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SELECTING INSTRUMENTS FOR
A GREENHOUSE GAS
REDUCTION POLICY
IN FINLAND

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Abstract: This report discusses the pro's and con's of different types of policy instruments for climate policy in Finland in relation to a systematic selection and evaluation of these instruments given the dual objectives of effective emission reduction and lowest possible economic cost. It is stressed that embedding of the evaluation process and the consideration of instrument packages next to single instruments are important ingredients. It can be expected that eventually not one but a few different policy packages achieve sufficiently high overall ratings. This will require a pondering of trade-offs in the framework of a tractable evaluation system, requiring the application of multi-criteria analysis (MCA).

Key words: policy instruments, climate policy, policy evaluation

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Tiivistelmä: Raportissa arvioidaan erityyppisten ohjauskeinojen hyötyjä ja haittoja ilmastopolitiikan välineenä Suomessa. Ohjauskeinojen valinnassa otetaan tavoitteina huomioon sekä tehokas päästöjen rajoittaminen että kustannusten minimointi. Arviointiprosessi ja ohjauskeinopakettien arviointi liitetään päätöksentekoprosessiin. On luultavaa, että yhden ohjauskeinojen paketin sijasta useampi paketti täyttää asetettavat kriteerit. Eri pakettien välisten trade-offien vertailu edellyttää läpinäkyvää arviointisysteemiä ja myös monikriteerianalyysin (MCA) käyttöä.

Asiasanat: ohjauskeinot, ilmastopolitiikka, ilmastopolitiikan arviointi

Foreword

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

- the different ways the emission reduction costs can impact on the economy and how this can be measured;
- the handling of scenario's and scanning of scenario's in the recent past;
- construction of a linkage between a macro-economic model (KESSU) and a technical-economic optimisation model for the energy sector (EFOM).
- scanning of climate policy instruments and how to evaluate them

This report concerns the last item. A separate report has been produced for the first item¹. Next a final report² covering the entire study has been made. Furthermore, working notes have been made regarding the second and third item.

The study has been guided by a expert group and a steering group. The expert group consisted of the researchers from VATT and VTT Energy and representatives from Ministry of Trade and Industry (Pekka Tervo), Ministry of Environment (Magnus Cederlöf) and the Ministry of Finance (Heikki Sourama). The Steering group was composed of Under-secretary of State Mr. Johnny Åkerholm (Ministry of Finance), Director-general Mr. Taisto Turunen (Ministry of Trade and Industry), Director-general Mr. Pekka Jalkanen (Ministry of Environment), and Director-general Mr. Reino Hjerpe (Government Institute for Economic Research – VATT, chairman of the steering group).

Adriaan Perrels

Project leader

¹ . Kemppi, H., J. Pohjola, *Hiilidioksidipäästöjen rajoittamisen kustannusten arvioinnissa käytetyt käsitteet ja mittarit*, VATT Keskustelualue, 2000.

² . Kemppi, H., A. Perrels, J. Pohjola, *Kasvihuonekaasu päästöjen alentamisen taloudelliset vaikutukset Suomessa - vaiheen 1. loppuraportti*, VATT Keskustelualue, 2000.

Summary

This report discusses policy package construction and testing from a conceptual point of view. It is applied to the selection and optimisation of climate policy in Finland. In next stages of the project actual application will take place in connection with the use of energy systems (EFOM) and macro economic (KESSU) models.

The report starts with stressing the importance of adequate embedding of the scientific evaluation of climate policy design in a comprehensive decision making framework in which the role and status of each stakeholder is clear, and the timing and authorisation of subsequent steps is logically organised. Inadequately embedded evaluation exercises will be less effective or even lead to confusion in the decision making process. In this context it is drawback that the decision making process started relatively late.

It has to be realised that instruments and measures are not the same thing, although both terms are often used as if they were interchangeable. An *instrument or policy instrument* refers to the *incentive* created by a public authority *aiming to incite* parties in the economy (companies, private consumers, local governmental organisations) to take measures leading to reduced emission levels of greenhouse gases. Macro-economic or generally spoken *top-down studies* tend to focus on the dosage of instruments, as if there is a straight connection between instruments and achieved emission reduction. Which measures are actually *incited* and to what extent is mostly only crudely represented, hence all kinds of filtering effects from instrument to measure, and from measure to emission impact are largely overlooked. Engineering or generally bottom-up studies tend to focus on identifying actual changes that can be made in equipment and buildings as well as in use behaviour, while the question how to incite these changes is not much touched upon. Somehow these approaches need to be integrated to get better assessments. In the short run this can be only done through iterative use of models and a systematic inventory of the trade-offs between the best rated policy options. In the long run truly integrated model approaches may become available.

Permit trade and taxation, provided the initial auction or tax revenue is somehow recycled to households and companies, incur – in principle - the lowest overall costs. These instruments make the best use of the input and output substitution effects, while the net effect of tax interaction (aggravating negative effects of taxation of labour and capital) and revenue recycling is small. *Performance standards* don't have the tax interaction neither the revenue recycling effect, but – in principle - don't make optimal use of the substitution and abatement mechanisms. However, market imperfections (e.g. as for energy efficiency in

buildings) can cause that the advantages of taxation over performance standards diminish, since performance standards improve the transparency of markets.

Physical quota/limits are generally not a preferable instrument as this constitutes both a shadow tax due to rationing and an abolishment of flexibility in substitution mechanisms. A Voluntary Agreement can consist of a combination of the above instruments and consequently all effects can be applicable.

