$$\Pi_j^Y(p) = \left[a_j^{DX}(p_j^{1-\sigma_{DX}} + (1-a_j^{DX})p^{FX\,1-\sigma_{DX}}\right]^{\frac{1}{1-\sigma_{DX}}}$$

$$-\left[a_j^M p_j^{M\,1-\sigma_{KEM}} + (1-a_j^M)\left[a_j^E p_j^{E\,1-\sigma_{KLE}} + (1-a_j^E)\left[a_j^K (p^{RK})^{1-\sigma_{KL}} + (1-a_j^K)(p_j^L)^{1-\sigma_{KL}}\right]^{\frac{1-\sigma_{KLE}}{1-\sigma_{KL}}}\right]^{\frac{1-\sigma_{KLEM}}{1-\sigma_{KLKE}}}\right]^{\frac{1}{1-\sigma_{KLEM}}}$$

with:

a_j^{DM} : Domestic production share of total production by sector j

a_j^{K} : Value share of capital within capital –energy composite

a_j^{L} : Value share of labour within capital -energy -labour aggregate

a_j^{M} : Value share of material within capital-energy-labour material aggregate

p_j : Price of domestic good j

p^{FX}: Price of foreign exchange (exchange rate)

p^{RK}: Price of capital

p_j^{E} : Price of energy

p_j^{M} : Price of material

p^{L}: Price of labour

σ_{KE}: Substitution elasticity between capital and energy

σ_{KEL}: Substitution elasticity between labour and capital and energy composite

σ_{KLEM}: Substitution elasticity between material and labour/ capital and energy- composite

Y: Activity level of production sector j.

Domestically produced and imported goods are aggregated by an Armington good demanded by final demand or by intermediate production as input factors within the economy. Profit function by *Armington production* is specified by:

$$\Pi_j^A(p) = p_j^A - \left[a_j^A p_j^{1-\sigma_{DM}} + (1-a_j^A)\left(p^{FX}\right)^{1-\sigma_{DM}}\right]^{\frac{1}{1-\sigma_{DM}}}$$

with:

p_j^{A} : Price of Armington good j

a_j^{A} : Domestically produced good j value share of domestic and import good aggregate

p^{FX}: Price of foreign exchange (exchange rate)

σ_{DM}: Substitution elasticity between domestically and imported good

A_j: Armington activity level

A composite energy good is produced by either conventional fossil fuels – oil, gas, and coal – represented by a nested CES technology (with an elasticity of interfuel substitution σ_{fuel}) or from a backstop source with Leontief technology structures. Oil and gas can be substituted by an elasticity of substitution twice as large as the elasticity between their aggregate and coal. The energy good production is determined by final demand of industry and households .

$$\Pi_j^E(p) = p_j^E - \Big[a_j^{ELE} p_j^{ELE\,1-\sigma_{ELE}} + (1-a_j^{ELE}) a_j^{OIL} (p_j^{OIL} + ef_j^{OIL,CO2} p^{CO2})^{1-\sigma_{FOSSIL}} \Big]$$
$$+ a_j^{GAS} (p_j^{GAS} + ef_j^{GAS,CO2} p^{CO2})^{1-\sigma_{FOSSIL}} + a_j^{COA} \Big[a_j^{HCO} (p_j^{HCO} + ef_j^{HCO,CO2} p^{CO2})^{1-\sigma_{COA}} \Big]$$
$$+ a_j^{SCO} (p_j^{SCO} + ef_j^{SCO,CO2} p^{CO2})^{1-\sigma_{COA}} \Big]^{\frac{1-\sigma_{FOSSIL}}{1-\sigma_{COA}}} \Big]^{\frac{1-\sigma_{ELE}}{1-\sigma_{FOSSIL}}} \Big]^{\frac{1}{1-\sigma_{ELE}}}$$

With:

a_j^{ELE}	Electricity value share of energy aggregate by sector j
a_j^{OIL}	Oil value share of fossil energy aggregate by sector j
a_j^{GAS}	Gas value share of fossil energy aggregate by sector j
a_j^{HCO}	Hard coal value share of coal aggregate by sector j
a_j^{SCO}	Soft coal value share of coal aggregate by sector j
σ_{ELE}	Substitution elasticity between electricity and fossil energy
σ_{FOSSIL}	Substitution elasticity between fossil energy inputs
σ_{COA}:	Substitution elasticity between hard and soft coal
$ef_j^{OIL,CO2}$	CO_2 share of oil in sector j
$ef_j^{GAS,CO2}$	CO_2 share of gas in sector j
$ef_j^{HCO,CO2}$	CO_2 share of hard coalin sector j
$ef_j^{SCO,CO2}$:	CO_2 share of soft coal in sector j
p^{CO2}	Price of carbon
E_j	Activity level of energy production

Demanded energy by households is produced by a CES function:

$$\Pi_{HH}^E(p) = p_{HH}^E - \left[\sum_{i=EG} a_{i,HH}^{CO2} (p_i^A + a_i^{CO2} p^{CO2})^{1-\sigma^{EG}} \right]^{\frac{1}{1-\sigma^{EG}}}$$

with:

$a_{i,HH}^E$	Value share of energy good i of household
p_{HH}^E :	Price of energy by household demand
σ_{EG}:	Substitution elasticities between energy goods
E_{HH}:	Activity level of energy production by household

The dynamic model is a growth model, i.e. within equilibrium conditions all sizes are rising by a same growth rate. In the long run, a cap on emissions by an overall upper limit of emissions turns out to be difficult to meet. Because of that a carbon free backstop technology can be utilised within future times at price f^{BS} \$/t CO_2. Zero profit condition is determined by:

$$\Pi^{BS} = p^{CO2} - p^{CG} f^{BS}$$

with:

p^{CG}: Price of consumption good

f^{BS}: Costs of carbon free energy supply

BS: Activity level of backstop technology

Capital is used for production with a capital price p_t^K and an utility price of p_t^{RK} and is depreciated by rate δ:

$$\Pi_t^K(p) = (1-\delta)p_{t+1}^K + p_t^{RK} - p_t^K$$

with:

p_t^K : Price of capital in period t

p_t^{RK} : Price of capital services in period t

K_t: Activity level of capital in period t

Investments are produced by Leontief technology:

$$\Pi_{t+1}^I(p) = P \quad p_{t+1}^K - \sum_j a_j^I p_{j,t}^A$$

a_j^I Value share investment of good j

I_t: Activity level of investments in period t

P: Time period

A representative agent for each region maximises its region's discounted utility over the model's time horizon under budget constraint equating the present value of consumption demand to the present value of wage income, the value of initial capital stock, the present value of rents on fossil energy production and tax revenue. The primary factors, capital, labor, and energy are combined to produce output in period t. In addition, some energy is delivered directly to final consumption. Output is separated in consumption and investment, investment enhances the (depreciated) capital stock of the next period. Capital, labor, and the energy resource earn incomes, which are either spent on consumption or saved. Saving equals investment through the usual identity (see Figure 6).

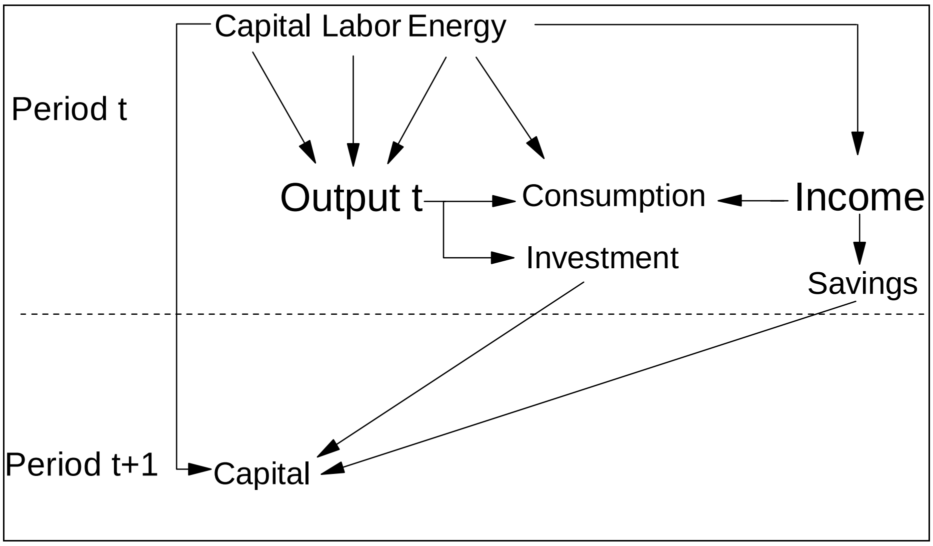

Figure 6: Dynamic structure.

One representative agent by each region demands a composite consumption good produced by combining the Armington good and the household energy aggregate good according to a CES configuration. σ_{end} describes the elasticity of substitution between the composite macro good and the energy aggregate. Aggregate end-use energy is composed of oil, gas, and coal with an interfuel elasticity of substitution equal to one. The backstop fuel is a perfect substitute for the energy aggregate. Purchase of the good is financed from the value of the household's endowments of labor, capital, energy specific resources, and revenue from any carbon tax or permit prices, respectively (see Figure 7).

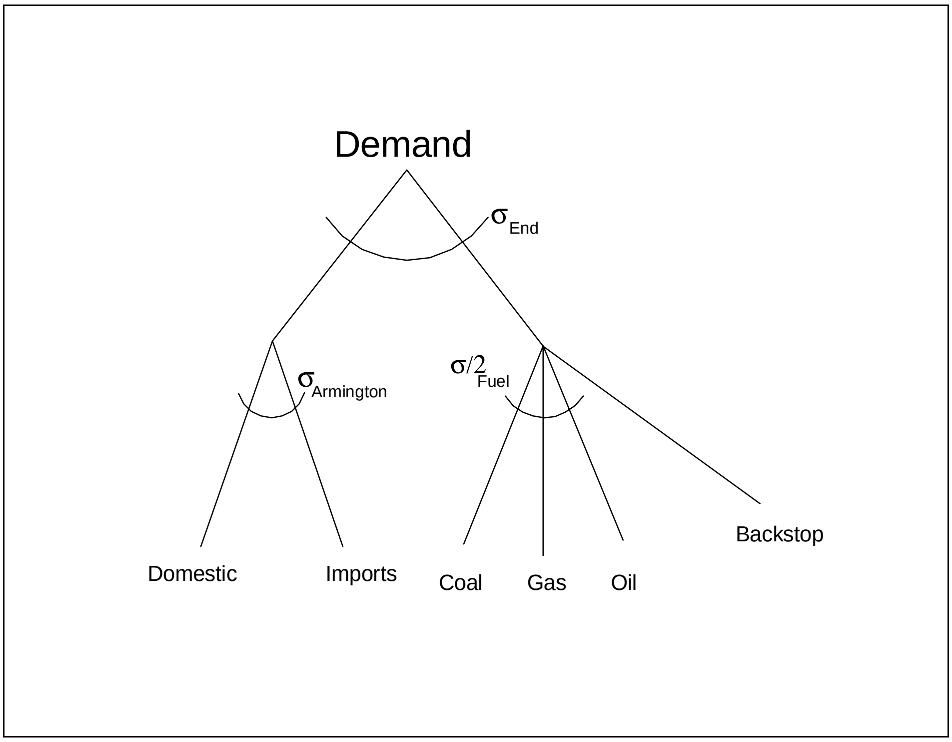

Figure 7: Final Demand Structure.

Mathematically, this dependence can be written:

$$\Pi^{CG}(p) = p^{CG} - \left[a_E^{CG} (p_E^{HH})^{1-\sigma_C} + \sum_i a_i^{CG} (p_i^A)^{1-\sigma_C} \right]^{\frac{1}{1-\sigma_c}}$$

with:

p^{CG}:	Price of consumption good
a_E^{CG} :	Value share of energy aggregate in final demand
a_i^{CG} :	Value share of non- energy good in final demand
CG:	Activity level of real consumption good production

4 On the roles of economic and technological measures in economic assessment of Finnish climate policies

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4.1 Introduction

The Kyoto Protocol to the United Nations Framework Convention on Climate Change sets reduction targets for emissions of greenhouse gases for industrialised countries, to be implemented during the years 2008-2012. The reduction target for the European Union is 8 % from 1990 levels. According to the Protocol, member countries of the European Union can have different targets, the targets being set under an EU agreement on burden sharing. Under the EU agreement, Finland must reduce her emissions to 1990 level. According to recent projections, the required reduction will by 2008 be 25-30 per cent from the level that would be reached without the commitment. Reaching the target will thus require investment in energy technology and energy saving, as well as the use of economic instruments, designed to discourage emissions of greenhouse gases.

The opportunities for direct technological measures to reduce emissions are relatively limited in Finland. This is because the energy-efficiency of Finnish energy production is already far above OECD average. This is due to several factors. For example, the share of combined electricity and heat generation (CHP) is already around 30% of total electricity generation, one of the highest in the world. This share cannot be easily increased, since with current fuel mixes, there is no suitable demand for the heat generated. However, according to recent estimates, energy consumption still has significant potential for energy saving via energy efficiency improvements, though not without cost. The potential for these improvements may be in excess of ten per cent of energy consumption. The macroeconomic costs of energy saving consist of both the direct cost of investments in more efficient technologies and their effect on the rest of the economy via increased prices and reduced incomes. For moderate improvements, the direct costs of improvements are fairly low. However, the costs rise rapidly for larger improvements, as do their negative effects on the economy.

Technology also matters indirectly. The Kyoto Protocol does not stipulate joint action on the parties with respect to economic measures, even though there is a wide agreement that flexible mechanisms – Kyoto mechanisms – can be used to achieve the emission targets. Of the Kyoto mechanisms, Joint Implementation and the Clean Development Mechanism involve direct technology investments in Annex I or developing countries. While the parties to the Protocol have yet to reach an agreement on the extent to which these mechanisms can be used, as well as the details of the mechanisms themselves, Kyoto mechanisms have come to be seen as an opportunity to increase exports of energy technology while at the same time curbing emissions. This view has also been expressed in Finland, where energy technology is a large export industry. It is conceivable that climate policies will increase the demand for energy technology globally. In some niches, Finnish firms may thus be in a position to increase their exports as a result of Kyoto. To an extent, this could off-set some of the negative effects of climate policies on the Finnish economy. However, much of the exports of energy technology consists of goods whose increased demand depends on the growth of energy consumption, and whose exports can conceivably be harmed as a result of decreased energy consumption.

But while technology is important, economic measures also have a role to play in abatement. Economic instruments have been advocated as an efficiency-increasing way to reduce the costs of abatement policies. The rationale is that economic instruments leave allocation decisions to the market and allow abatement to occur at the least cost. In effect, all economic instruments set a penalty on emissions. In this way, economic measures can be used to create incentives to investment in emission-curbing technologies. The macroeconomic costs of economic instruments of emission control depend on the combination of other economic policy measures. Thus, studying alternative ways of abatement, something has to be assumed about other taxes as well. It is well known, for example, that environmental taxes exacerbate existing distortions in the tax system, most notably via their effect on real wages and labour supply. The so-called double-dividend literature suggests remedying this problem by lowering taxes on labour income or the indirect costs of labour, such as employers' social security contributions. However, aside from environmental gains, this policy will not be beneficial unless the environmental tax is less distortive than the tax it replaces. Finally, the costs of abatement policies depend on the actions of other Annex I-countries, via the effects of abatement costs on world prices of goods and internationally traded emission permits.

In the current paper, we discuss the use and potential of economic instruments and technology for abatement in Finland. The paper is organised as follows. In section 2, the pros and cons of economic measures are discussed. In section 3, we discuss the potential for technological measures in Finland and also take up the issue of technology exports. Section 4 discusses the extent to which use has been made of this data. Section 5 concludes.

4.2 Economic instruments and their effects

4.2.1 Carbon penalties

According to economic theory, optimal abatement policies should be cost-effective. Cost effectiveness is attained when marginal costs of abatement are equal across emission sources, for if marginal costs differed, it would in principle always be possible to increase abatement without increasing costs.

The basic idea behind economic instruments is to set a penalty on emissions. This penalty can take the form of, say, carbon dioxide taxes. The tax imposes a cost on emissions, which polluters seek to minimise. In doing this, they find it optimal not to increase their emissions beyond the point where the marginal cost of abatement is equal to the carbon tax. Accordingly, were the marginal cost higher than the tax, the polluter could increase revenue by increasing emissions; if the marginal cost were lower than the tax, revenues could be increased by increasing abatement. By choosing the appropriate level for the carbon dioxide tax, regulators can guide the economy towards a given emission target without having to stipulate the emissions of any particular polluter. If the carbon dioxide tax were the same for all polluters, the conditions of the minimisation problem would be the same for all polluters, thus leading to a cost-effective allocation of emission reductions for a given emission target and for a given technology. Of course, the sectoral effects of penalties would differ between industries. Thus, industries that depend heavily on fossil fuels would face a larger burden than industries that do not. At the margin, however, industries would be equally treated by a universal emission tax, which suffices for cost-efficiency.

Under perfect competition, efficient abatement can also be attained with auctioned emission permits. With auctioned permits, instead of setting the carbon penalty, the regulator sets directly the overall level of emissions by choosing the number of permits available. Polluters are then required to buy permits to match their emissions. A polluter chooses an emission level where the marginal cost of abatement equals the price of the permit. If polluters have equal access to the markets for emission permits, abatement will be efficiently allocated. Moreover, in theory, the price of permits for a given national emission target will equal the carbon dioxide tax that would be required to secure the same target. In practice, emission permits may be easier to implement because regulators need less information to apply them. On the other hand, it is unlikely that all polluters could be included in emission trading.

Emission trading need not take the form of auctioned permits. To an extent, emission trading between polluters can also secure cost-effective abatement. This trading could be implemented by initially giving polluters emission permits and allowing polluters to trade them. Under perfect competition, the prices of these permits should equal the marginal costs of abatement. The allocation of abatement measures should also be cost-effective. However, the outcome will depend on the initial allocation of the emission permits. One suggested scheme is grandfathering, where the initial allocation of emission permits is based on past emissions. But while grandfathering is simple to implement, it also has some obvious drawbacks. It creates an incentive to overstate past emissions. Furthermore, it penalises past abatement by assigning lower permits to polluters who have already reduced their emissions by, say, increasing their energy efficiency.

Voluntary emission restrictions are perhaps less frequently regarded as economic instruments than emission taxes and tradable permits. However, they can be regarded as a form of grandfathered permits. In effect, polluters who voluntarily assume abatement targets do so under an agreement that they will not be penalised for emissions within their target. This is precisely the way in which grandfathered emission permits work: polluters do not face emission penalties for emissions that are covered by their emission rights. Thus, voluntary restrictions have the same drawbacks as grandfathered permits.

Permit trading is often seen as a way for polluters to avoid abatement. This view is a misunderstanding of permit trade, since the seller of the permits will need to reduce emissions by the amount the buyer may increase his. There is no incentive for trade, unless the abatement costs of the seller are less than those of the buyer. Thus, the benefit of permit trade is based on its ability to facilitate the efficient allocation of abatement measures across polluters, not on reducing abatement targets.

To an extent, then, all the economic instruments offer the potential of increasing the cost-effectiveness of abatement policies. However, there are important differences between the measures, which stem from their interactions with the rest of the economy. These arise from the existence of other taxes and on the use of the revenue generated by the instruments.

4.2.2 The effects of other taxes

The result that emission penalties – whether taxes or emission permit prices – should equal the marginal costs of abatement applies strictly only under very restrictive conditions. In particular, if other taxes are not optimally designed, optimal emission penalties will no longer follow the simple rule outlined above. In practice, most taxes are not set optimally and are somewhat ‘distortionary’ in the sense that they break the efficiency conditions between prices, marginal costs, and marginal productivities. The best known example is the distortionary effect of income taxes and social security contributions in creating a tax wedge between the marginal productivity of labour and the marginal disutility of labour, which leads to inefficiency in the labour market. Other examples can be found from excise taxes or from value-added taxes, which also drive a wedge between marginal costs and prices of goods. Because of the inefficiencies in taxation, taxes or other instruments that affect relative prices have more than proportional effects on prices, which exaggerates their effects. The economic instruments for abatement policies generally fall into this category, regardless of the instruments chosen.

There are no general guidelines for dealing with the interactions between carbon penalties and other taxes. Bovenberg and Goulder (1996) have shown that, given distortionary taxes, optimal environmental taxes are lower than they would be in the absence of other distortionary taxes. The reason for this is that other taxes may magnify the effects of environmental taxes. Similar results have been obtained in the case where polluters have market power. In practice, however, tax systems comprise exemptions and built-in subsidies that tend to mask any simple interdependencies. It is not possible to theoretically derive the net effects of these other policies. In some countries, efforts have nevertheless been made to identify other taxes and policies that undermine the effects of instruments of emission policies.

4.2.3 The effects of revenue

While economic instruments generally have potential for efficiency gains through the cost-effective allocation of abatement measures, they fundamentally differ in terms of the revenue they generate. Carbon dioxide taxes and auctioned emission permits generate revenue for the state, whereas grandfathered permits generate revenue for the polluters to whom the permits have been granted. Voluntary emission restrictions can also be interpreted as generating revenue in the way grandfathered permits do.

While revenue does not, as a first approximation, have to affect the efficient allocation of abatement, it may be very important to the macroeconomic effects of abatement. This result stems from the distortionary effects of emission penalties on other markets. The most discussed effect is to be found in the labour market, where emission penalties increase the distortions already present. This effect is caused by the effect of carbon penalties on consumer prices, which increase if abatement results in higher carbon penalties. As a result, real wages and thereby labour supply are affected, which may lead to a less efficient equilibrium in the labour markets. To avoid this problem, taxes on labour should be lowered to offset the negative effect. This may be accomplished by lowering income taxes or indirect labour taxes, such as employers' social security contributions. The lowering of other indirect labour taxes to compensate for the increases in emission taxes requires revenue, and in this sense, economic instruments differ from each other. Obviously, if the revenue accrues for polluters in possession of grandfathered emission permits rather than for the government, there are no revenue-neutral policy options for offsetting the distortionary effects of abatement policies (there may, however, exist revenue-losing policies).

Much has been made of the possibility of double dividends in connection with revenue from increased emission taxes being used to finance reductions in labour taxes. This policy combination is argued to increase efficiency in the labour markets simultaneously with achieving emission targets. To an extent, the popular double-dividend discussion is misguided, since the reduction of distortionary labour taxes is necessary to gain full environmental benefits – the first dividend – in the first place, rather than being a supplementary gain. Of course, this fact does not rule out the possibility of increased efficiency resulting from such a policy. It should be noted, however, that the argument applies to distortionary taxes in general. As a rule, raising some distortionary taxes while reducing others will yield efficiency gains only if the taxes that are raised are less distortive than the ones they replace.

4.2.4 Economic instruments in Finland

In the early 90s, Finland became the first country in the world to adopt carbon dioxide taxes. Currently, the tax is fuel specific. Coal and oil are taxed at FIM 102 per ton of carbon dioxide, whereas the tax is FIM 50 for natural gas and around FIM 17 for peat. The tax is applied to fossil fuels, as well as peat, that are used for consumption and for the generation of heat. Electricity generation is exempted from the carbon dioxide tax. However, electricity taxes are to an extent used in conjunction with emission taxes in the sense that electricity taxes and carbon dioxide taxes have usually been raised simultaneously and equiproportionately.

4.3 The role of technology in Finland

4.3.1 The potential for energy efficiency improvements

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

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

The Finnish energy saving potential has recently been estimated by Lehtilä and Tuhkanen (1999). According to their study, autonomous increases in energy efficiency are likely to be modest. For their analysis, they assume that autonomous process-specific decrease in the use of electricity is 0.2% per annum, while the use of process heat declines by 0.5% per annum. In residential use, specific heat consumption decreases more (by 10 % for 1995-2010), as does electricity consumption. Further increases in energy efficiency are possible, but at a cost.

Lehtilä and Tuhkanen study technically feasible ways to increase energy efficiency (i.e. to decrease specific energy consumption). These include technical measures in both energy production and energy use. An example of the former is fuel-switching in power production; Lehtilä and Tuhkanen find in many of their scenarios a switch towards natural gas, for example. An example of energy saving is the instalment of heat pumps in housing, which is found to offer a 5% energy saving potential by 2010. Proceeding in this way, Lehtilä and Tuhkanen study the existing alternative technologies and their costs, taking into account both the technological and economical restrictions imposed on technology choice by the already installed technologies. In their analysis Lehtilä and Tuhkanen then optimise the measures for given energy use and emission targets, which are both defined in exogenous scenarios, and calculate the least cost way for the energy system to attain these targets, given the choice of technologies spanned by their analysis on alternative technologies and their instalment costs.

By studying the technically feasible options available in each sector of the economy, cost curves can be constructed for energy saving for each of the sectors. These show marked differences in costs between the sectors. For example, electricity conservation is found to be some 20 % more expensive in iron and steel industries than in paper and pulp industries, ranging from 300 FIM/MWh for up to 2 per cent decreases in consumption to over 450 FIM/MWh for energy savings in excess of 10 %.

There is a problem with this kind of bottom-up approach (which has been noted by Lehtilä and Tuhkanen on several occasions) in that it does not take into account the effects of energy prices on the rest of the economy (nor is pretending to). Thus, while energy saving proves to have substantial possibilities in aiding Finland to reach her target, energy saving is also something of a mixed blessing, because it imposes costs that in turn affect prices and thus spread to the other sectors of the economy. How is one to account for these effects?

The sector-specific costs could be used in a macroeconomic model to study the effects of energy saving measures. An alternative would be to use the results of Lehtilä and Tuhkanen as inputs into a top-down model. These approaches have the disadvantage that they miss the optimising aspect of the choice of energy technologies. However, there exist models that combine the top-down and bottom-up approaches; since there is conceptually no conflict between the two approaches, hybrid models are also the natural approach in economic models in taking technology into account.

4.3.2 The potential for energy technology exports

The Kyoto Protocol stipulates that the reduction commitments can be met with flexibility mechanisms in addition to domestic measures. Two of these mechanisms, Joint Implementation and the Clean Development Mechanism, enable Annex I-countries to acquire emission reductions via direct investment in emission reducing measures in other Annex I-countries or in developing countries. This has created an interest in these mechanisms also in Finland. It has been argued that increases in exports of energy technology may even outweigh the negative GDP-effects of abatement. How realistic is this argument?

The Finnish energy technology cluster has roots extending well into the nineteenth century. It evolved during the past century from being a supplier of domestic forest industries and shipyards to a major global factor in some specialised market niches. In 1998, exports of energy technology industry exceeded 16 billion FIM, and its value added was close to 7 billion FIM. The industry has been growing steadily for the past two or three decades; more significantly from the GDP point of view, it became a net exporter in the early nineties.

The largest export commodity group in the energy cluster is converters. These are appliances that are used to regulate large scale electric motors. Their exports amounted to 2.5 billion FIM in 1998. The technology stems from Finnish innovations and Finnish producers are still world leaders in this niche, although they are nowadays owned by multinational corporations. The largest producer of converters is ABB Industry.

The second largest export commodity group is diesel generators, the third being diesel engines. The export value of the former was 2 billion FIM in 1998, and of the latter, some 1.3 billion FIM. The largest producer is Wärtsilä NSD, which started building maritime diesel engines under licence in 1939. Since the 1960s, Wärtsilä NSD has acquired production capacity from abroad and has currently plants in several European countries. Much of the R&D continues to take place in Finland, however, and the domestic production capacity is large as well.

The fourth largest export commodity group consists of as generators and electric motors, which are produced by ABB Industry and ABB Motors. Other significant Finnish exports include boilers, used in power generation. Here again, domestic innovation – in the form of the so-called circulating fluidised bed combustion - is the reason for a significant world-wide market share. Exports of boilers amounted to more than 400 million FIM in 1998.

The Finnish energy technology cluster, then, is producing technology for both energy use and energy production. Of its total exports, 48% were accounted for by European countries in 1998, whereas Asia and the former Soviet Union accounted for 34%, and the Americas for 14%. The growth of exports has been accounted for by increased demand for generation capacity in the latter group of countries, whereas in Europe, energy use has had a larger share. It is conceivable that exports of energy technology will be affected by abatement measures taken in Europe and North-America, insofar as increased energy efficiency is seeked from more efficient control of industrial appliances and modernised power plants. Diesel generators, on the other hand, are in the vogue because they offer the kind of flexible generation capacity needed in liberalised electricity markets, and also due to their suitability in the often difficult conditions in developing countries. However, to counter the costs of abatement by increasing exports of energy technology would, in the worst case, require the doubling of value added, and it is not quite sure, whether this could be achieved in Finnish plants alone. This would probably also put the energy cluster in competition over resources with other clusters, such as telecommunications.

There is also considerably uncertainty about the costs of abatement in Annex I countries, which will affect the scope for JI. Several studies have attempted to estimate the costs of international permit prices, which give a rough idea of the costs of JI projects as well. Currently, it cannot be stated with any certainty, how expensive it will be to acquire emission permits. The studies on the Kyoto mechanisms do imply that emission trading between Annex B countries would lower abatement costs significantly. However, there is a great variation in the estimated international price for emission rights (and thus the marginal costs of abatement). For example, without emission trade, Shackleton (1998) estimates that the permit price would be USD 63 per ton of carbon in the United States, USD 252 in Japan and USD 167 in other OECD countries. With Annex B trading, the price would fall to USD 37 per ton of carbon. Tulpule et al. (1998)

estimate the US price of permits to be USD 346 and the EU price to be USD 714 without Annex-B trading, which would converge to an Annex-B price of USD 114 with Annex-B trading. Manne and Richels (1998), in turn, estimate an Annex-B price of USD 100 per carbon ton with Annex-B trading and USD 79 USD with global emission trading. The highest estimates stem from models that tend to consider international trade in greatest detail, but the estimates from these otherwise convincing models are differ from the lowest estimates by two orders of magnitude! Perhaps firms have a point in starting emission trading internally.

4.4 Evaluation of the effects of the Kyoto Protocol on the Finnish economy

The evaluation of the economic effects of abatement entails analysing the direct costs of energy saving and emission reductions at industry level as well as the interactions between the sectors and different markets. Ultimately, a study of the welfare effects of abatement is also desirable, in order to assess the social consequences of abatement. These goals set the scope for the evaluation methodology. The assessment of the interactions of sectors in response to environmental policy measures, in turn, calls for a general equilibrium approach. This approach can be combined with a microeconomic model of consumption and saving, facilitating the analysis of welfare effects of various policies. It is not possible to judge these effects on purely theoretical grounds and thus a numerical approach is needed.

At ETLA, a CGE model for Finland has been used to cover many, but not all, of the aspects discussed above. In the model, each sector of the economy is taken to consist of symmetric firms, the number of which corresponds to the Finnish economy in the base year of the model data. These firms use the products of other sectors, capital, and labour as inputs for their production. In each industry, domestic firms compete with imports from the rest of the world. Domestic exports also compete in the world market with the exports from other countries. Firms are assumed to have a degree of market power and therefore to follow mark-up pricing, the mark-ups depending the price elasticity of demand for their products as well as the number of competitors.

The use of inputs is modelled on the basis of the input-output structure in the base year, but it is assumed to be endogenous to an extent in the simulations. In particular, relative prices affect the use of domestic versus import goods from each industry. This intra-sectoral substitutability between domestic and import goods depends on the price elasticity of demand within the sectors consuming these goods. There is also inter-sectoral substitutability, which, however, has been assumed to be very low.

The model takes into account the main power generation technologies used in Finland. This is of relevance, since the Finish energy system differs from most other OECD-countries by its significant reliance on co-generation. The model also covers most fuels. These two features make the model suitable for an analysis of both abatement measures as well as macroeconomic effects. They are also necessary for taking into account the sector-specificity of some energy taxes.

The analyses conducted with the model has covered several issues of abatement. The basic results are that abatement has a negative effect on Finnish GDP, but several factors can alleviate the costs. GDP effects are found to be lower, if it is assumed that world prices rise in addition to Finnish ones, that is, if Finland does not act alone. Abatement costs are, furthermore, found to be significantly lower, if Finland has access to international emission trading. Domestic policies, however, usually have a marked effect as well, suggesting that costs can be high regardless of Kyoto mechanisms if domestic policies are executed suboptimally (Honkatukia 2000).

With respect to energy saving, the model has been used to study energy saving scenarios (Honkatukia 1999). In these scenarios, all sectors of the economy are forced to invest in increased energy efficiency, improving specific efficiency in the use of electricity and heat from 2.5 % up to 12.5 %. The effects of these investments on marginal costs has been obtained from Lehtilä and Tuhkanen (1999). The results of this analysis indicate that energy saving (thus defined) increases the costs of abatement. Note however, that the setting differs from Lehtilä and Tuhkanen, in that by forcing energy saving on all sectors, measures are assumed to be taken regardless of their sectorally considerably differing marginal costs, whereas as Lehtilä and Tuhkanen assume that measures can be taken according to least cost and taking all of the energy sector into account. The obvious extension would thus be to consider scenarios, where measures are taken according to their marginal cost, utilising the cost curves reported by Lehtilä and Tuhkanen.

4.5 Conclusions

The Finnish abatement target necessitates both economic and technical measures to be taken. Abatement is likely to have significant economic consequences, since Finnish energy technology is already very efficient, and many economic measures have been used for a long time already. However, it has been estimated that significant improvements can still be made in Finnish energy technology by investment in energy saving measures.

Evaluating the economic effects of energy saving is not an easy task, because it requires detailed information on specific processes and their potential for improvement. This is something of a challenge for top-down models, since these models usually utilise industry-level data. Utilising industry-level cost data obtained from bottom-up models gives an idea of the effects of energy saving, but not one without shortcomings. Following this approach, we have found that energy saving will have repercussions and in general increase the macroeconomic costs of abatement. This is due to the loss in competitiveness that energy saving causes by increasing export prices, and to the negative effect on labour supply due to increases in consumer prices. The result is not definitive, though, since it does not allow for optimal energy saving, which is assumed in bottom-up models.

In popular discussion, it is often claimed that abatement may have positive effects via increased investment in energy technology that may benefit countries producing energy technology. Finland is regarded by many to belong to these countries. It is difficult to predict the extent of increased investment in energy technology caused by the Kyoto process, but presumably the effect may be large globally. But given the product mix of the Finnish energy technology cluster, growth bordering on spectacular would be required for energy saving technologies only to produce the necessary positive effect. It appears more likely that the energy technology cluster will grow as a result of growth in energy consumption in emerging economies.

Finally, the effects of different combinations of economic measures have an effect also on the costs of energy saving. In this respect, one finds the effects usually present in top-down models that certain uses of revenue are better from the utility point of view than others. Whether some measures are better in stimulating investment in energy saving and whether this is desirable utility-wise remains to be assessed in the Finnish case.

5 Towards a sustainable Finnish economy. Results of mixed material flows and economic analysis*

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The basic view of material flow accounting and analysis (MFA) is that the different environmental pressures caused by economies – emissions, wastes, disappearance of natural environments – are due to the amounts of materials flowing through each economy. The greater the material flows, the harder the environmental pressures. What the economy takes in from nature sooner or later re-enters nature in one form or another. Emissions into air mostly come from the production and consumption of energy. Energy in the form of energy carriers is part of material flows. However, most of the energy is used to process and transport materials – including itself as energy carriers. Most of the efforts to reduce emissions focus on raising energy efficiency or adopting into use possibly harmless forms of energy. However, if we could reduce the amounts of materials to be processed and transported, the need for energy would diminish automatically.

As to the input side, the amount of natural resources taken into an economy may have the most radical effect on limiting the outputs of the economy. However, for this shift of focus to take place, we need empirical knowledge of the material flows and understanding of how they are tied up with the economic structures. This paper presents some results of the material flow research under way in Finland.

5.1 Background

Material Flow Accounting or Material Flow Analysis (MFA) is a research field that develops methods for measuring the use of natural resources and for analysing the flows of materials through economies.

The concept of Total Material Requirement (TMR) and the methods of measuring it have been developed especially in Wuppertal Institute in Germany (Schütz & Bringezu 1998). The first international application of this research approach was the construction of the time series of 1975 – 94 for four countries: The Netherlands, Japan, Germany and the USA (Adriaanse et al 1997). Later on, the method has been applied in Australia, Italy and Poland and recently also in Finland.

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* The article is based on results of the ongoing research project *Eco-efficient Finland: Total Material Requirement and the Possibilities to Reduce it in Finland* (ECOEF project), which is part of the Environmental Cluster Research program of the Finnish Ministry of the Environment. For the project, a consortium of researchers was established consisting of researchers from Thule institute, Agricultural Research Centre, Finnish Forest Research Institute, Geological Survey of Finland, University of Joensuu and Finnish Environment Centre. Docent Ilmo Mäenpää is the leader of the project. The home page of the project is available at http://thule.oulu.fi/ecoef.

The pioneering work on MFA was already done in the late 1960’s (Boulding 1966, Daly 1968, Ayres & Kneese 1969). At that time, special attention was given to the exploitation of natural resources, which were expected to be depleted within quite a short time (Meadows et al 1971). It soon appeared, however, that the fear about the exhaustion of natural resources was exaggerated, and the interest in MFA consequently faded.

The goals of sustainable development (WCED 1987) emphasised again the need to examine the interaction between the economy and the environment in an all-inclusive and long-term context. In this context, the use of natural resources has acquired a novel interest. Now, the main interest is not on the exhaustion of individual natural resources, but on the view that the amount of material that flows through the economy, i.e. the throughput, is a general basic factor on which the different environmental pressures of economy are based (e.g. Hinterberger et al 1997). The utilisation of natural resources damages nature and disturbs its balance. On the other hand, according to the laws of physics, the amounts of air pollutants, water pollutants and solid wastes emitted by the economy into nature are tied up with how much material is taken in.

As a consequence, input has emerged as far more important than the traditional end-of-pipe thinking. Economic factors are also important: purification of emissions and garbage disposal always mean extra cost. More effective use of materials may result in total savings, as both material costs and the cost of managing emissions and wastes decrease.

5.2 Development of total material requirement in Finland

Total Material Requirement (TMR) refers to the total amount of natural resources used in an economy as metric tons. TMR consists of the following main components:

– Domestic direct material inputs consist of the flows of domestic natural resource commodities that enter the industrial economy for further processing.
– Domestic hidden flows consist of the earth moving and other material processing that occurs when providing domestic direct inputs. These materials never enter the economy.
– Imported direct material inputs consist of materials – both raw materials and refined products - that enter the economy from abroad.
– Imported hidden flows are materials, direct inputs and hidden flows that are used for the production of imported commodities abroad and which are not contained in the direct mass of the imported products.