Recently so-called market transformation policies are advocated in various countries. It means that the transparency of the market is improved and information and transaction cost are lowered thereby enhancing technology uptake. In practice this means a mixture of instruments put together in the framework of a voluntary (or rather negotiated) agreement. Ingredients can be: emission tax, first mover subsidy, information dissemination and accessibility, obligatory and/or subsidised energy scan, benchmarks, targeted R&D programmes.

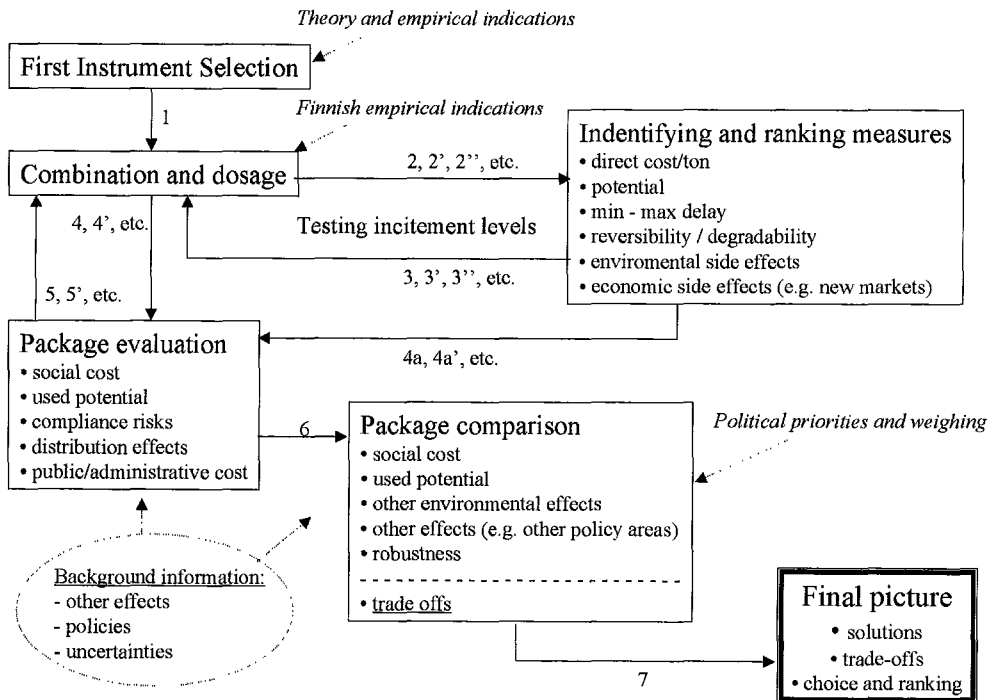


Figure S1. Overview of the policy package evaluation.

The envisaged instrument selection does not only focus on individual measures but also policy packages. First, there is a pre-selection round based on a limited

set of criteria, notably reduction cost per ton of CO₂ equivalent. The process is summarised in figure S1. Steps 1, 2, 3 and 7 are based on multi-criteria analysis (mca), while steps 4, 5, 6 are based on simulations with the linked EFOM and KESSU models.

Next to simulation of the ministerial programmes, simulations will be carried out that aim for minimising direct cost (EFOM optimum) and minimising social-economic cost (joint optimum EFOM and KESSU) respectively.

From a short term perspective, economically the most interesting measures to be incited are:

- Fuel switching in electricity and district heat;
- Abatement of non-CO₂ gases;
- Enhancement of (clean) power imports;
- Easy parts of energy efficiency in energy conversion, industry and new building construction.

As the climate change problem is a *structural* matter, it makes sense not to optimise solely for 2010, but to take care that the longer term trajectory for further reductions can be unfolded in a cost-efficient way. In that case already in this decade also measures concerning:

- Rigorous energy efficiency measures in industry, buildings (new and existing), transport&logistics and spatial planning;
- Renewables (wind and sun in addition to already attractive biomass);
- Tradable permits (all three flexible mechanisms), experiments and promotion of its international implementation.

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1 Introduction

As part of the study concerning the assessment of national economic effects of a climate policy for Finland special attention is paid to construction of policy packages and ways to arrive at a collection and dosage of measures that is effective, efficient, compatible with the rules of the Climate Convention, and as much as possible equitable as well.

This report discusses first policy package construction and testing from a conceptual point of view. Subsequently, it is applied to this study and in particular to on the one hand scenario choices that precede the actual package composition and on the other hand to the clarification of limitations imposed by the models. Chapter 2 introduces the wider context of policy package design and the importance of sufficient involvement of stakeholders. It stresses the embedded character of the process. Chapter 3 discusses policy instruments, their pro's and con's, their connectivity with measures and a set of preliminary conclusions on what seems generally preferable and less preferable. Chapter 4 introduces the several types of measures and their initial appeal for a Finnish policy mix based on a set of selection criteria. It concludes with a description of a quantitative approach that can assist the decision making. This system involves the use of simulation results from the KESSU-EFOM macro model - energy model linked system. Chapter 5 wraps up the findings of this report and makes recommendations for the next steps in the Kyoto policy design process.

2 Embedding the selection system in a decision making environment

2.1 Conceptual principles

Prior to the instrument selection as such one should agree on the Baseline Scenario. The Baseline Scenario describes to what extent the world and Finland will develop regardless of Finnish policies. For some issues, one may be interested to specify alternative situations, implying Variants of the Baseline Scenario. In case only one scenario is applied for the baseline, one has to choose for the most likely developments in economy, technology and demography. Influences of a some key variables can be checked in a sensitivity analysis. The discussion about the establishment and interpretation of Baseline scenarios is dealt with in the 'Skenaarioraportti' of this project³. Subsequently, various policy philosophies can be specified that generally characterise in what direction one intends to steer and what side conditions one wants to be specified. After that the selection of instruments can start.