The domestic and imported direct material inputs make up the material flows in the processing and distribution networks of the economy. The direct material inputs together with the domestic hidden flows constitute the material basis of the domestic environmental pressures. The imported hidden flows consist of the additional global ecological rucksack connected to the domestic material flows.

The development of TMR and its main components in Finland in the years 1970 – 1997 are presented in figure 1. TMR in Finland was nearly 500 million tons in 1997, i.e. over one and half times higher than in 1970. The share of domestic natural resources has been fairly constant, as the direct inputs and hidden flows together amount to about 240 million tons. The imported material inputs and their hidden flows, on the other hand, have increased from 80 million tons to over 230 million tons. Thus, the impacts of Finnish economy on external global natural resources have grown rapidly.

There are two declines in the development of natural resource use: the first in the mid-1970's after the first oil crisis and the second at the time of the deep economic recession of the first half of the 1990's.

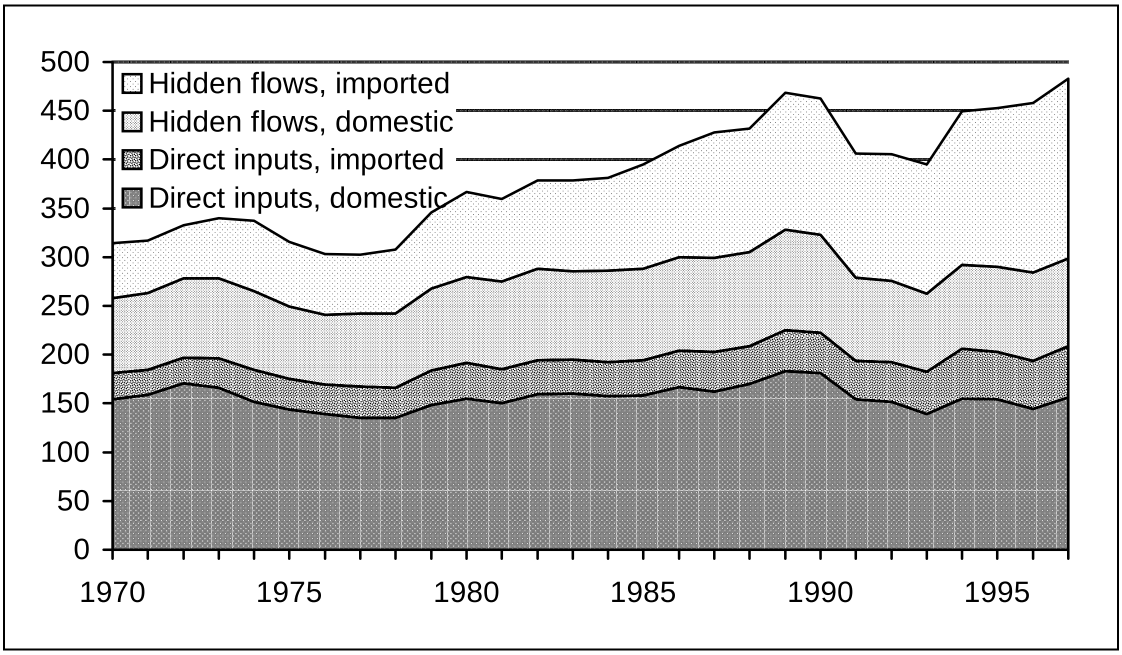

Figure 1: Total Material Requirement of Finland (TMR) in 1970-1997, million tons.

Figure 2 shows the development of TMR by the main material groups. The groups include both domestic and imported direct inputs and their hidden flows. Minerals and imported processed products have been the growing material groups. The share of gravel and other earth materials has been notably reduced in the 1990's.

The development of material intensity in the Finnish economy, or the ratio between the total material requirement and the direct inputs to GDP is shown in Figure 3. Material intensity dropped in the first half of the 1970's, and even after that the development of the efficiency of material use has been very modest. The average yearly rate of reduction of TMR/GDP was one percent and that of DMI/GDP 2.1 percent in the period 1970 – 1997. During the period 1980 – 1997, the average reduction rates were 0.6 and 1.7 percent, respectively.

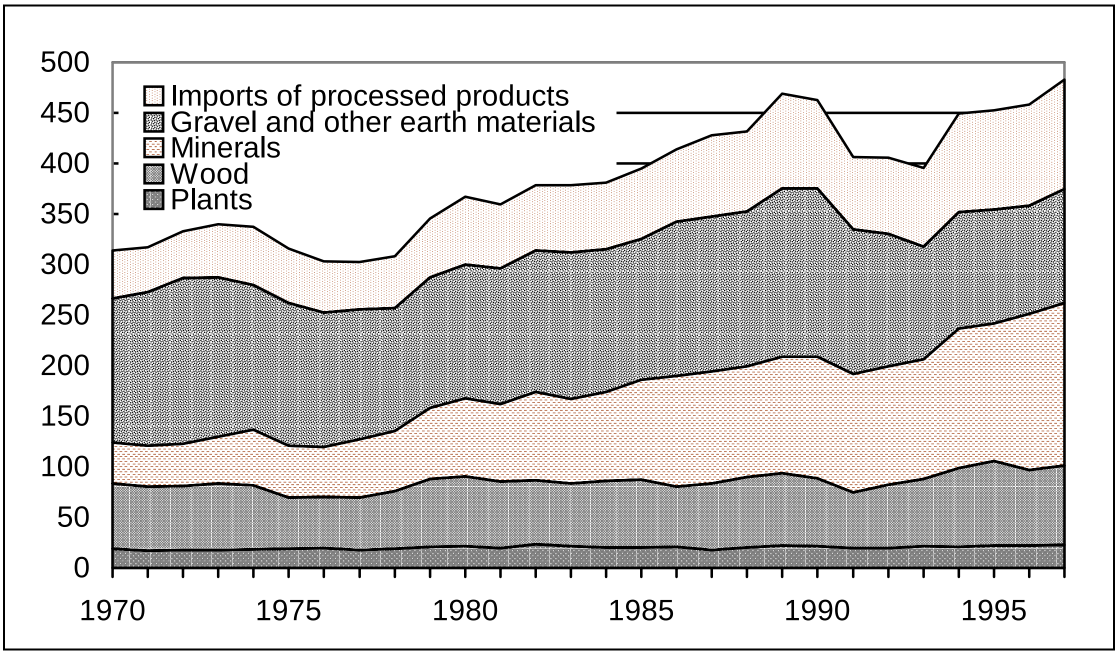

Figure 2: Composition of Total Material Requirement of Finland in 1970-1997, million tons.

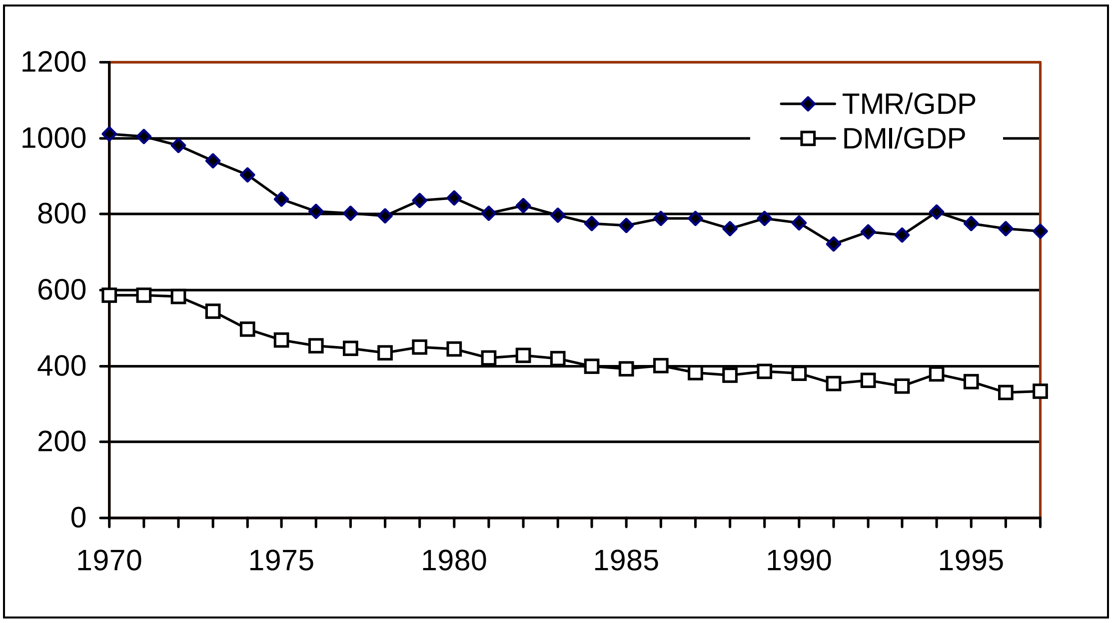

Figure 3: Development of material intensity in the Finnish economy or the ratio between the total material requirement (TMR) and the direct material input (DMI) to GDP in 1970-1997, tons/million FIM at the 1995 prices.

The four-country study (Adriaanse et. al. 1997) enables comparison of the Finnish material use with that of other the countries. In figure 4, the development of Finland's TMR per capita is presented with the corresponding values of Germany, Japan, The Netherlands and the United States. In the 1970's, TMR per capita was highest in the United States, but the ratio has been diminishing since then. Material use per capita in the European countries was some 60 tons in the 1970's, but has since grown in such a way that the per capita TMR values of the USA and the European countries converged at 70 – 90 tons in the 1990's. The material use of Japan has been much lower, about 40 tons per capita.

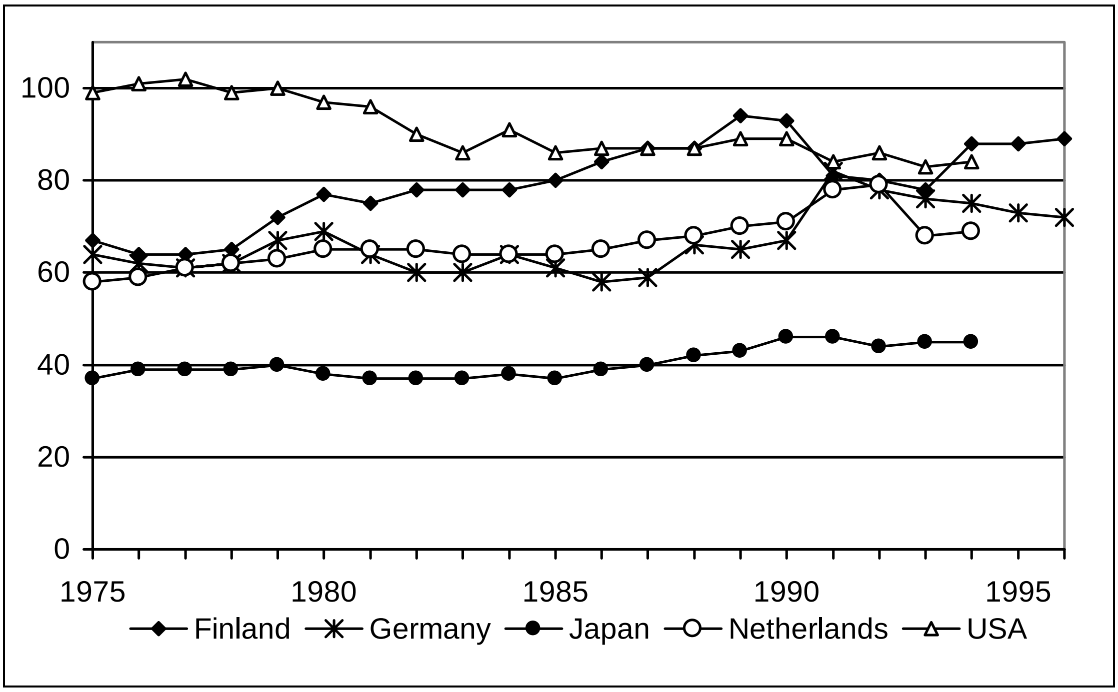

Figure 4: Total Material Requirement per capita in Finland, Germany, Japan, The Netherlands and the USA in 1975-96, tons/capita.

The compositions of TMR by material groups are compared between Finland and Germany in Figure 5. The share of wood in Finland is 21 %, while in Germany this share is negligible. The share of minerals is 31 % in Finland, but as high as 56 %in Germany. Gravel and other earth materials account for a share of 24 % in Finland, but only 12 % in Germany.

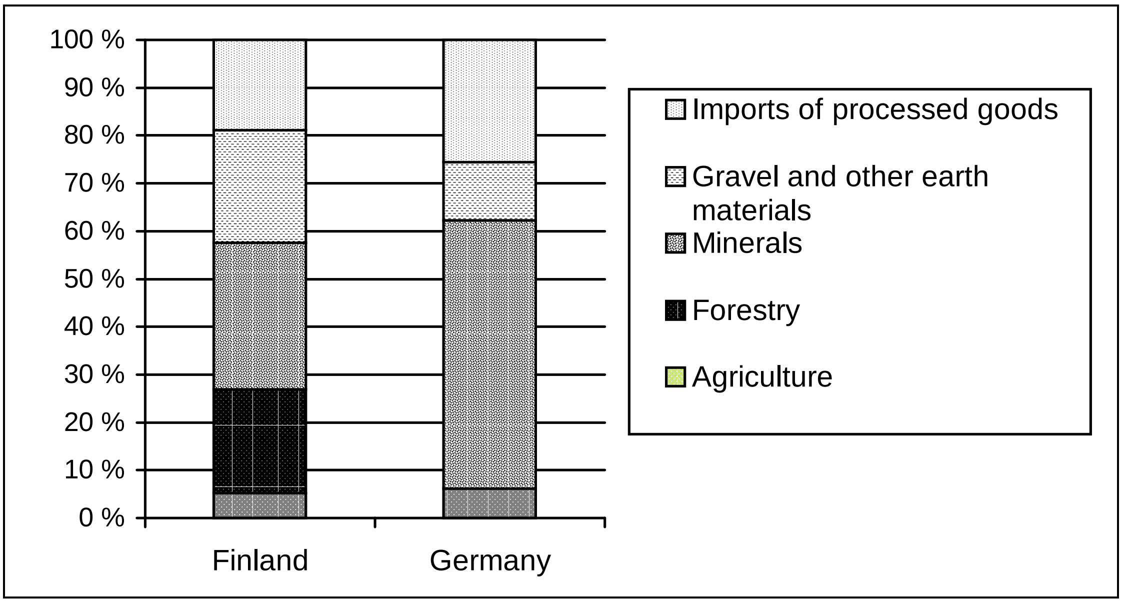

Figure 5: Composition of Total Material Requirement in Finland and Germany in 1995.

5.3 Input-output analysis of material use

For the year 1995, a more detailed study was made on the use of direct material inputs and the associated hidden flows by industries. Then, the input-output model was applied to trace the material flows through the economy up to the final use of the products.

Figure 6 shows the material intensities of industries as tons of material required to produce products worth one million FIM in value. The material requirement is divided into three components. Direct use includes the domestic and imported raw materials used directly by the industry. Indirect use consists of the raw material contents of the intermediate inputs used by the industry and produced by other industries. The direct material inputs of imported refined products are also categorised under this heading. Hidden flows consist of the hidden flows associated with both direct and indirect material use.

Civil engineering (22) has the highest material intensity in consequence of its use of gravel and other earth materials. Basic metal industry (14) also has a high material intensity because of its large hidden flows, especially those associated with non-ferrous metal ores. Forest industries (7 and 8) have relatively low material intensities thanks to the low hidden flows generally associated with biotic materials. It is worth noting that electrical products (17) have an extremely low material intensity. The manufacturing of electrical equipment has recently been and probably also will be the most expansive industry in Finland.

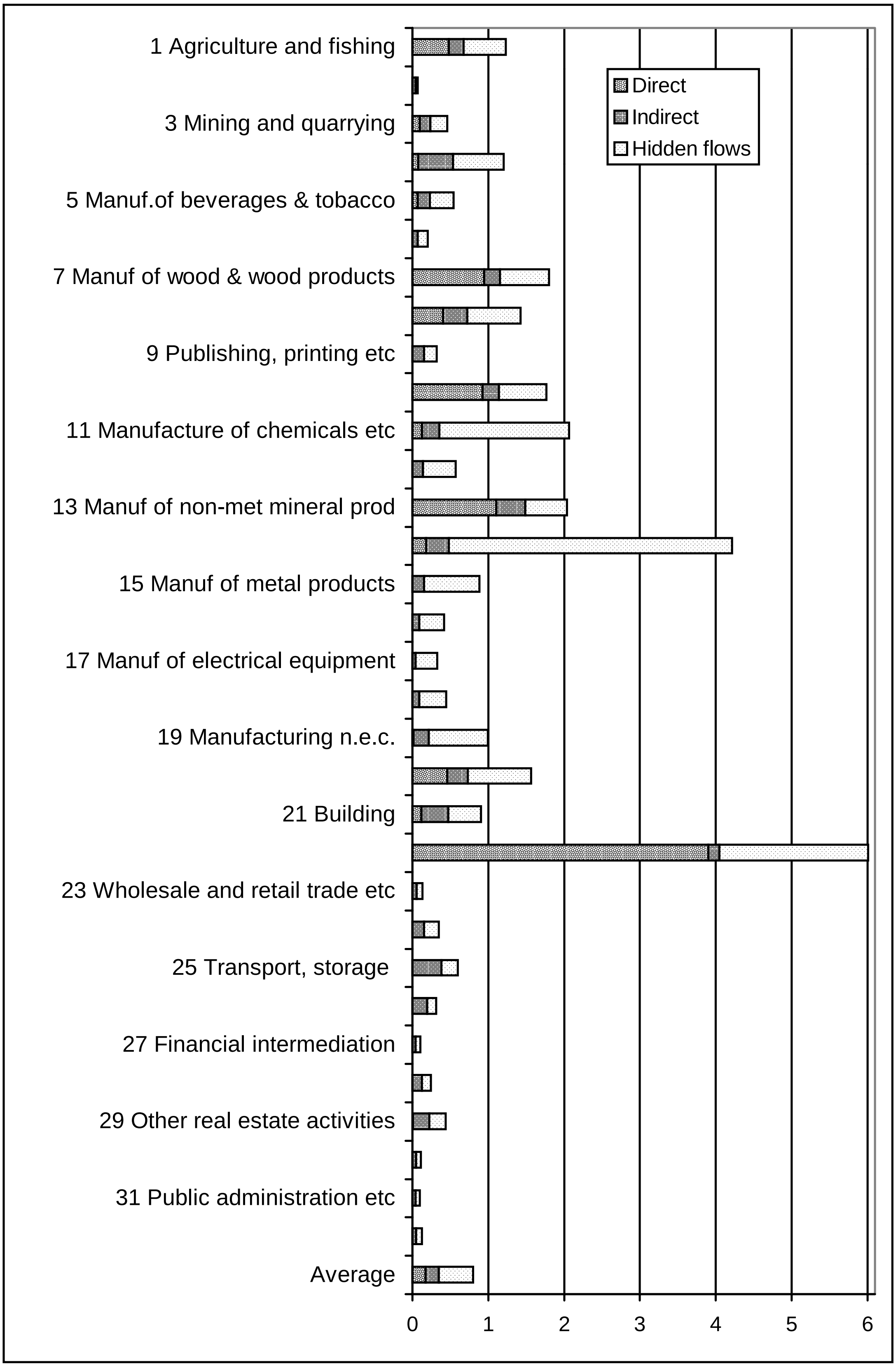

Figure 6: Total material requirement of products by industries 1995, tons/million FIM.

Having introduced the material intensities of products and knowing the product composition of the final use categories of the economy, we can calculate the material requirement of final use. In Figure 7, the distribution of final use by categories is presented, for the sake of comparison, as both monetary values and tons of material requirement. The share of private consumption is 40 % in money, but less than 20 % in terms of TMR. The monetary share of exports is 30 %, but half of the TMR of the economy is taken up by them.

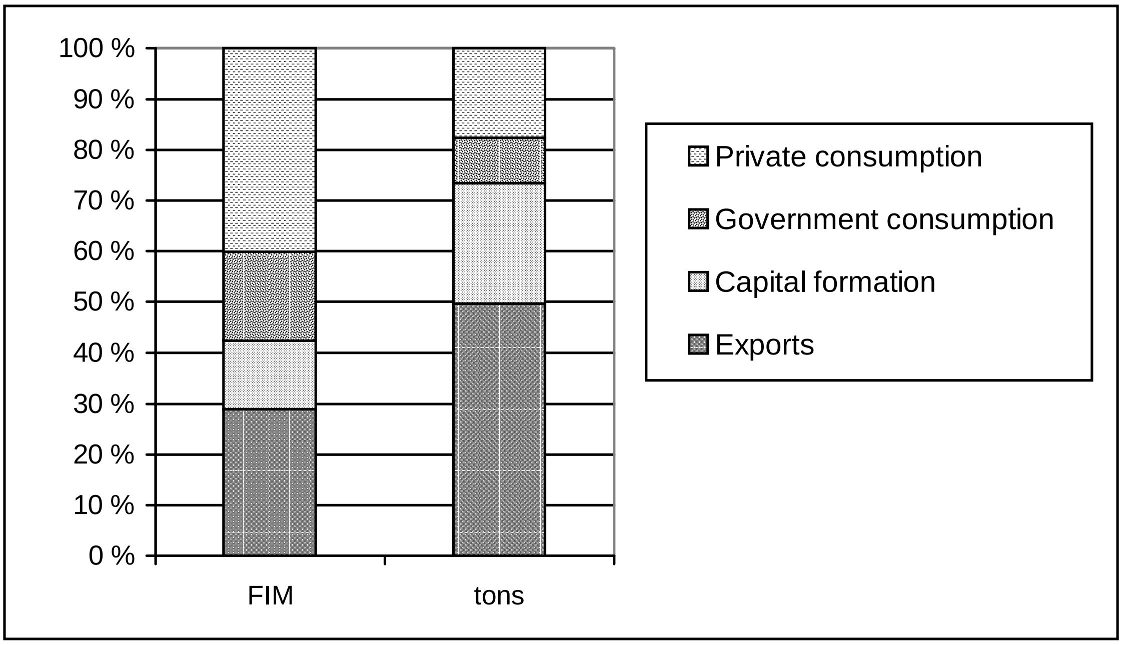

Figure 7: Distribution of the final use of products in 1995 as Finnish marks and as tons of material requirement, %.

A summary of the material flows of the Finnish economy is presented in Figure 8. On the input side, the use domestic natural resources is divided by the main material groups. On the output side, the use of materials is divided into the final use categories. Moreover, final use is divided into the direct mass of the final products and the additional indirect mass of the materials required to produce the final products. Additional indirect mass also includes the materials used in producing the services included in the final use categories. Both in private consumption and in exports, the indirect mass is almost seven times the direct material mass.

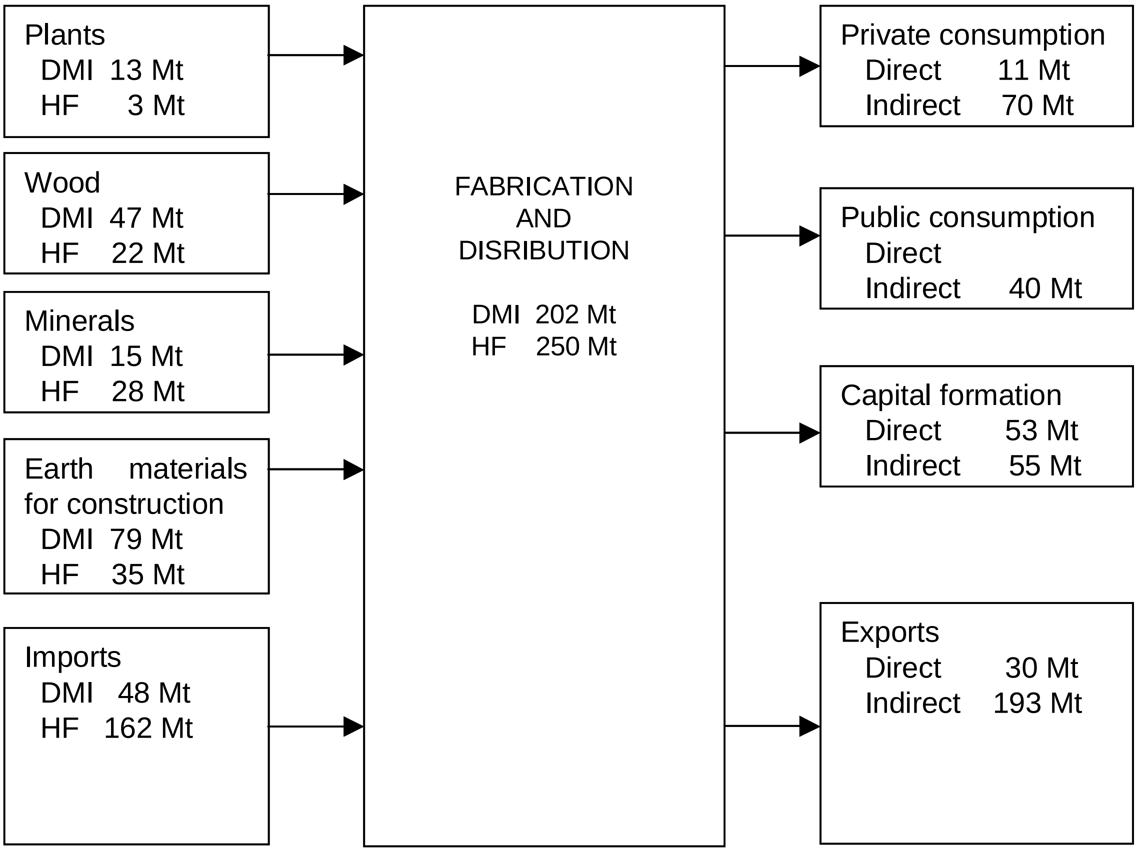

Figure 8: Material flows of the Finnish economy in 1995, million tons; DMI = direct material inputs, HF = hidden flows, Direct = direct mass of final products, Indirect = additional mass of materials needed to produce the final products.

5.4 On the structural development of the Finnish economy

Next, we will turn to the structural development of the Finnish economy to gain deeper understanding of the factors behind the development of material intensity. Special attention will be given to the development in the 1990's after the deep recession. Figure 9 shows the growth of the main production sectors of the economy as volume indexes.

In the 1970's and 1980's, the growth of the service sector was faster than that of manufacturing. During the recession in the early 1990's, manufacturing fell more deeply than services. However, manufacturing soon began to increase again, and since then the growth of manufacturing has been faster than that of services. This 'new industrialisation' is an exception to the long-term trends and exceptional in the international comparison, too.

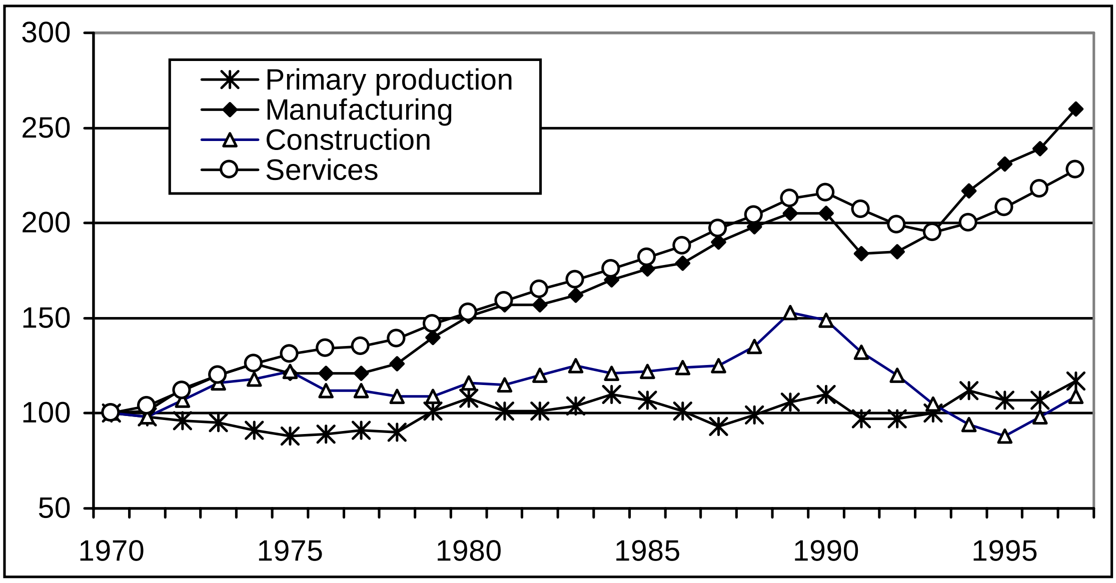

Figure 9: Volume development in the main sectors of the Finnish economy in 1970-1997, 1970 = 100.

The development of foreign trade is closely related to the new industrialisation phenomenon. In Figure 10, the volume growths of the GDP, exports and imports are depicted. After the recession, the exports turned to an exceptionally steep and continuous growth trend. The growth of imports was also accelerated. Thus, the opening of the Finnish economy to foreign trade has been very vigorous in the 1990's.

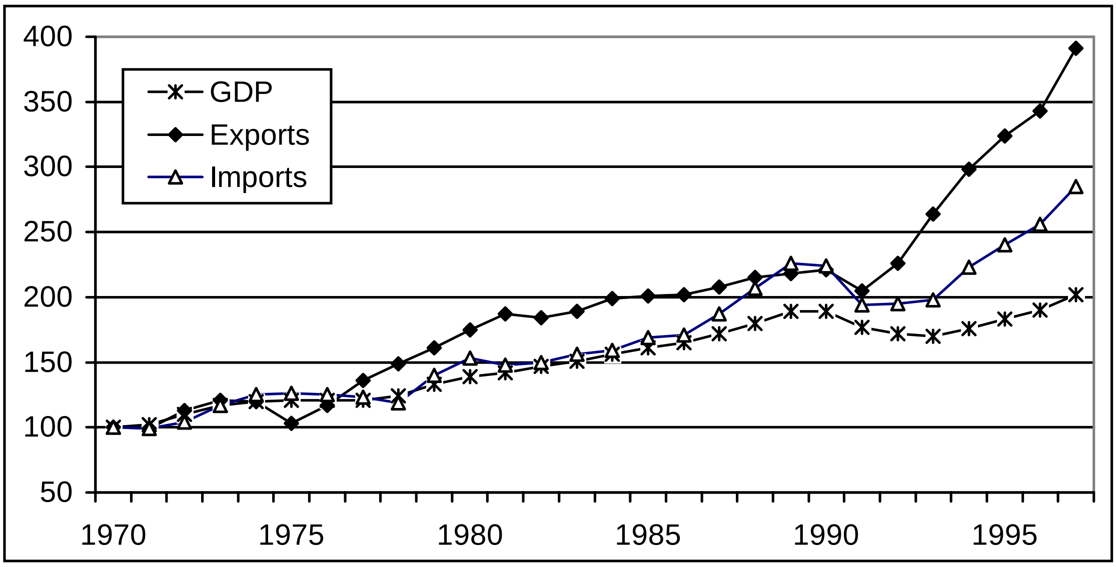

Figure 10: Finnish foreign trade and GDP volumes in 1970-1997, 1970 = 100.

Luckily for Finland and its material requirement, the growth engine both in manufacturing and in exports has been the electrical industry, whose material intensity is extremely low. In Figure 11, the development of export volumes is measured in two different ways. The FIM volume is the volume of exports measured at the constant 1995 prices, and it thus indicates the 'economic volume' of the exports. The ton volume shows the exported goods summed up in tons, incidating the 'physical volume' of the exports. We can see from the figure that the economic volume of the exports grew rapidly at the end of the study period, while the growth of physical volume ceased. Thus, the value of exports and their material use have been de-linked. Nevertheless, the physical volume of exports increased strongly in the 1990's.

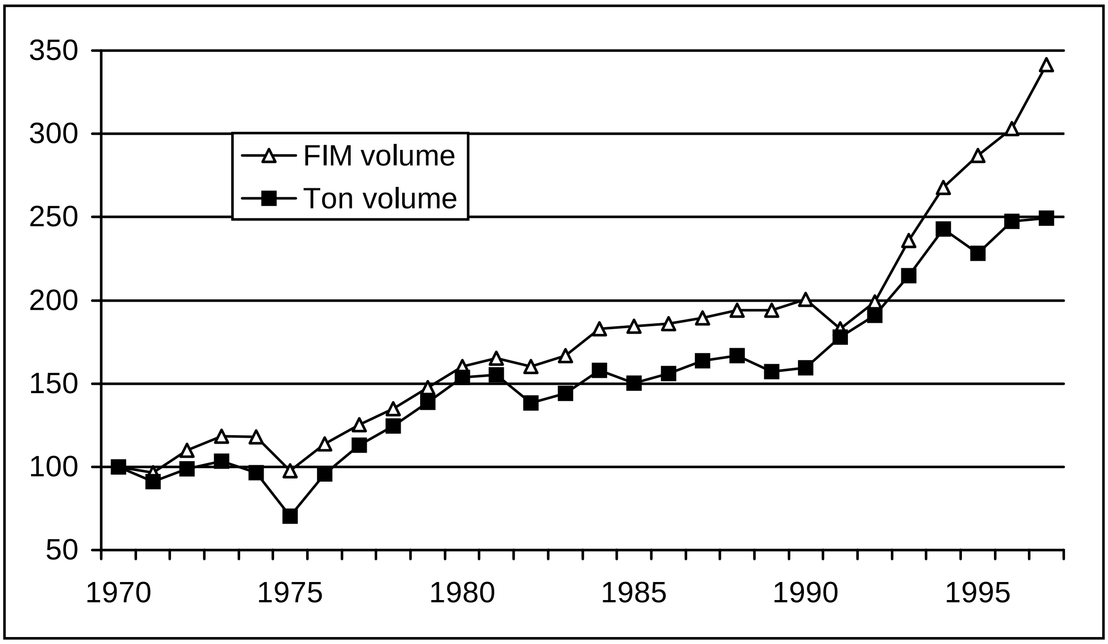

Figure 11: FIM volumes and ton volumes of Finnish exports in 1970-1997, 1970 = 100.

Figure 12 depicts the development of the physical volume of exports by product groups. For the growth of physical volume in the 1990's, the contribution of forest products has been essential. The physical volume of electrical products is included in the stripe (curve??) of metal products.

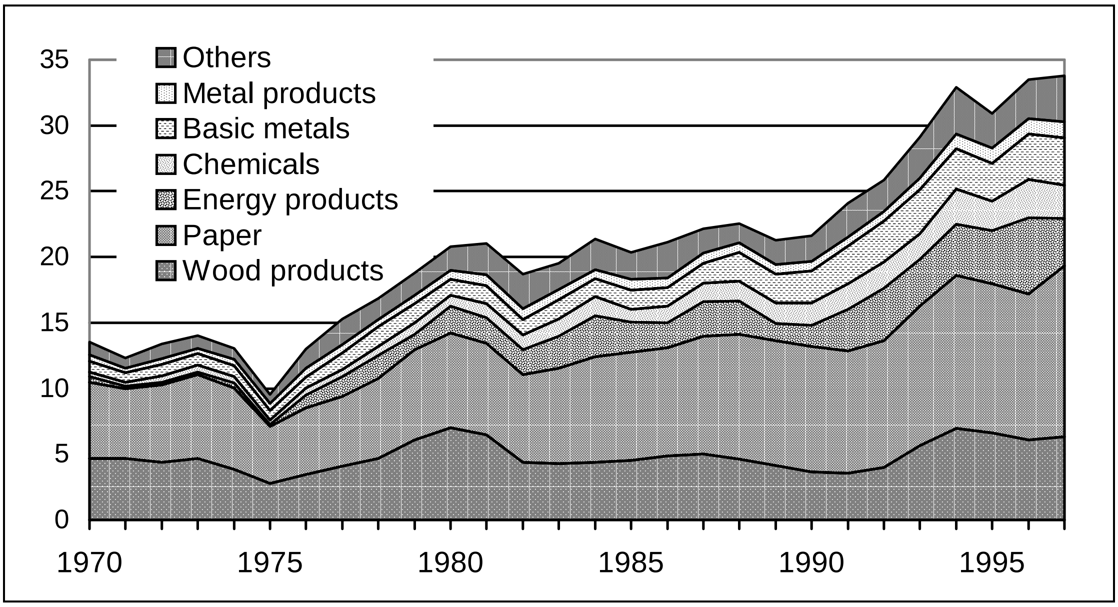

Figure 12: Exports by product groups in 1970-1997, million tons.

5.5 Partitioning the economy-wide material intensity measure

The use of total material requirement (TMR) as a measure of the natural resource use of a country has an inherent problem. It includes the use of foreign natural resources in producing the imported goods. At the same time, it also includes the natural resources used for producing the exported goods, which, in turn, are imports to the foreign countries. Therefore, if the TMRs of all countries are summed up, the sum is not the 'World TMR', as the goods exchanged in international trade are accounted for twice: once as exports and a second time as imports.

In the material intensity indicator TMR/GDP, the TMR concept is also problematic. Consider the definition of GDP from the viewpoint of final use:

i) $GDP = C + G + I + (E – M)$,

where C = private consumption, G = public consumption, I = capital formation, E = exports and M = imports. The equation can also be presented in the form of a supply and use balance:

ii) $GDP + M = C + G + I + E$.

The TMR concept, which indicates the supply of natural resources, is more consistent with the sum GDP + M than with the mere GDP. On the use side, TMR consists of the material requirements of producing the products for the four main final use categories, C + G + I + E.

In an opening economy, both E and M increase and thus raise TMR. But in the long term, foreign trade tends to balance the situation and make E and M equal. Thus, in the definition of GDP (i), the term (E - M) tends to vanish regardless of how large foreign trade is, while GDP tends to be close to the domestic final use C + G + I.

However, the concept of Total Material Consumption (TMC) is suggested as a supplementary measure for TMR (Schütz & Bringezu 1998). TMC can be defined as the TMR of domestic final use. Similarly, we can introduce the concept of Total Material Exports (TME) as the TMR of exports. Clearly, we have:

i) TMR = TMC + TME,

or

ii) TMC = TMR – TME.

The problem with the TMC and TME concepts is that they can only be calculated by using input-output tables. Indeed, in figure 8 of chapter 3, the necessary computations are shown for the year 1995.