The selection and screening of instruments proceeds through various phases.

1. First, for separate main policy areas instruments and measures are devised, albeit not down to the last detail.
2. Second, the effectiveness, feasibility, side-effects, etc. within the own policy area are checked. This results in a ranking of instruments per sector/policy area and concomitant estimated cumulative amount of CO₂ equivalents saved.
3. Subsequently, the rankings of the various policy areas/ sectors are put together. It is however risky to cut down the number of measures in one round using only few criteria.

The problem is that there may be several interaction effects between measures, and consequently the effectiveness of measures may be lower or higher than originally estimated. Typical kinds of interaction effects are:

- reinforcement from supportive actions;
- reduction of estimations due to mutually exclusive options;
- double counting;
- price effects due to markets size changes triggered by extension of measures;

³ . See H. Kempfi, *Suomen Talouden ja Kasvihuonekaasupäästöjen Skenaariot 1990-luvulla*, VATT, 2000

- timing effects, e.g. measure C gets only sensible after completion of measure B;
- uniform sensitivity estimates (e.g. outside shocks, interest rates, ..)

The above discussion mentions already the inclusion of the stakeholders in the selection process. This is important since a purely analytical selection only involving researchers and or a small selection of policy makers bears significant risks with respect to lacking general support in society and after all constructive behaviour of companies and consumers is vital for achievement of the policy goals.

Five major steps in policy design and implementation can be distinguished (from Perrels, 1999):

1. Problem analysis, formulation of objectives and restrictions;
2. Generating and defining (baseline)environments, instruments and packages;
3. Estimation of impacts of single instruments and packages in given environments;
4. Evaluation of the alternative packages;
5. Final decision making, implementation and monitoring.

In the introduction this whole process was briefly hinted at, but subsequently, the discussion focused on point 2 and 3. It is however important both for the consistency of the resulting package and the societal support to take care well of the preceding steps. The more monitoring information and ex-post evaluation is available the easier it will be to go through steps 1 and 2. The process is summarised below in figure 1.

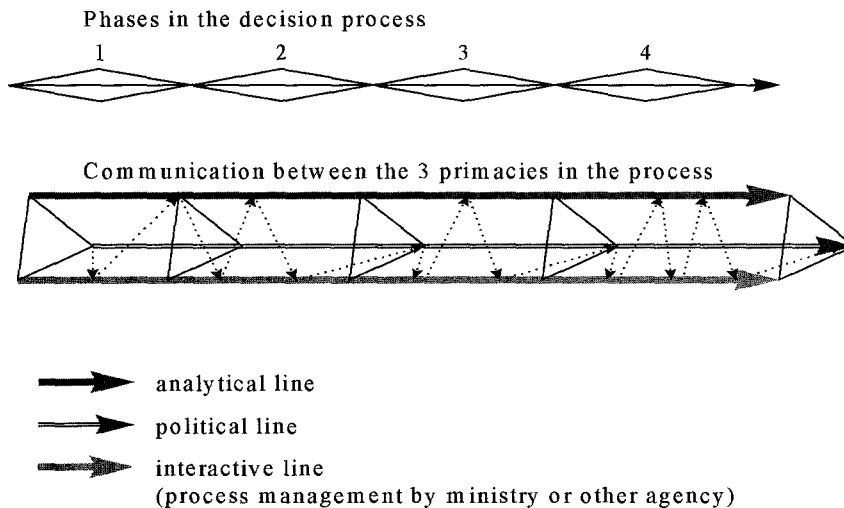


Figure 1. Summarising the steps and relative primacies in the instrument selection process.

The upper segment of figure represents the recurrent diverging and converging information processing in the subsequent stages of the evaluation. Diverging refers here to the initial tasks in every step in which one is looking for various alternatives. Subsequently, in the second part of every stage one is concluding or converging towards a solution. This recurrent information handling needs proper information management, notably in terms of pre-specified quality criteria in order to be able to switch timely from divergence to convergence and to come to a conclusion of a segment. Next it requires proper management of the different kind of actors in the evaluation process. This is pictured in the lower part of figure 1.

In every stage of the evaluation process there is a typical consultation cycle, which may differ somewhat from phase to phase. The political line represents the legitimation of the process. To start the selection process as well as during progress of the selection one needs approval before one can proceed sensibly. It is however important that all stakeholders agree that these approved steps in the process have a high degree of irreversibility, otherwise the reliability of the process is undermined. In the case of greenhouse gas policies there seems to be reasonable consensus about the significance of the problem, but however less on the ways to combat the problem and what might be allowed and/or fair mechanisms to use. Furthermore, also scientifically the uncertainties on best strategies are still large. This looks like a process where initially there should be sufficient stress on agreeing on scenarios and acceptable measures. When that

policy framework and manoeuvring space is defined the stress can shift (more) towards scientific analysis. Subsequently several rounds of consultation on the results of studies will be necessary, implying an alternation between scientific and policy analysis.