However, we have estimated the TMC and TME measures for the whole study period 1970 – 1997 as follows. The final use categories C, G, I and E are disaggregated into products at the most detailed level in such a way that the time series of their volumes are available. Then, the TMR intensities of the products are computed by the input-output model for the year 1995. Then, by means of the detailed time series, the TMR estimates for C, G, I and E are computed based on the TMR intensities of the year 1995. The estimate for TMC is then the sum of the TMR estimates of C, G and I and the estimate for TME is the TMR estimate for E.

Assuming the material intensities of the detailed level products to be constant is naturally a crude method. However, the accuracy of the estimates can be tested by using the equation (ii) above. Namely, the estimate of TMC can be compared with the difference between the total TMR and the estimate of TME. The comparison is presented in Figure 13. The two estimates remain relatively close to each other.

The average of the two estimates is used as the final estimate of TMC and the difference TME = TMR – TME as the final estimate of TME.

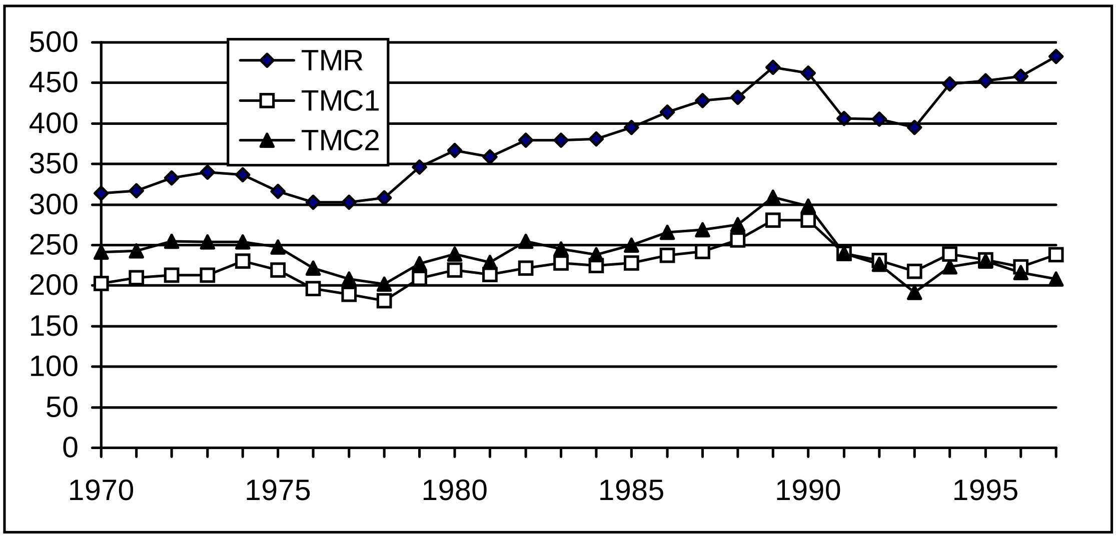

Figure 13: TMR and the estimates for TMC: TMC1 = direct estimate of TMC, TMC2 = estimate by the difference TMR – TME, million tons.

Figure 13 shows the fundamental difference between TMR and TMC: while the TMR has a clearly growing long-term trend, the TMC has not grown.

Figure 14 compares the development of the two material intensity indicators of the economy, TMR/GDP and TMC/GDP.

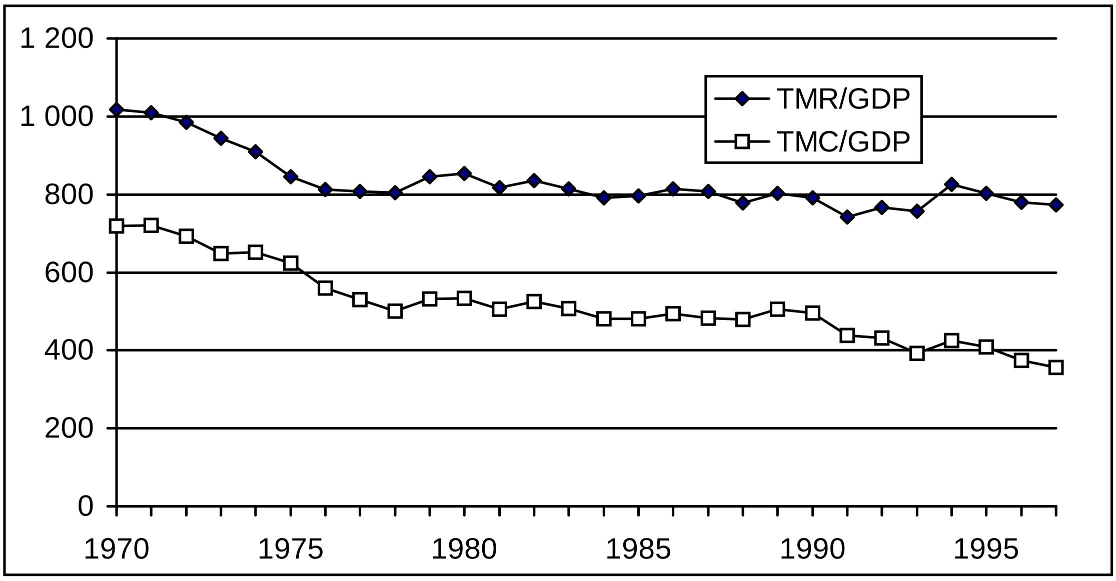

Figure 14: Material intensity of the economy measured as the ratio of total material requirement (TMR) and total material consumption (TMC) to GDP in 1970-1997, tons/million FIM at the 1995 prices.

While TMR/GDP has remained relatively constant since 1975, the TMC/GDP ratio has continued to decline. The average yearly reduction rates of the material intensity indicators at the different time periods are given in Table 1.

	TMR/GDP	TMC/GDP
1970-97	1.0	2.6
1980-97	0.6	2.3
1990-97	0.3	4.6
1970-80	1.8	2.9
1980-90	0.7	0.7

Table 1: Average yearly reduction rates of the material intensity indicators in different time periods, percent per year.

As the total material exports, TME, is the difference TMR – TMC, we can see from Figure 13 that while TMC has remained relatively constant, TME has grown almost threefold during the study period.

For the efficiency indicator of TME, GDP is not a feasible denominator. Instead, the economic volume E, i.e. the monetary value of exports measured at the constant 1995 prices, can be used. Figure 15 shows the development of the TME/E indicator.

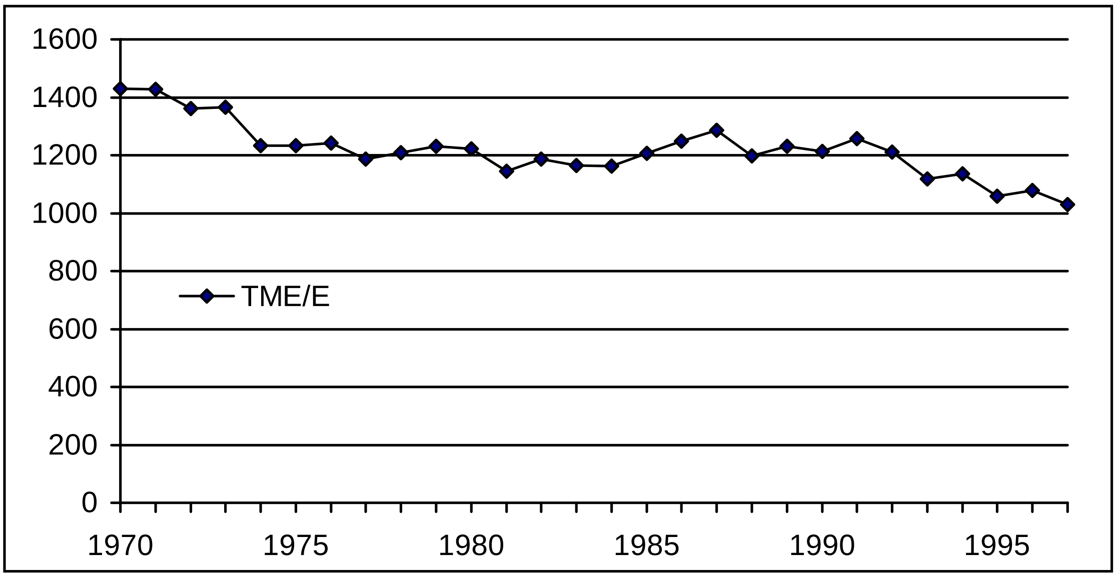

Figure 15: Material intensity of exports in 1970-97, tons/million FIM at the 1995 prices.

The figure shows that the reduction of the average material intensity of the exports has been modest. The average efficiency improved during the first half of the 1970's, then remained relatively constant up to 1990, until it began to improve again in the 1990's.

From the point of view of sustainable development, however, the material efficiency of exports is more complicated than the development of average efficiency. From the global point of view, if a product, even when it is relatively material-intensive, can be produced in one country with better efficiency than in the other countries, then the increase of production and exports in that country improves sustainability at the global level, even though this will raise the average material intensity of the country's exports. However, from the selfish domestic viewpoint, material-intensive exports increase the domestic environmental pressures of the economy.

5.6 Concluding remarks

The total material requirements of the Finnish economy increased by over 50 percent in the period 1970-1997. In the same period, GDP grew twofold. Efficiency improvement in the use of materials thus seems to have advanced slowly.

In a small open economy which has been opening fast recently, as in Finland, the role of foreign trade is important. Over half of the total material requirements of Finland are used to produce the exported products and the growth in the material requirements is, speaking, due to the growth of exports alone. The material requirements of the domestic final use of the products does not seem to have increased in the study period in spite of the economic growth.

Considering the sustainability conditions of a small open economy, the material intensity indicators have to be divided into two parts: materials required for domestically used final products and materials required for exports. The sustainability goal for domestic final use is obviously to reduce its material intensity. For exports, the condition is not so straightforward. In the global perspective, the increase in the production of material-intensive products is compatible with sustainability, if the material efficiency of production is higher than the average elsewhere. Nevertheless, the material flows of the exporting industries are also part of the material flows of the domestic economy, which is the basis for domestic environmental pressures.

6 Energy and emission impacts of the organisation of space and infrastructure – investigations for the Helsinki region

Irmeli Harmaajärvi*, Senior research scientist, VTT Communities and Infrastructure, Espoo, Finland*

Impacts of urban structure on greenhouse gas emissions in the Helsinki Metropolitan Area were examined in 1999 by VTT Communities and Infrastructure. The study was commissioned by the Environmental Office of the Helsinki Metropolitan Area Council and carried out in co-operation with the Environmental Office, the Development Office and the Transportation Department of the Helsinki Metropolitan Area Council.

The aim of the study was to find out the possibilities to minimize greenhouse gas emissions by developing urban structure and transportation system in the Helsinki Metropolitan Area.

The study examines carbon dioxide emissions in the Helsinki Metropolitan Area through three alternative future urban structure models: the Basic Model, the Infill Model and the Urban Sprawl Model. In all models population is supposed to increase to 1 073 300 inhabitants in the year 2020. Number and location of work places are the same in all models. There are differences in location of dwellings and the transportation system.

Figure 1 presents the population density (inhabitants per square kilometre) in the Helsinki Metropolitan Area in the year 1997.

6.1 Land Use in 2020

6.1.1 The Basic Model

The model is based on the regional land use structure of the Helsinki Metropolitan Area Vision 2020 and the Helsinki Metropolitan Area Transportation System 2020 (PLJ 1998), which have been agreed by the Helsinki Metropolitan Area Council. The model includes complementary building, and new construction is located in the vicinity of the main lines of public transport, especially of rail traffic. Population density in this model in the year 2020 is described in figure 2 and changes of building stock (1998 – 2020) in figure 5.

6.1.2 The Infill Model

This model utilises infilling and densifying possibilities even more efficiently than the Basic model. No new areas are located detached from existing structures. Building possibilities are sought near work places and services in the vicinity of public transport. Growth of living space is supposed to be 1 square metre per resident slower than in the Basic Model. Transportation is based on the Helsinki Metropolitan Area Transportation System 2020.

Population density in this model in the year 2020 is described in figure 3 and differences in location of dwellings compared to the Basic Model in figure 6.

6.1.3 The Urban Sprawl Model

In this model urban structure is totally sprawled within the Helsinki Metropolitan Area. Maximum dwellings (detached houses) are located outside the Ring III. New construction is located in the inner city only to compensate the decrease in housing. Transportation system emphasizes use of private cars.

Population density in this model in the year 2020 is described in figure 4 and differences in location of dwellings compared to the Basic Model in figure 7.

6.1.4 Transportation structures

In the Basic Model and the Infill Model the West Metro and the Marja Railway have been built. In the Urban Sprawl Model there are no new railways, but instead the Ring IV has been built. Some roads like the Pasila Highway, the Rings I, II and III as well as radial highways have been built on a higher level.

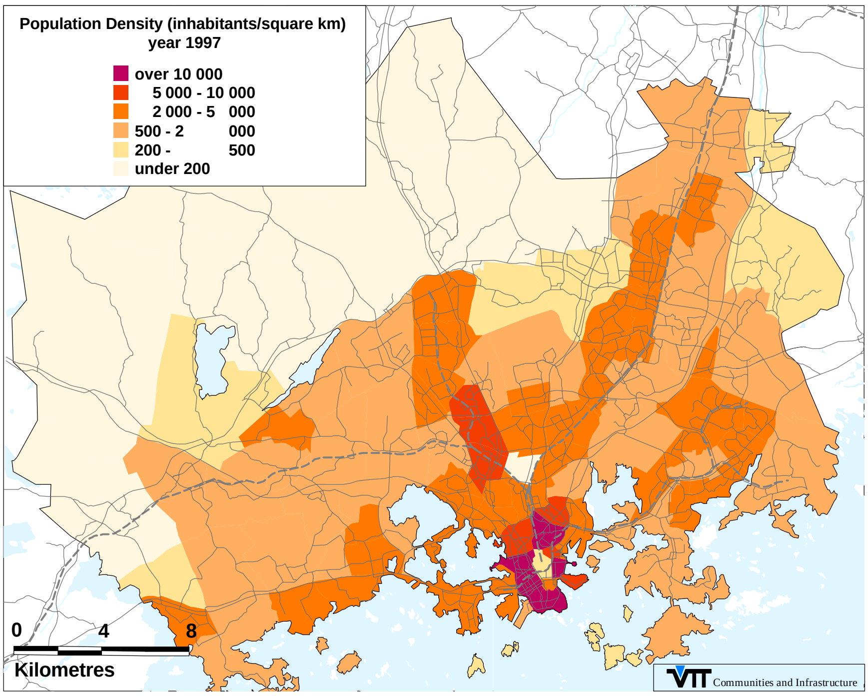

Figure 1: Population density (inhabitants per square kilometre) of 117 sub areas in the Helsinki Metropolitan Area in the year 1997.

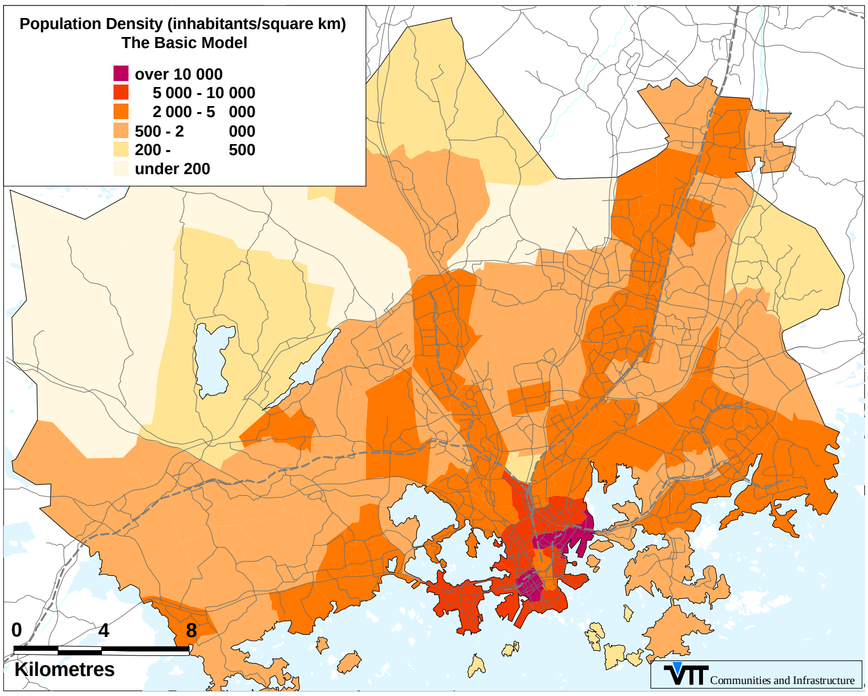

Figure 2: Population density (inhabitants per square kilometre) in the Helsinki Metropolitan Area in the year 2020 in the Basic Model.

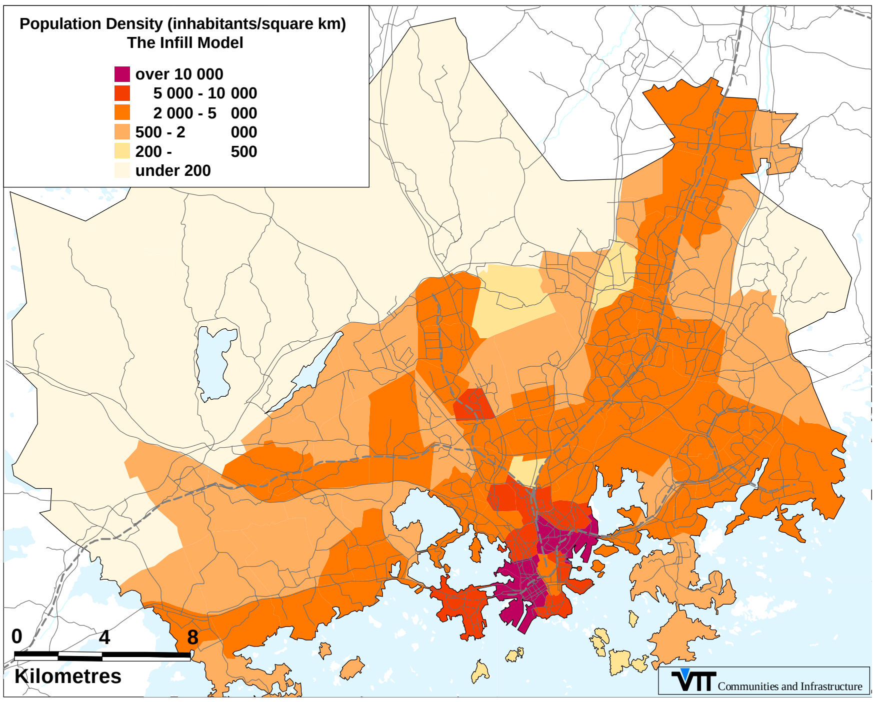

Figure 3: Population density (inhabitants per square kilometre) in the Helsinki Metropolitan Area in the year 2020 in the Infill Model.

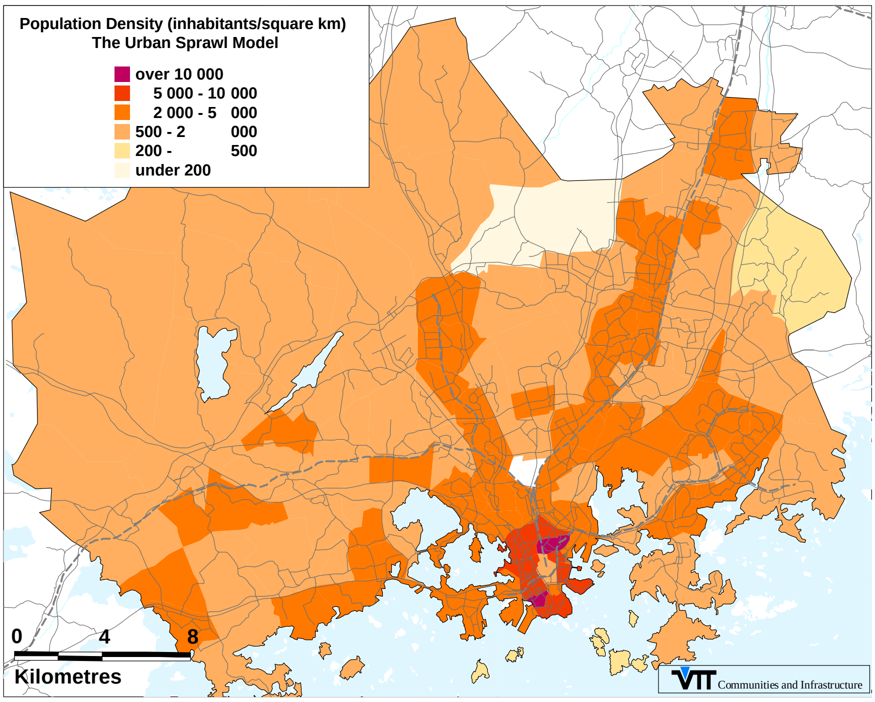

Figure 4: Population density (inhabitants per square kilometre) in the Helsinki Metropolitan Area in the year 2020 in the Urban Sprawl Model.

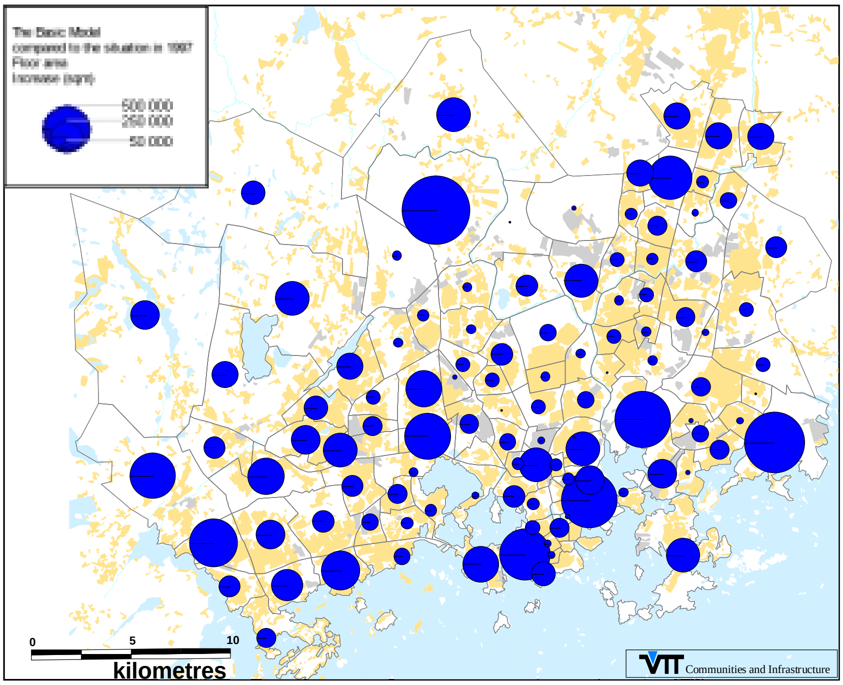

Figure 5: Floor area of buildings in 117 sub areas of the Helsinki Metropolitan Area in the year 2020 in the Basic Model compared with the situation in the year 1997.[15]

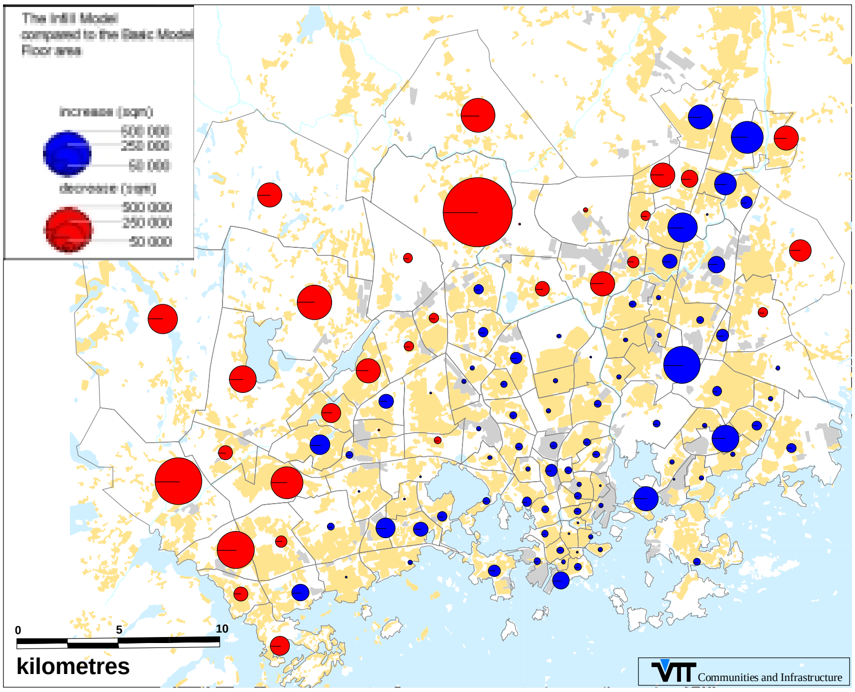

Figure 6: Floor area of buildings in 117 sub areas of the Helsinki Metropolitan Area in the year 2020 in the Infill Model compared with the Basic Model.

[15] The colour version of figures 5-7 can also be found on http://www.vatt.fi. In the figures above blue relates to increase and red to decrease of floor area.

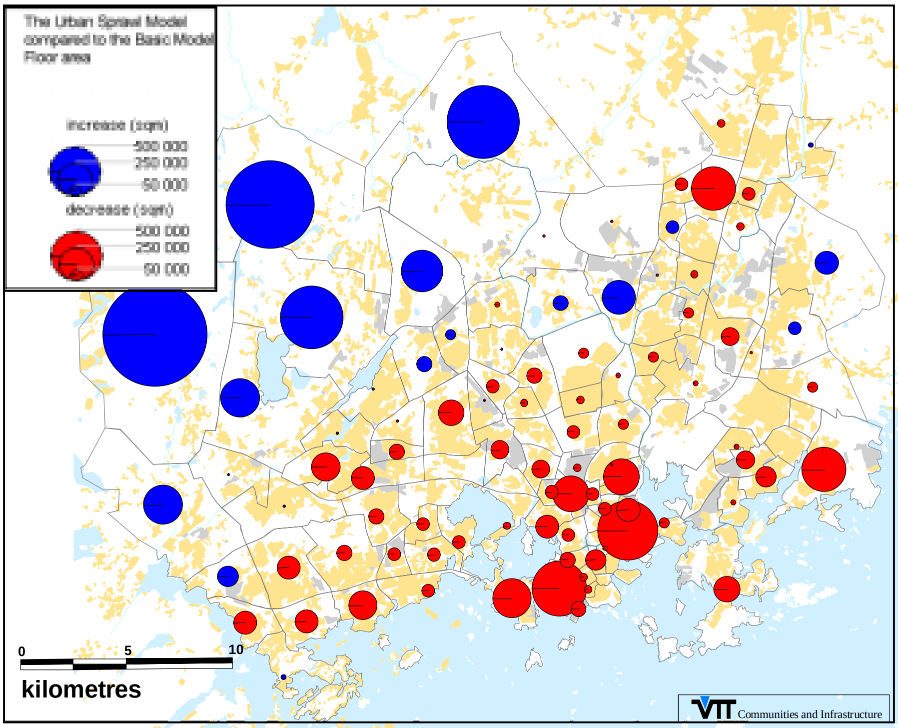

Figure 7: Floor area of buildings in 117 sub areas of the Helsinki Metropolitan Area in the year 2020 in the Urban Sprawl Model compared with the Basic Model.

6.2 Evaluation of CO2 emissions

6.2.1 CO2 emissions of energy production for heating dwellings

Emissions of energy production were evaluated roughly by heating system of dwellings (district heating or electric heating). Areas of district heating in the year 2020 were defined on the basis of existing network and building efficiency. Heating energy consumption is supposed to be 120 kWh/square metre per year. Specific CO_2 emission of district heating is supposed to be 300 g/kWh and specific CO_2 emission of separate electricity production 520 g/kWh.

6.2.2 CO_2 emissions of transportation

Future development of transportation mileage has been evaluated in each land use model on the basis of location of population and work places etc. and relevant transportation system. Specific fuel consumption is supposed to reduce 30 % from the current level. The average amount of private cars is highest in the Urban Sprawl Model (499 cars/inhabitant) and lowest in the Infill Model (474 cars/1000 inhabitants). In the Infill Model pedestrian and bicycle trips are committed 4 % more and in the Urban Sprawl Model 12 % less than in the Basic Model. The share of public transport of the motor traffic is at present 39 %, in the Basic Model 38,6 %, in the Infill Model 39,4 % and lowest in the Urban Sprawl Model: 35,8 %. Car mileage is in the Infill Model 3 % less and in the Urban Sprawl Model 13 % more than in the Basic Model. Time is used in car traffic most in the Urban Sprawl Model and least in the Infill Model.

6.2.3 CO_2 emissions in the Helsinki Metropolitan Area in different land use models

Energy production of heating dwellings (by district heating or by electricity) causes carbon dioxide emissions in the year 2020 in the Basic Model 1 956 000 tons, in the Infill Model 1 869 000 tons and in the Urban Sprawl Model 2 112 000 tons per year *(Figure 8)*. Infilled urban structure causes emissions 4 % less and sprawled structure 8 % more than the Basic model when considering the whole urban structure of the Helsinki Metropolitan Area. When considering the new structure the Urban Sprawl Model increases emissions even 53 % and the Infill Model decreases them 30 %.

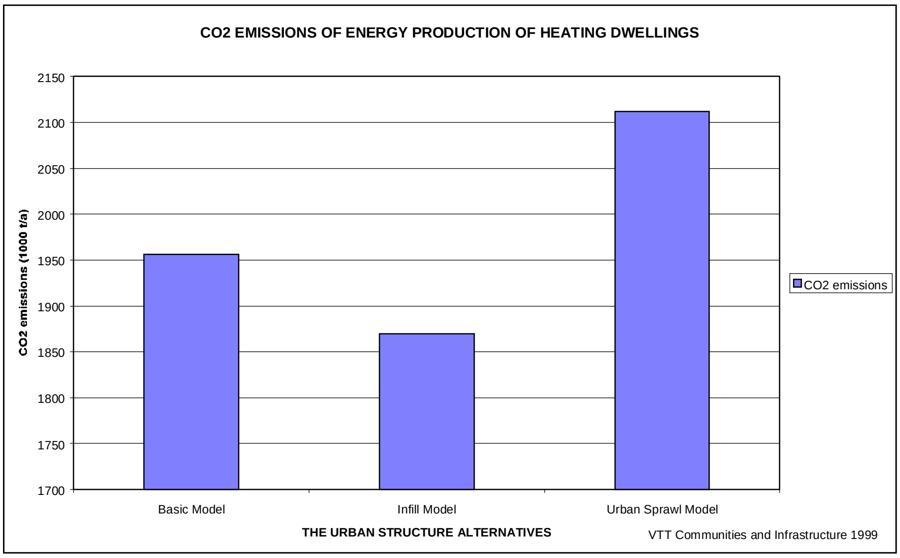

Figure 8: CO2 emissions of energy production for heating dwellings in the Helsinki Metropolitan Area in the year 2020 in different land use models. Urban sprawl increases and infill decreases emissions. District heating causes less emissions than separate electricity production.

Transportation causes carbon dioxide emissions in the year 2020 in the Basic Model 890 000 tons, in the Infill Model 873 000 tons and in the Urban Sprawl Model 963 000 tons per year *(Figures 9 - 13)*. Infilled urban structure causes emissions 2 % less and sprawled structure 8 % more than the Basic Model. Considering the new structure urban sprawl increases emissions 37 % and infilling decreases them 9 %.

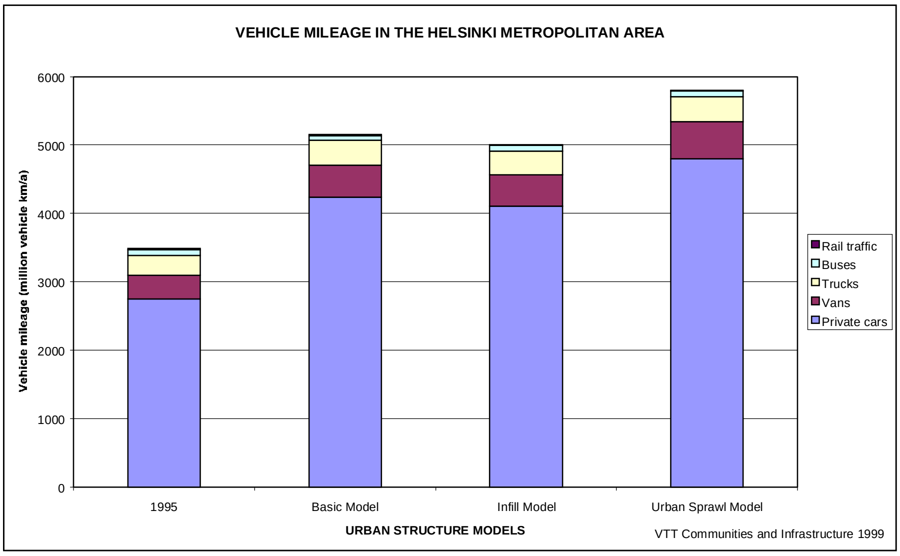

Figure 9: Vehicle mileage in the Helsinki Metropolitan Area in the year 1995 and 2020 in different land use models. Vehicle mileage increases 30 % in the Basic Model compared to current situation. Urban sprawl increases and infilling decreases mileage. Major part comes from private cars.

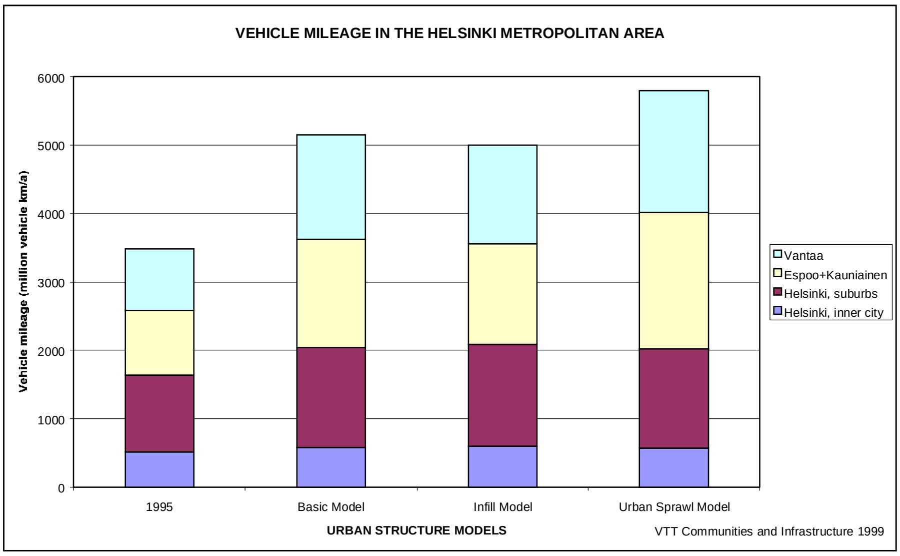

Figure 10: Vehicle mileage in the Helsinki Metropolitan Area in the year 1995 and 2020 in different land use models. Vehicle mileage increases especially in other parts than inner city of Helsinki. Urban sprawl increases and infilling decreases mileage.

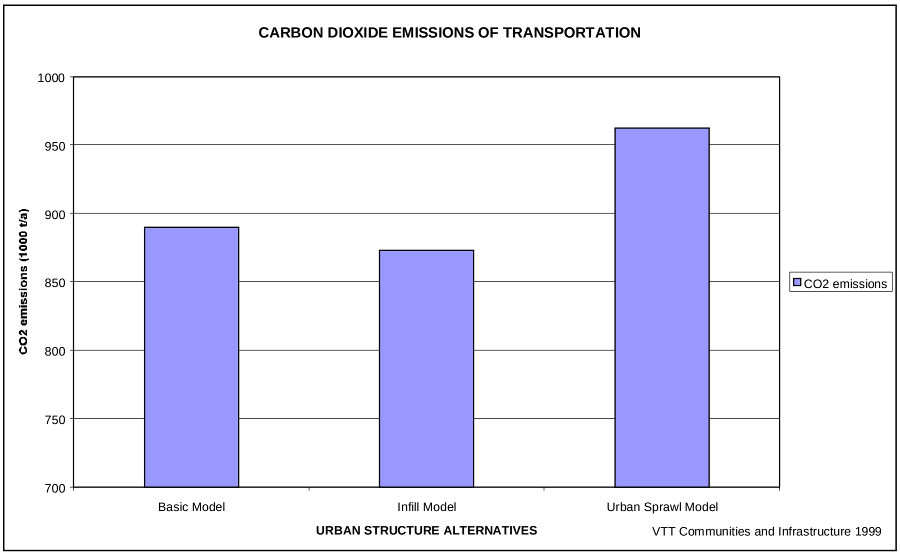

Figure 11: Carbon dioxide emissions in the Helsinki Metropolitan Area in the year 1995 and 2020 in different land use models. Emissions are about the same in 2020 as in 1995 because of remarkable reduction of specific fuel consumption. Most emissions are caused by private cars. Urban sprawl increases and infilling decreases emissions.

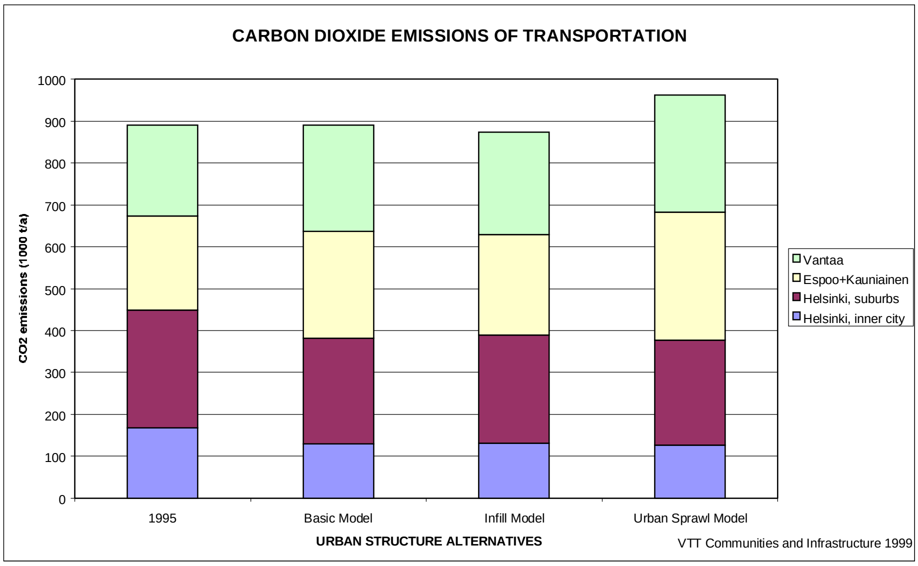

Figure 12: Carbon dioxide emissions in the Helsinki Metropolitan Area in the year 1995 and 2020 in different land use models. Emissions decrease in Helsinki and increase especially in the Urban Sprawl Model in Espoo and Vantaa. Urban sprawl increases and infilling decreases emissions.