2.2 Real world applications

Large infrastructure planning and town planning has already a longer history of embedded decision making (see for example: Mannheim et al 1975; Nijkamp, Rietveld, Voogd 1990), however energy and environmental planning has much less so. This can be partly explained out of the different histories. Energy planning has been, and still is, to a large extent a company task, which automatically implies less public involvement, in particular during early strategic stages⁴. However, the experiments with Voluntary Agreements in various countries (see e.g. Korevaar et al. 1997, Varone and Aebisher 1999, Krause et al. 1999) created consultative frameworks. Also where environmental and local planning meet the number of applications increases in various European countries (e.g. the EU ULYSSES project, EC 1998b). Last but not least the planning and programming of R&D can only be sensibly done when the various stakeholders (state, research and knowledge users such as industry) are involved. A recent overview study on Energy R&D programming practices shows that in this dimension the consultative structure is already reasonably well developed in Finland (the EU SENSER report, 1998). Some other climate policy related publications of the EU also stress the importance of interactive stakeholder oriented policy design. However the applications discussed here move in the direction of joint planning, which means that the scenarios and policy options are selected and fine tuned by all parties involved. The project responsibility for decision making remains however with the public authority in charge and eventually with the appropriate elected body (parliament, municipal council, etc.). A recent example of a light form of joint planning across stakeholders is the Dutch Climate Policy Implementation Plan. The subsequent steps to design the Policy Implementation Plan are described below. Between brackets the step numbers as defined in 2.1 are mentioned.

⁴ . Given the increasingly important ability to be adequately and timely responsive towards customer needs and judgements, this relative closedness of early stages might change, viz. the studies about consumer oriented constructive technology assessment (CCTA).

Timing & Steps

Parties involved

A. October 1998,
document of options part 1

environmental and economic research
(RIVM/ECN/CPB), VROM⁵

(coincides with step 2 & 3 of five steps
on page 9)

document of options part 2

reactions from stakeholders
(sectoral associations, NGOs, Consumer
association, other research institutes)

B. December 1998,
advice advisory council

various ministries, research
(fine tuning of step 2 & 3)

C. June 1999,
Climate policy implementation plan
(‘Uitvoeringsnota Klimaatbeleid’)

VROM
(start of step 4)

D. September 1999,
scientific evaluation

CPB and ECN/RIVM
(step 4)

E. additional notes

VROM
(preparing step 5)

F. November 1999,
discussion in parliament

VROM, other ministries
(step 5)

Please note that this is the National Policy Plan, i.e. the overall framework. The (re-) negotiations with several sectors still have to be done, but these sectors were all consulted during this first phase. Preferably, commitments are not made before the overall picture is clear and it is proven that the policy line seems to have wide - though perhaps not unanimous – support.

⁵ . RIVM is the state institute for public health and the environment, ECN is Dutch national energy research institute, CPB is the governmental economic forecasting institute, VROM is the of Ministry of housing(V), spatial planning(RO) and environment(M).

The Finnish preparations for a policy programme started relatively late. The first step is the coalition (Lipponen II) programme declaration in which a number of items and objectives are mentioned (May 1998). The cabinet installed a ministerial working group in April 1999, while in due course several studies (such as the present one) were started. The further time table looks as follows:

- Sector programmes ready in June 2000 (plans by KTM, YM, LVM and MMM, supported by research institutes and stakeholders representatives (industry and commerce, municipalities)
- Total programme ready by the end of 2000 (input from this study and other research projects)
- Discussion in cabinet and preparation for submission to parliament in first quarter of 2001 (with input from KTM, YM, VM, LVM and support from research institutes where necessary)
- Submission of plan to parliament and subsequent discussions in mid 2001

Another main process finding is that it is quite difficult to link the distinguished actual measures (physical and/or behavioural) with instruments (being economic or institutional). That is also identified as a main issue in this study. For the second phase indeed it will require that macro and micro, and technical and social studies are to be connected, preferably beyond the point of results exchange.

2.3 The envisaged structure

The evaluation process for the Kyoto policy design runs through seven main steps, excluding actual implementation and monitoring. Some steps are a detailing of the more generic list mentioned in the previous section. The sequence is pictured in figure 2 below. The steps are:

1. First instrument selection
2. Combination and dosage of instruments
3. Identification of measures
4. Reassessment of initial instrument package (testing incitement levels towards measures)
5. Package evaluation (based on economic/engineering models)
6. Package comparison (applying MCA on economic outcomes + other criteria and risks)
7. Formulating a final (most preferred) package

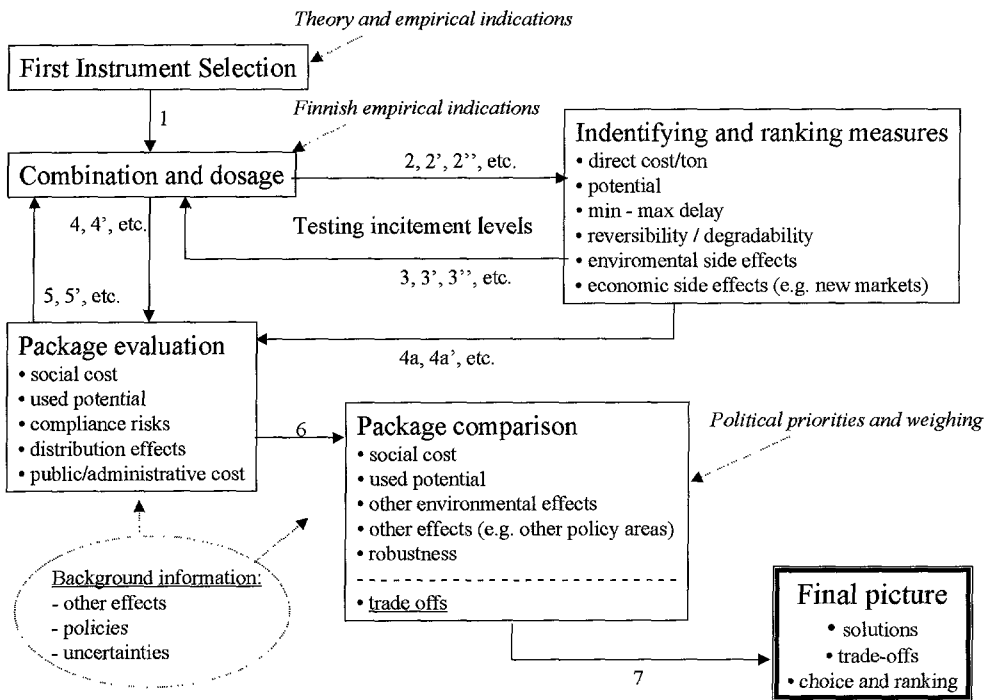


Figure 2. Overview of evaluation sequence.

The process can start when there is sufficient agreement on the fact that action should be taken and that a public policy should be set up. There are general guidelines, such as achieving the target at minimum societal cost (e.g. impact on GNP, employment, inflation and public finance) and avoidance of too large (re)distribution effects. The initial selection of instruments can be only based on prior knowledge (literature). The combination and dosage of instruments cannot be done at once since one needs to know what measures need to be addressed and in what intensity. Therefore a iterative process unfolds between the two issues. Once further simple testing cannot bring any improvement, the packages can be tested in the model system (EFOM-KESSU and CGE). This can take a few iterations as well (steps 4 and 5). Several optimised packages, each representing a distinct policy approach, can finally be tested and compared in wider framework, which also allows for trade-offs between various effects (step 6). This final evaluation may lead still to small adaptations in the plans. Finally, one of these packages will be selected as the preferable one and can be subsequently translated into actions and commitments (step 7). Please note that the implementation requires a new cycle. Especially the establishment of adequate regular and comprehensive monitoring will be an important ingredient for national and international climate change plans in the next decade and beyond.

3 Identification and selection of instruments and measures

3.1 Points of departure for instrument selection

Four categories of instrument types can be distinguished⁶, being:

1. *Regulating instruments* that due to direct or indirect intervention influence the volume of the energy or emissions used; a subdivision can be made between:

a. rationing and prescription (e.g. emission quota, mandatory technologies and procedures)

b. performance standards and benchmarks (e.g. total material requirement TMR targets)

2. Instruments that imply *deregulation*, either through the establishment of (quasi) markets or by delegating a large degree of freedom to companies or institutions within the framework of a negotiated package deal; examples are:

c. permit trading (establishment of markets), green certificates;

d. Voluntary agreements (maximise degrees of freedom through delegation). A voluntary agreement (VA) can be regarded as a box that can be filled in various ways.

3. *Fiscal and financial instruments*, such as taxes, levies for self financing systems, subsidies and grants, which either increase the price of polluting to the polluter or decrease the price of being cleaner, and thereby incite (more) action to invest in energy efficiency, abatement, fuel switching or renewables.

4. *Supportive actions*, that - each in different ways - aim at the improvement of knowledge levels and market transparency, either by adding knowledge (R&D) or by improving the accessibility (dissemination, training, etc.). Such actions lower the costs, especially the transaction cost, for environmentally benign technical and organisational innovations. Last but certainly not least a systematic evaluation and monitoring of policy implementation belongs to this category. Supportive actions (category 4) can virtually always be combined with other types of instruments.

⁶. See also Kemppi, H., J. Pohjola, *Hiilidioksidipäästöjen rajoittamisen kustannusten arvioinnissa käytetyt käsitteet ja mittarit*, VATT keskustelulaite, 2000

Instruments from the different categories can be combined to various extents. This chapter discusses whether that combination makes sense and how to judge that. There are general guidelines and some fairly robust initial assumptions, but actual cost levels, market shapes, institutional and behavioural factors may cause that the best mixes are country specific. In § 3.3 and § 3.4 we will come back to this in relation to policy package construction. By means of economic analysis the costs of alternative instruments can be shown and thereby trade-offs between different effects and sensitivity to changes in key scenario variables can be demonstrated. However, the overall suitability of instruments in the existing policy framework, the setting of different (i.e. economic, environmental and social) priorities and the judgement of the trade-offs between these priorities is eventually a political choice.

In this chapter first the selection of individual instruments will be discussed. Subsequently, the difficulties to connect instruments to measures is dealt with. Next the interaction between instruments when forming packages will be discussed. This material will be used in the next chapter to demonstrate a pilot evaluation model.

In the context of this study prior work of inter alia the Finnish National Advisory Council (Valtioneuvoston kanslia, 1997), VTT (Lehtilä and Tuhkanen, 1999b) and SYKE (Hildén et al. 1999) should be mentioned. Notably the last mentioned publication aims at an ordering of instruments. It makes an inventory of the currently used instruments and provides suggestions for new or renewed ones and to some extent it tries to connect instruments to the measures mentioned in Lehtilä and Tuhkanen (1999a and 1999b). Additionally, the report makes a SWOT⁷ analysis of the different instruments. A systematic cross-instrument synergy check is not made. Even more problematic for our analysis in this study is the absence of comprehensive tools that can connect instruments to (physical) measures and say something about the incitement capabilities of an instrument. Macro-economic models can judge that capability only at quite generic level and should be used in fact after prior more detailed assessment of the capabilities of an instrument. To date, such combination tools exist neither in Finland nor elsewhere. Jacobsen (1998) discusses a so-called hybrid approach, in which macro-economic and micro-simulation models are linked. However, not all energy use is covered and neither is the model designed to tackle the instrument-measure identification problem pointed at here.