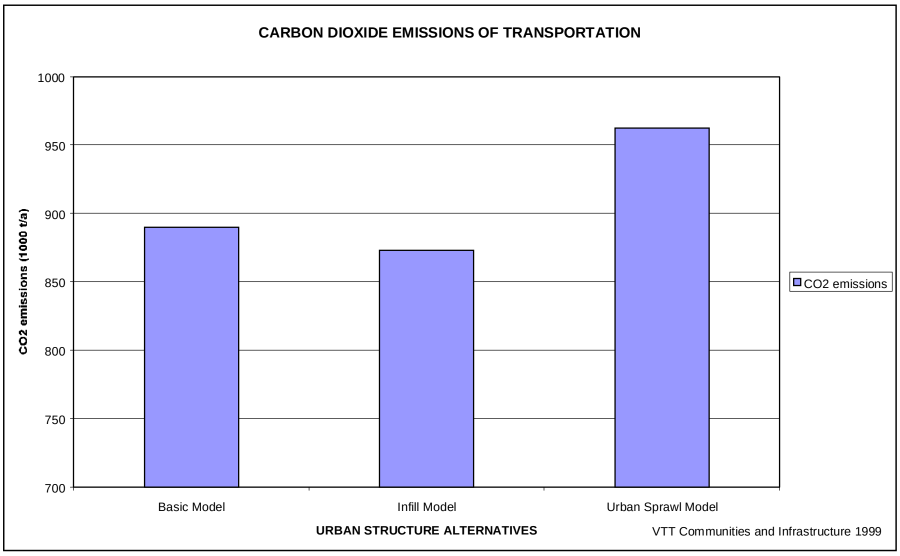

Figure 13: Carbon dioxide emissions of transportation in the Helsinki Metropolitan Area in the year 2020 in different land use models. Urban sprawl increases emissions 8 % in the whole urban structure and 37 % in the added urban structure. Infilling decreases emissions.

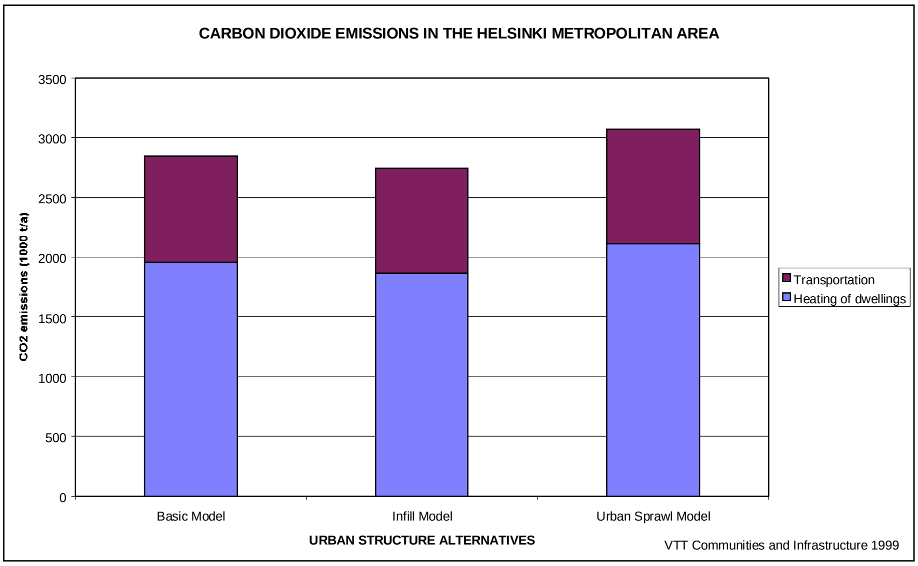

Figure 14: Carbon dioxide emissions in the Helsinki Metropolitan Area in the year 2020 in different land use models. Urban sprawl increases and infilling decreases emissions.

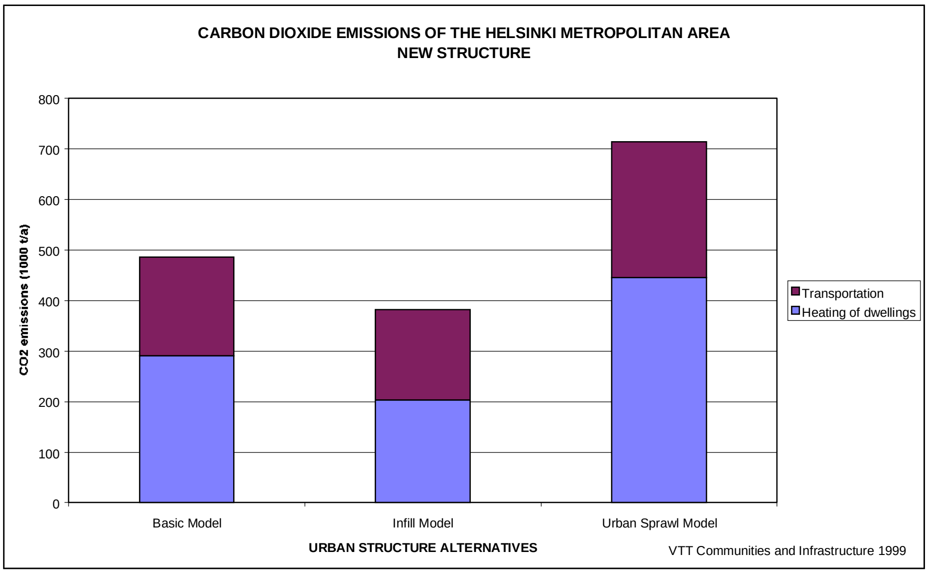

Figure 15: Carbon dioxide emissions of the new structure in the Helsinki Metropolitan Area in the year 2020 in different land use models. Urban sprawl increases emissions even 50 % and more infilling decreases emissions 20 %. Decisions on development of land use and transportation system are made today.

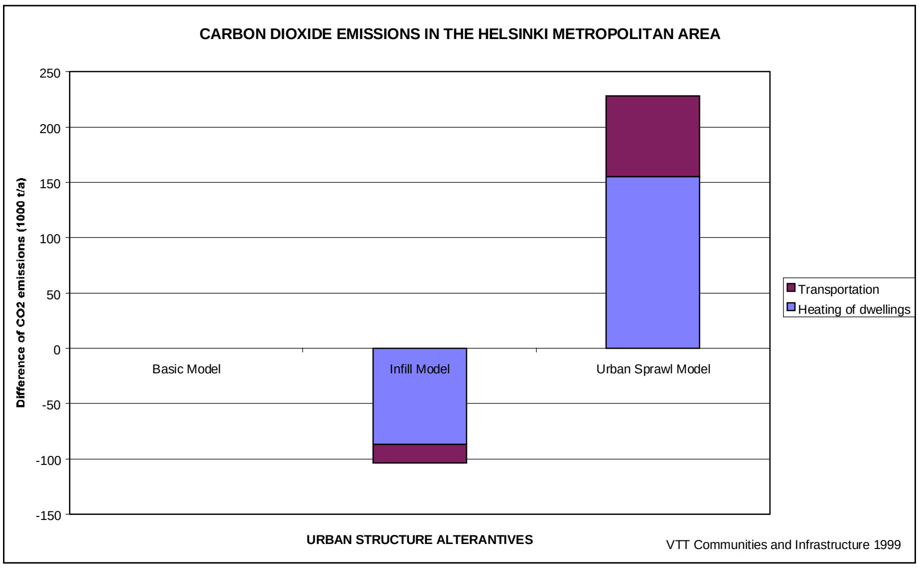

Figure 16: Differences of carbon dioxide emissions in different land use models in the Helsinki Metropolitan Area in the year 2020. The Urban Sprawl Model increases emissions 230 000 tons per year and the Infill Model decreases emissions 100 000 tons per year compared to the Basic Model.

The Urban Sprawl Model causes annually 230 000 tons more CO_2 emissions than the Basic Model. This amounts to 8 % more emissions considering the whole urban structure and even 50 % more emissions considering the added part of the structure.

The Infill Model causes annually 100 000 tons less CO_2 emissions than the Basic Model. This amounts to 4 % less emissions considering the whole urban structure and 20 % less emissions considering the added part of the structure.

The results of the study show that sprawl of the urban structure of the Helsinki Metropolitan Area should definitely be prevented. Infilling and densifying urban structure reduces greenhouse gas emissions substantially.

Especially in relative dense areas complementary building should be planned carefully to avoid conflicts with other goals. Possibilities to reduce CO_2 emissions by developing urban structure in the whole country can be remarkable. At the same time it is probably possible to save other emissions and costs, as well.

7 Policy package design and testing

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This paper gives an overview of the policy process in the Netherlands after the conclusion of the Kyoto protocol. It describes the consequent steps that eventually resulted in the Climate Policy Implementation plan as well as the contents of the plan itself. ECN has been involved in supporting the National Ministry for Housing, Spatial Planning and the Environment. From this point of view some insight is given in some scientific and methodological questions that came up during the period of preparing the implementation plan.

7.1 Dutch Policy Process on greenhouse gas emissions since Kyoto

7.1.1 Policy objective

In June 1999 the Dutch Government presented the Climate Policy Implementation Plan. This plan shows the policy instruments that have been chosen to reach the Dutch contribution to the Kyoto target. The policy process to come to this implementation plan started in the beginning of 1998, right after the settlement of the Kyoto protocol in December 1997. The division of the target of the EU (-8%) in June 1998 resulted in a reduction of 6% for the Netherlands compared to the emissions in 1990/1995. To determine the emissions in the budget period an existing scenario has been used (figure 1).

The scenario Global Competition (GC) is characterised by a high economic growth (3.3% per year), by relatively high energy prices (28 $/barrel in 2010) and rapid technological developments. In this scenario the greenhouse gas emissions based on existing policy rises to 256 Mton CO2-equivalents. The base year emission is 219 Mton. A 6% decrease means an allowed emission of 206 Mton. This leads to a gap of 50 Mton CO2-equivalents in 2010.

Part of this gap can be reached by means of the so called Kyoto-mechanisms. In May 1998 there were new elections for the government in the Netherlands. During the construction of the coalition preliminary agreements were made on the possible role of the Kyoto mechanisms. These agreements meant that the maximum share was set to 50% of the expected gap. Of the expected gap of 50 Mton, at least 25 Mton is to be reached by means of domestic measures.

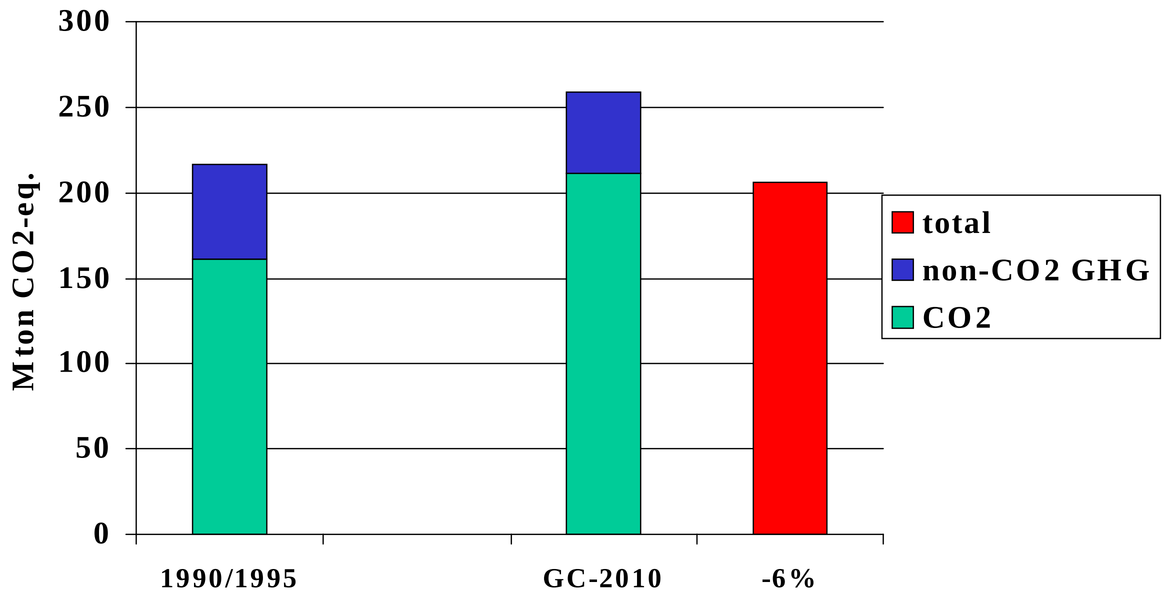

Figure 1: Base year emissions, expected greenhouse gas emissions and Kyoto target for the Netherlands.

7.1.2 Document of options

In March 1998 a working group of several ministries started to make preparations for the implementation plan by defining the main sectors and technologies where possible reductions of greenhouse gases could be reached. Two Dutch institutes (Netherlands Energy Research Foundation (ECN) and the National Institute on Public Health and the Environment (RIVM)) were asked to collect information on the selected sectors/technologies. This resulted in a total of over 60 options with a total reduction potential between 70-75 Mton. Each option has been described in terms of reduction potential, costs, necessary pace of implementation, possible policy instruments to reach the reduction and public acceptance. Based on the options several packages to reach the reduction target have been designed. The ranking of options in each package is based on criteria like costs, possibility for instrumentation, and additional; environmental benefits (like reduction of acidifying emissions). The description of the options together with the packages has been published by the institutes in a so called document of options (October 1998).

7.1.3 Implementation Plan

In December 1998 the Advisory Council for the Ministry advised on the use of the Document of Options and important directions for the Implementation Plan. The main elements of the advice stress the importance of not limiting to solutions for the short term but also to keep in mind that substantial reduction for the longer term is necessary. The council emphasises the need for technological and instrumental innovation.

After the publication of the implementation plan in June 1999 the institutes were asked to make a scientific evaluation of the Implementation Plan. The main objective of the evaluation was to determine whether the policy instruments that had been decided to, would be sufficient to reach the proposed reduction. This evaluation together with the advises of several councils were important inputs for the discussion on the implementation plan in parliament in the beginning of November 1999.

7.2 Options for reduction of greenhouse gas emissions

The document of options shows a domestic reduction potential of 73 Mton. This total potential is divided amongst six so called reduction fields according to figure 2.

The largest reduction field in terms of reduction potential is the field of the non CO2 greenhouse gases. The possible reductions are rather large, partly because till now no explicit policy instruments have been implemented to reduce these emissions. Another rather large reduction field are the sinks/CO2-storage. In this field sinks are nearly negligible, the main contribution comes from CO2 removal in industry or electricity sector, combined with storage in empty gas fields or aquifers.

Energy savings in total account for 30% of the reduction potential of which 9% relates to savings in transport. These savings can be reached by means of buying more efficient cars, by means of driving less or by means of driving more efficient. Energy savings in the remaining sectors relates to savings in households (new and existing dwellings), savings in offices, savings in industry or in horticulture.

Possible measures in the electricity production account for 14% of the reduction potential. This potential consists of measures like an earlier shut down of power stations, using natural gas in stead of coal in power stations and postponement of shutting down the nuclear power plant in the Netherlands.

The last reduction field is the field of renewable energy. This field describes the possible reduction potentials of solar energy (thermal and photo voltaic), wind energy, biomass and heat pumps. This reduction field accounts for 8% of the total reduction potential, which means an extra reduction of 5-6 Mton compared to the scenario used.

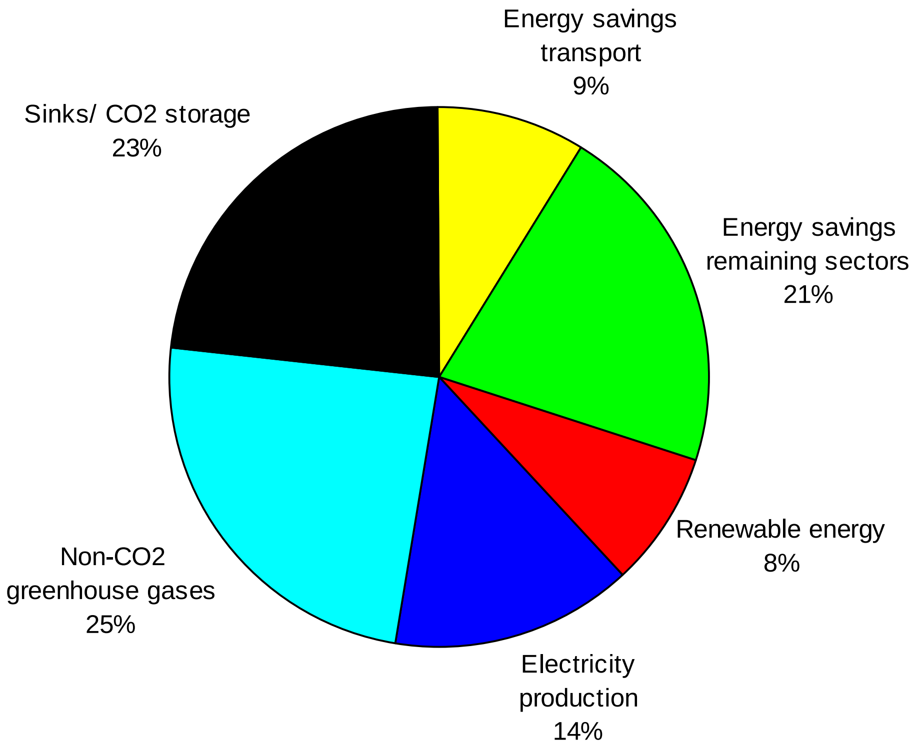

Figure 2: Reduction potential in the Netherlands per reduction field in 2010, total 73 Mton.

7.3 Cost calculation

There is not one way of calculating costs. The method to be used depends heavily on the objective of the cost calculation and the actors for whom the costs are calculated. In the process of the implementation plan three kinds of costs have been used:

- national costs
- end user costs
- government costs

In all the cost calculations the cost effectiveness is determined by the difference between the annual costs of investments and the revenues from saved energy, divided by the annual greenhouse gas reduction. The main differences relate to the parameters used in the cost calculation.

National costs

The national costs relate to the costs of a country as a whole. The aim is to determine the costs and benefits of measures, independent of the actor which is to actually take the measure. This means that fuel taxes etc. are not taken into account. Also a more or less national discount rate is used.

End user costs

The end user costs are used to describe how costs are regarded bv the one by whom the measure is actually to be taken. This means that sectoral energy prices are used (including energy tax) and that sector dependent interest rates are used.

Government costs

The government costs do not relate to the measures to be taken to actually reduce greenhouse gas emissions but to the expenditures of the government to stimulate end users to actually take the measures. This means the costs of subsidies or other financial/fiscal policy instruments.