In this report we make a crude first attempt to construct such an instrument, which can be fine tuned in Phase 2. In practice we will focus first on taxes, emission rights, some larger subsidy schemes. Later on – in phase 2 - the synergy and catalytic effects of regulation and supportive measures can be dealt with more extensively.

⁷ . SWOT = Strengths, Weaknesses, Opportunities, Threats

3.2 The top-down – bottom-up dilemma

In putting up policy packages one can choose a top down approach or a bottom-up approach. In the top-down approach the design starts with collecting the most promising instruments. Subsequently, by means of macro-economic modelling, market potential analysis and energy systems studies the effectiveness is tested in the framework of a macro economic scenario. The uncertainties are about whether the right effects are incited in the right time.

In the bottom-up approach effective measures are distinguished by means of engineering-economic studies, that allow for a lot of detail. Given that well defined measures are taken for a certain percentage, emission reductions are certain. However, the needed instruments to bring about the measures, have to be assumed. So, the uncertainties are whether the defined actions can indeed be incited by the instruments assumed. The dilemma of both approaches is summarised in figure 3 below. The top down approach distinguishes and analyses the instrument alternatives well but has to make quite crude distinctions between the possible measures and hence creates an uncertainty. The bottom up approach is detailed about the distinctions and capabilities of measures, but is necessarily simplistic about the instruments that should steer the measures. Though the different available toolboxes allow us to do detailed analyses on both instruments and measures, there are no methodologies yet that can connect them and allow for a *simultaneous* analysis. The objectives of the present study imply that the top-down approach will be prevalent. In fact, after having chosen the instruments and transformed them into EFOM –input, EFOM connects instruments to measures (investment and fuel switching). The instrument-measure connectivity will be further discussed in 3.4. The way the two approaches represent emission reduction costs is discussed in the background report on cost interpretations of emission reduction⁸.

⁸ . H. Kemppi, J. Pohjola, 'Hiilidioksidipäästöjen rajoittamisen kustannusten arvioinnissa käytetyt käsitteet ja mittarit', VATT, 2000.

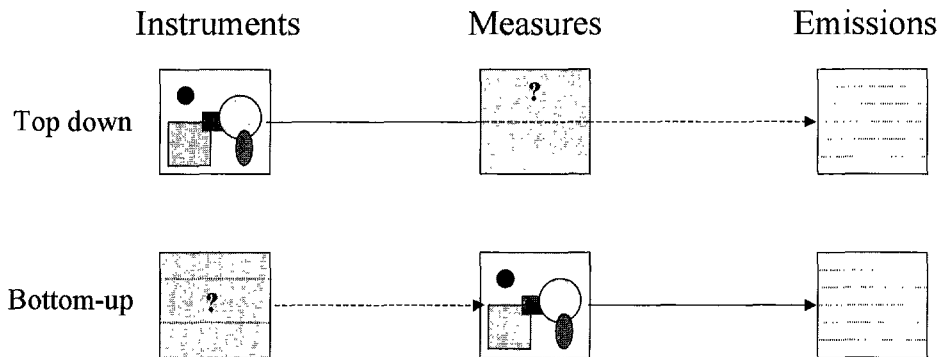


Figure 3. Summarising the course of logic and consequent uncertainties in 2 policy design approaches.

3.3 Initial ranking of instruments

In a top-down approach the following impacts of instruments and incited measures on economic performance and emission levels can be distinguished:

1. *Input substitution effect*, in practice it means either switching to a less polluting fuel (substitution within production factor energy) or improving the energy efficiency (substitution from energy to capital, i.e. more equipment or more intelligent equipment);
2. *Output substitution effect*, which means making and selling more 'clean' and less 'dirty' goods, for the energy conversion sector this coincides with input substitution;
3. *Abatement effect*, which represents the actual reduction of emissions at a given level of production and input needs, either by energy related substitution or by specific abatement technology;
4. *Induced higher order effects*, implying that the substitution and abatement effects are causing adaptations throughout the economy, either back in the supply chain (backward linkages) or forward through sales markets (forward linkages);
5. *Tax interaction effect*, which is the aggravated impact of a levy or regulation on overall cost levels in an economy due to existence of other taxes and regulations;
6. *Revenue recycling effect*, which is the overall cost reducing impact of compensatory measures such as lower income taxes or relaxation of

regulations (this is for example relevant if emission tax is compensated by reduction of other taxes);

7. *Rebound effect* (the phenomenon of increased energy and material use – and therefore probably increased emissions – due to extra purchasing power stemming from energy saving or compensatory tax measures).

The effects 1-3 constitute a cost to the sectors where these effects occur, and in the top down approach they are supposed to be the minimum cost alternative. Depending on the degree of competitiveness of the markets on which the sectors operate, costs will be carried over to other sectors, e.g. to suppliers of fossil fuels due to reduced demand, to final consumers due to increased product costs or to employees due through a contraction in sectoral employment. A macro-economic model is required to assess this kind of induced effects (4).

The tax interaction effect (5) reinforces some of the price effects just mentioned. If the direct cost burdens of environmental tax policy are compensated, for example by lowering social security cost to employers and the income tax of households the so-called revenue recycling effect occurs, which compensates a part of the negative effects albeit at the macro-level and not necessarily within each product or factor market. It means that the repair of the purchasing power of households allows them to move back to the original welfare level. However, due to the new prices and probably also new products the purchased product mix is somewhat different than before⁹. If the labour market would be flexible regarding choice in contractual working hours, than that mix would probably change too. This means that comparison of pre- and post-instrument welfare changes are not entirely accurate¹⁰. This applies especially to the long run.

The repair of purchasing power causes also a rebound effect (7). The incremental (non-energy) goods bought require energy for their production, this should in fact be deducted from the original reduction energy consumption achieved by the emission tax. In a comprehensive economic model this impact is taken care of, but when assessing the instrumental effectiveness of carbon taxation (notably for households) the rebound effect of indirect energy use should be taken into account.

Thanks to theoretical studies and model investigations there can be made a preliminary ranking of instruments in terms of their economic efficiency for given set of environmental targets. Provided a set of basic assumptions is

⁹ . An empirical indication of the existence of the problem is the asymmetric behaviour of parameters in expenditure systems. It means that if a N% price increase is followed after some time by a N/(100+N)% decrease, consumption patterns do not exactly return to the original position (see e.g. Deaton and Muellbauer, 1983).

¹⁰ . See also section 3.5.2 and H. Kempfi, J. Pohjola, 'Hiilidioksidipäästöjen rajoittamisen kustannusten arvioinnissa käytetyt käsitteet ja mittarit', VATT, 2000

fulfilled, the following preliminary ranking of the most prominent instruments is generally valid:

1. permit trade and similar type of market creation (item 2a in the list in 3.1);
2. emission taxation; levies with differentiated schemes and penalties/rewards (item 3);
3. performance standards (item 1b);
4. physical regulation (quota or prescribed technologies, item 1a).

By their nature supportive actions are not listed separately in the above ranking.

Permit trade and taxation, provided the initial auction revenue or the tax revenue is somehow recycled¹¹, incur – in principle - the lowest overall costs. These instruments make the best use of the two substitution effects, while the net effect of tax interaction and revenue recycling is small. Performance standards don't have the tax interaction neither the revenue recycling effect, but – in principle - don't make optimal use of the substitution and abatement mechanisms. In case of quota it gets even worse as this constitutes both a shadow tax due to rationing and an abolishment of flexibility in substitution mechanisms. A VA can consist of a combination of the above instruments and consequently all effects can be applicable.

The proviso about basic assumptions is not a pro forma statement. If actual market conditions deviate substantially from the basic assumptions, both the ranking and the absolute levels of efficiency can be significantly affected. As already indicated above physical regulation remains virtually always a less preferable option, from an economic point of view at least. Therefore we will not consider this option further in the instrument selection. Physical regulation can be justified when non-compliance would incur very high risks of any kind, that can materialise in the short to medium run. Also high uncertainty about risks can lead to strict regulation.

3.4 Imperfections and their consequences

Incomplete information and information cost

An important underlying assumption in the models available is that all economic agents belonging to the same group have the same level of information. In the case of EFOM and CGE there is even the assumption of full information. The econometrically established relations in KESSU can contain market imperfections, but what kind exactly is not a priori clear and the relations are

¹¹ . Compensation can be done by lowering company taxes or employers' social security contributions for companies and lowering income taxes for households. There are disputes going on to what extent revenues can be earmarked, without losing too much of the positive effect of compensation.

fixed (and thus the imperfections). In reality not all agents in one sector will have equal information and neither will any of them have complete information. This implies that if more tax is added to the fossil fuel price and thereby – in theory – some efficiency or abatement measures become profitable, not necessarily a quick response follows. The agents may be unaware of the new profitable potential or somehow expect higher measurement cost (transaction cost). Even if some agents have recognised the option, it may take considerable time until most of the sector has switched, since the spread of the information update in a sector is not instantaneous (asymmetrical information across competitors).

Cost effectiveness
[FIM per ton CO₂]

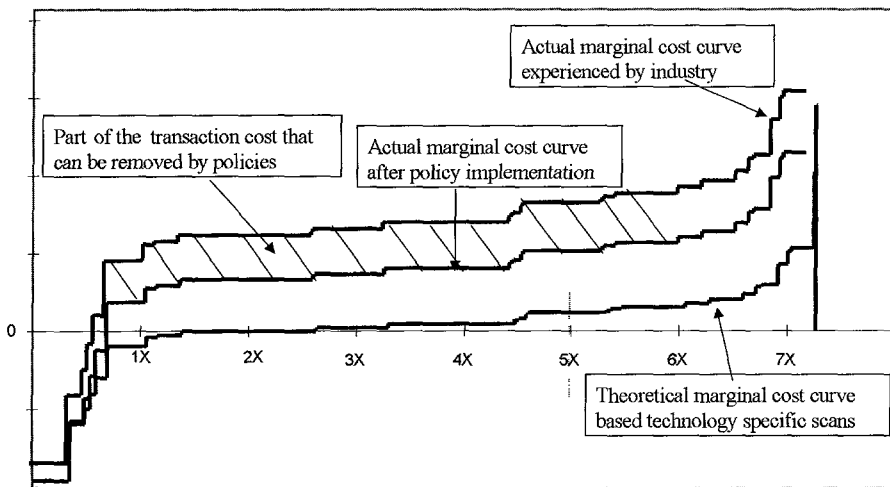


Figure 4. Marginal abatement cost curves and transaction cost.

The impacts of transaction cost imply that there is a difference between the ‘theoretical’ marginal abatement cost curve based on technology scans and the actual marginal cost curve as the industries experience. This is illustrated in figure 4. From a policy point of view it is important to know to what extent the elevated marginal cost curve could be lowered thanks to policies that reduce the transaction cost. Such policies will focus on the increase of knowledge and on the improved accessibility of that knowledge. This will typically mean efforts regarding research and development, demonstration and dissemination (R&DD&D), but improved accessibility may also involve new concepts for ownership of (commercially relevant) knowledge. Other things being equal, such information & knowledge instruments improve market transparency and thereby make pricing instruments (taxation) more effective. However, even with

improved knowledge asymmetry may be not always easy to alleviate depending on the type of market.