For a proper way of cost calculation one should also take into account non-financial elements which are important for the decision whether or not the measure is taken. This relates for instance to aspects like comfort, extra time needed of environmental benefits. Because it appeared difficult to find more or less objective ways to translate these aspects into costs these aspects were not taken into account. The main reason for this was not a scientific but for reason of transparency.

Cost example

The different methods for cost calculation can lead to very different outcomes. This is illustrated by the following example.

A measure to save 500 m3 of natural gas requires an investment of 1000 Euro. To stimulate this measure the government gives a subsidy of 20% of the investment. The lifetime of the measure is 10 years. The saving leads to CO2-reeduction of 0,9 ton. The gas price according to the national cost calculation is 25 eurocent, the end user pays a price of 50 eurocent. The interest rate according to national costs is 5%, for the end user this is 15%.

This example leads to the following cost effectiveness:

	capital costs (Euro/year)	revenues (Euro/year)	cost effectiveness (Euro/ton)
national	130	125	5
end user	160	250	-100
government	26	--	30

From the national point of view the cost effectiveness is 5 Euro/ton. From the end user point of view the capital costs increase due to the higher interest rate, but because of the much higher value of natural gas saved the revenues increase much more. This leads to a cost effectiveness of -100 Euro/ton. The capital costs of the government subsidy are 26 Euro. The savings do not generate income for the government, so the cost effectiveness is 26/0,9 equals around 30 Euro per ton.

7.4 Cost results

For each of the options described the cost effectiveness has been calculated according to the methods described above. This lead to the cost curve as shown in figure 3.

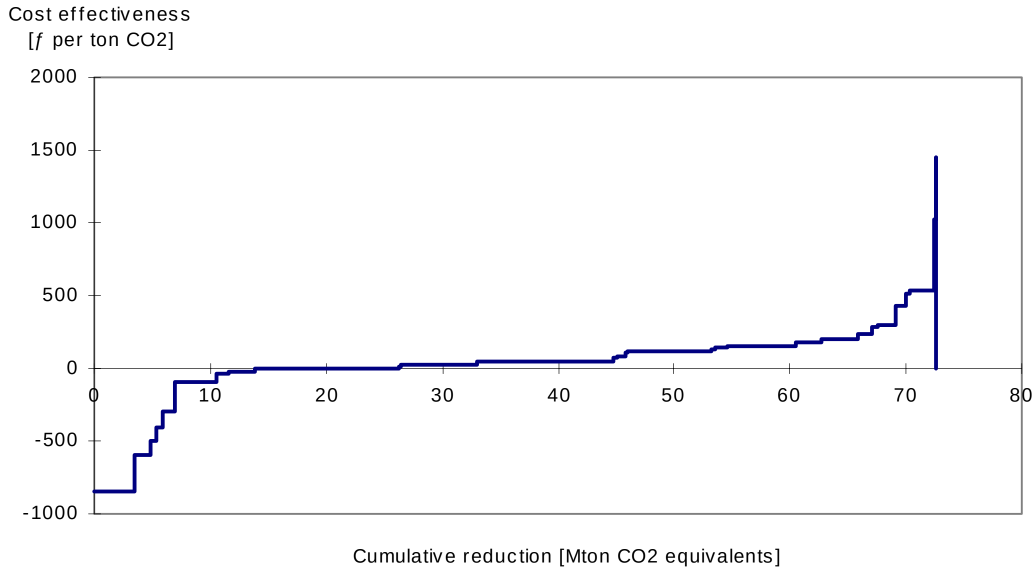

Figure 3: Cost curve according to end user costs.

The costs of the options vary between -800 and + 1400 *f*/ton (1 Euro equals 2.2 *f*). The figure shows that about 15 Mton reduction can be reached by options with negative costs, i.e. revenues. However this does not necessarily mean that those options are easy to implement. These options often have other characteristics why they are not implemented automatically, like it means loss of comfort or requires high investments. The figure also shows that the first 25 Mton of reduction can be reached by options with relatively low costs per ton CO2. Above 25 Mton of reduction the costs increase rather rapidly and at 50 Mton reduction the marginal costs are already around 100 *f*/ton.

Figure 3 shows the cost curve for all options together. However it is also interesting to analyse the curves per reduction field. This is shown in figure 4.

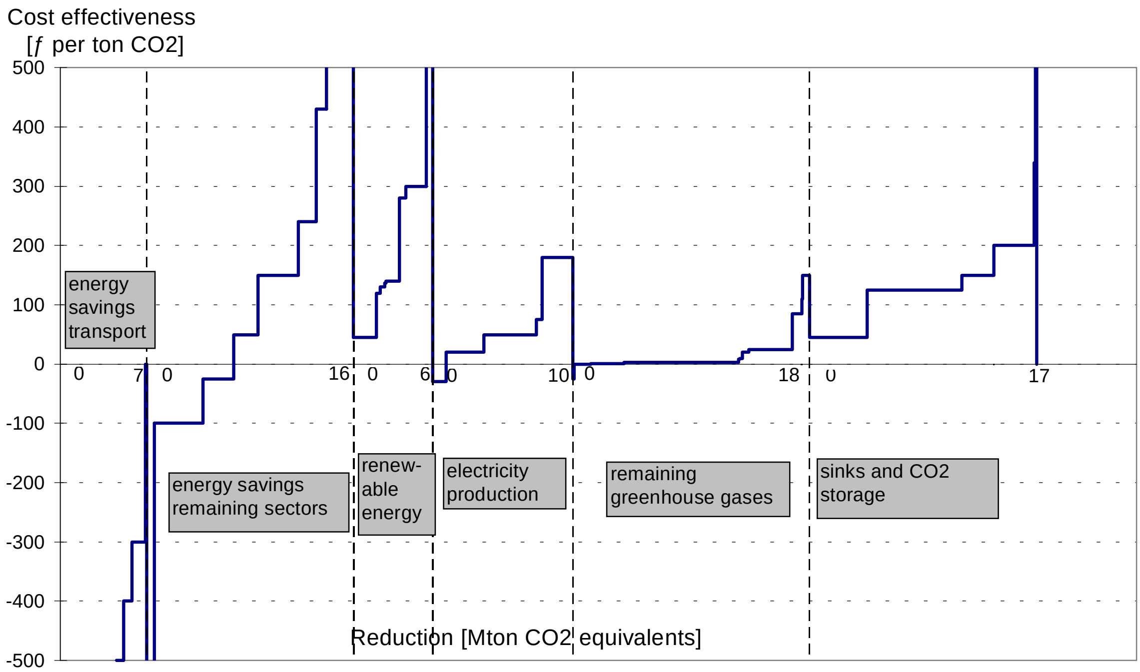

Figure 4: Cost curve per reduction field according to end user costs.

It turns out that the cost effectiveness per reduction field varies greatly. The options with the most favourable cost effectiveness can be found in the “energy savings transport” and “remaining sectors”. Negative costs indicate that the end user will benefit financially if he takes the measure. There could, however, be different reasons why these measures are not taken spontaneously (e.g. the measure leads to loss of comfort, it requires large investments, etc.). “Energy savings remaining sectors” shows the largest spread in cost effectiveness. Part of the potential is encountered again in all four cost categories. Other reduction fields with relatively favourable to average cost effectiveness are “non-CO2 greenhouse gases” and “central electricity production”. “Renewable energy” represents the least favourable cost effectiveness, 2/3 of the potential has a cost effectiveness greater than 50 ƒ/ton CO_2.

Package construction

To reach a certain amount of reduction different packages of options can be constructed. The options to be chosen depends primarily on the criterion used. The criterion most often used is the cost criterion. For policy makers however there are more criteria than costs. This will be shown later by discussing the policy package chosen. Figure 5 shows how packages are constructed when the costs are the only criterion used.

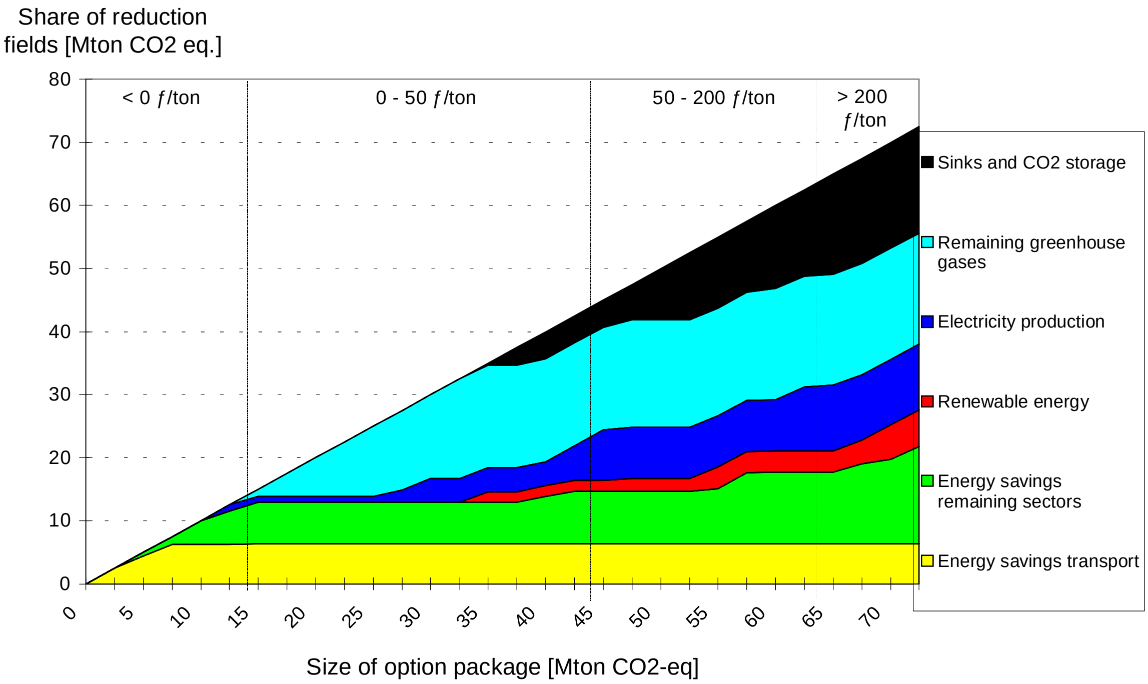

Figure 5: Cost optimal package according to end user costs.

With a small domestic package, options in "energy savings transport" and "energy savings remaining sectors" surface. Subsequently, options follow from the central electricity production (starting with extending the availability of the nuclear plant in Borssele) and non-CO2 greenhouse gases. Only with a package of approximately 30 Mton do options emerge from the "renewables" and "CO_2 sinks/storage".

As already mentioned before the cost effectiveness expresses only part of the benefits and disadvantages as experienced by the target group which will execute the measures. Aspects such as availability of policy instruments, the extent of the investments, additional tax burden or loss of comfort also play a role in the assessment of options. These aspects can not be captured in the cost effectiveness concept. For this reason an analysis has been carried out to investigate the effect of other aspects on the contents of an option package with domestic reductions of 15 tot 45 Mton. The aspects have been clustered into three criteria:

- ‘environment-wide’ (to what extent does an option have perspective for the longer term and does it contribute to the decrease of other environmental problems);
- ‘cost-wide’ (where the cost effectiveness according to the national cost approach is also calculated, as well as financial consequences for the target groups);
- availability of policy instruments (where mainly the nature of the policy instruments to be deployed and the distinctive features of the target group play a role).

Taking into account these aspects results in annual costs for a package of 50 Mton from 0,.5 billion Euro for a cost optimal package and to 2 billion Euro for an environment wide package.

7.5 Climate policy implementation plan

In June 1999 the government presented the implementation plan. The options chosen and the policy measures decided to were largely based on the document of options. However because the total potential is 70-75 Mton and the domestic target has been set at 25 Mton selections have been made. The implementation plan uses three packages. A base package to reach the projected target, a backup package in case the target is not met by the options from the base package and an innovation package to explore options for the longer term. Figure 6 shows for each reduction field which part of the potential has been chosen by the policy makers to formulate policy instruments.

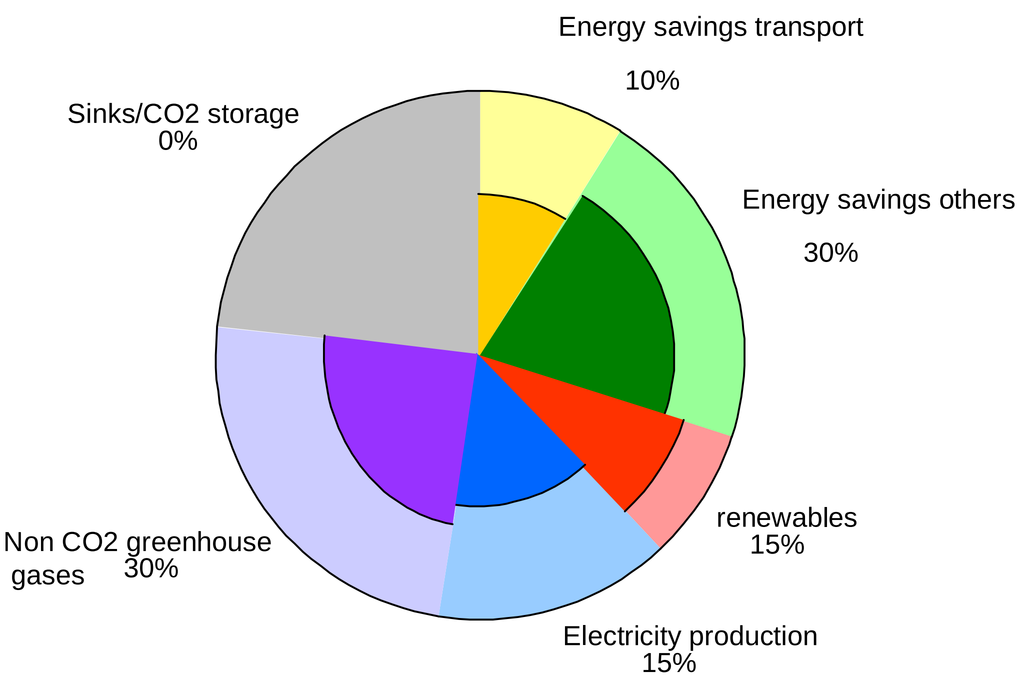

Figure 5: Cost optimal package according to end user costs.

The pie represents the reduction potential. The darker part of each piece represents the potential that has been chosen in the implementation plan. The figure shows that the burden has been divided over all the reduction fields, except for the field of sinks/CO_2 storage. CO_2 storage under ground is still relatively controversial in the Netherlands. The option has been chosen in the backup package. Remarkable is also the relatively high share of renewables , despite their relatively high costs. This is one of the illustrations that not only costs play an important role in designing packages, but also the contributions to solving other environmental problems and the image of certain options.

7.6 Scientific evaluation

After the publication of the implementation plan ECN, RIVM and CPB were asked to evaluate the policy package and determine the effectiveness. The most important conclusion from this evaluation was that 10 Mton of the projected 25 Mton of reduction is not sure yet. The most important reasons for this is that some agreements that are already mentioned in the plan have not been reached yet (agreement with coal fired power stations to reduce their emissions) or the effectiveness of some policy measures is not sure yet. The national as well as the end user costs of the total package are expected to be around 0.7 billion Euro per year in 2010. The costs for the government in terms of subsidies or fiscal facilities are around 0.5 billion Euro per year. The largest share of these costs is determined for renewables. The macro economic effects ar estimated at 0.2% loss of GDP in 2010 and hardly any effect on employment.

To my personal opinion the implementation plan is just a start. It may eventually help to reach Kyoto protocol but for the longer term more structural solutions need to be chosen. The plan shows a balanced burden sharing over all the sectors and is mostly on already existing initiatives. Therefor politically it has been accepted very positive but difficult choices have been postponed. Furthermore the large share of the Kyoto-mechanisms requires much attention for this subject, because these mechanisms still face large uncertainties regarding availability and price.

7.7 Research questions

During the process of the Climate Policy Implementation Plan several questions have been implicitly or explicitly dealt with. The most important ones from my point of view are:

1. Which approach do you use for the policy process, bottom up (measures to be taken) or topdown (policy instruments to be used)?
2. How to determine costs and which methodology is basis for choice?
3. How to deal with non financial aspects?

Ad 1 Bottom up versus top down

During the process we have had extensive discussions with our colleagues from CPB, because they claimed you should only use the top down approach. The main reason for this that you would otherwise end up in a large number of different policy instruments, losing the overview over the total field. To my opinion the approach of first determining where actual reductions can be reached (bottom up) and consequently determining which policy instruments are suited and how they can be combined (top down) proved to work very well. The clear separation between the options (top down) and the policy instruments also lead to higher quality of the discussions.

Ad 2 Which cost methodology

This paper shows that there is not one best way of calculating costs. It is important to keep in mind that the costs can be calculated form different points of view and it depends on the objective of the cost calculation which method is best suited.

Ad 3 Non financial aspect

The issue of non-financial aspects to be taken into account remains difficult and has not been solved in this project. Some aspects can be converted to costs (for instance time) and also for emissions methodologies have been developed, but till now they are difficult to implement. Translating the non financial aspects into costs proved to encourage discussion in stead of reducing it.

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VATT Seminar

Greenhouse gas policy questions and social-economic research implications for Finland in a national and international context

Location: World Trade Centre – Aleksanterinkatu 17
Monday 29 November, 1999

9.15	Arrival of guests, coffee	
	Morning Chair: ***Esko Niskanen*** VATT	
9.30	Opening and welcome	***Reino Hjerppe*** director VATT
9.45	Introduction to the seminar – setting the stage Speaker:	 ***Adriaan Perrels*** VATT
10.30	The views and wishes of the Ministry of the Environment Speaker:	 ***Magnus Cederlöf*** YM
	11.15 *Coffee break*	
11.30	The views, wishes and (planned) actions of the Ministry of Trade and Industry Speaker:	 ***Anja Silvennoinen*** KTM
	12.15 *Lunch*	
	Afternoon Chair: ***Adriaan Perrels*** VATT	
13.15	World Economic Implications of Kyoto Mechanisms Speaker	 ***Claudia Kemfert*** IER (Germany):
14.00	The role of carbon sinks in achieving net reduction goals for Finland – an economic perspective Speaker:	 ***Johanna Pohjola*** VATT
	14.45 *Coffee and Tea*	
15.00	Bilateral trading of greenhouse gas emissions – testing regimes in a GE framework Speaker:	 ***Matti Liski*** HKKK
15.45	Energy and emission impacts of the organisation of space and infrastructure – investigations for the Helsinki region Speaker:	 ***Irmeli Harmaajärvi*** VTT Communities & Infrastructure
16.30-17.00	Concluding discussion day 1	

Tuesday 30 November, 1999

9.00	Arrival of guests, coffee	
	Chair: ***Adriaan Perrels*** VATT	
9.15	Technology transfer across borders, the tension between macro-economic and industrial approaches (a double presentation) Speaker(s):	***Juha Honkatukia*** ETLA ***Torsti Loikkanen*** VTT
	10.35 Coffee break	
10.50	Towards a sustainable Finnish economy, results from mixed material flows and economic analysis	***Ilmo Mäenpää*** Thule institute
11.30	Policy package design and testing, experiences and research needs Speaker:	***Michiel Beeldman*** ECN (Netherlands)
12.20	Concluding discussion	
	13.00 Lunch	

VATT Seminar

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29-30 November, 1999, Helsinki

Location: World Trade Center, Aleksanterinkatu 17

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