It is obvious that irrespective the main instrument (taxation or performance standards) the supportive actions are really needed, as they are a kind of effectiveness boosters.

Leaving permit trade aside for a moment, taxation will be -in principle- the most efficient instrument. The cost differential with performance standards is however not so large (up to 5% in a study for the USA – an economy with generally lower tax rates than in the EU, Goulder et al, 1998). The more other taxes are already in place prior to the new emission tax, the smaller is the difference. This is due to the detrimental tax interaction effect, which is stronger for an emission tax than for a performance standard (where additional efforts cease as soon as the standard is reached). Furthermore, the existence of market imperfections will reduce the effectiveness of a tax measure (without support measures) more than for example a performance standard, which usually has a stronger guidance function. This kind of indications are also found in CPB (1998, 1999). Recently, the report of Valtioneuvoston kanslia (2000) on the use of environmental and energy taxation in Finland mentions that the introduction of carbon tax in Finland in 1994 has had effect¹². On the basis of a quick scan the 102 FIM / ton CO₂ is assumed to have prevented emission of 4 Megaton of CO₂ by 1998.

In the situation of no a priori very evident national economic superiority of one instrument over the other, the public authorities involved may lean toward standards (often within a VA framework) instead of taxation. This preference can be explained by means of concepts from public economics theory. Firstly, there is the asymmetry in effectiveness between large groups with relatively small stakes and small (but influential) groups with large stakes¹³. For a start the small group with large stakes has more incentive and – usually - less transaction cost to organise a lobby aimed at a resulting policy that is relatively beneficial to the lobby members. In case of environmental policy it could mean a differentiation of tax levels over target groups, ample compensation by lowering other taxes or relaxing (non-environmental) regulations or replacement of taxes by voluntary schemes. The Principal-Agent theory stipulates that, if taxation is chosen, it often comes alongside with earmarked recycling of the revenues, which in many cases will lead to welfare losses compared to an optimal taxation scheme (implying non-earmarked recycling). Brett and Keen (2000) demonstrate that under very specific institutional circumstances earmarking can give the best results. The VA

¹² . Valtioneuvoston kanslia, *Ympäristö- ja energiaverotuksen käyttö Suomessa*, Kanslian julkaisusarja 2000/3.

¹³ . This started with publications of Olson (1965) and Stigler (1971), but has been widely developed since.

schemes in for example Denmark and the Netherlands seem to fit fairly well in this line of reasoning (Beeldman, 2000; Hansen and Larsen, 1999).

Voluntary Agreements are not a priori a good or bad solution, it depends on their contents. If they are used as framework arrangements for supporting measures and to optimise the transparency of the abatement and efficiency markets, they can be combined efficiently with taxation. In case voluntary agreements with performance standards are preferred over taxation, at least for some sectors, a very sophisticated setting of the standards, e.g. involving progressing schemes, may approach the efficiency of the taxation. Yet, over- or underrating remains a risk, certainly in the medium to long term. Observing what has happened in some other countries (Denmark, The Netherlands) and given indications from the principal-agent model, voluntary agreements are not totally unlikely and in fact exist already in Finland with respect to energy saving. The shaping of these voluntary agreements may have imperfections stemming from the political-economic dimension in a national economy.

Uncertainty about key scenario variables (e.g. economic growth in main export countries, key world market prices, strategic political uncertainties) can also cause a reluctance to invest in abatement and efficiency measures, beyond a no-regrets level. Increased uncertainties usually reduce the no-regret potential.

Information imperfections and the decreasing effectiveness of taxation

If there exists a significant potential for abatement¹⁴ at current or just above current price levels of fossil based energy, while this potential is apparently not used (see e.g. Beeldman, 2000; Lehtilä and Tuhkanen, 1999a), it starts to be questionable that taxes would suddenly ignite action. Obviously, beyond some point actions will be incited, but in case of large differences between theoretical and actual marginal abatement cost there may be a large amount of dead-weight in the taxes. In such situations there must be important other inhibitions active. In growth industries it may be due to capital scarcity and the relative low productivity of abatement investment compared to production investment. Yet, in such a situation the price signal should be quite effective. Another reason for big inhibitions are very limited or seriously misconceived information and other transaction cost. Setting a standard in such a case will help a great deal to define clearly a market. The possibly limited effect of taxes in case of already existing large potential gains can be illustrated by means of a penetration curve as depicted in figure 5. The penetration in that curve is among others explained by the marginal cost differential and the tax level. Other items (discussed later) are for example the age distribution of the capital stock, as well as uncertainties about key scenario variables in the short to medium run.

¹⁴ . Abatement is here meant to cover both actual abatement and efficiency measures.

Figure 5 shows the ultimate result (after N periods) of a given tax rate, while there are varying degrees of initial (= pre-investment) cost-differentials. Initially both taxation and increased cost differential show a growth in contribution to the penetration of an abatement or efficiency measure. However, beyond a certain cost differential the tax starts to count less. The exact position of the maximum depends on the specification of the penetration function, but in principle the shapes remain similar. Therefore, knowledge about the transaction cost is not only relevant to industries and other investors, but also to the authorities that have to decide about the dosage, sectoral applicability and timing of taxes.

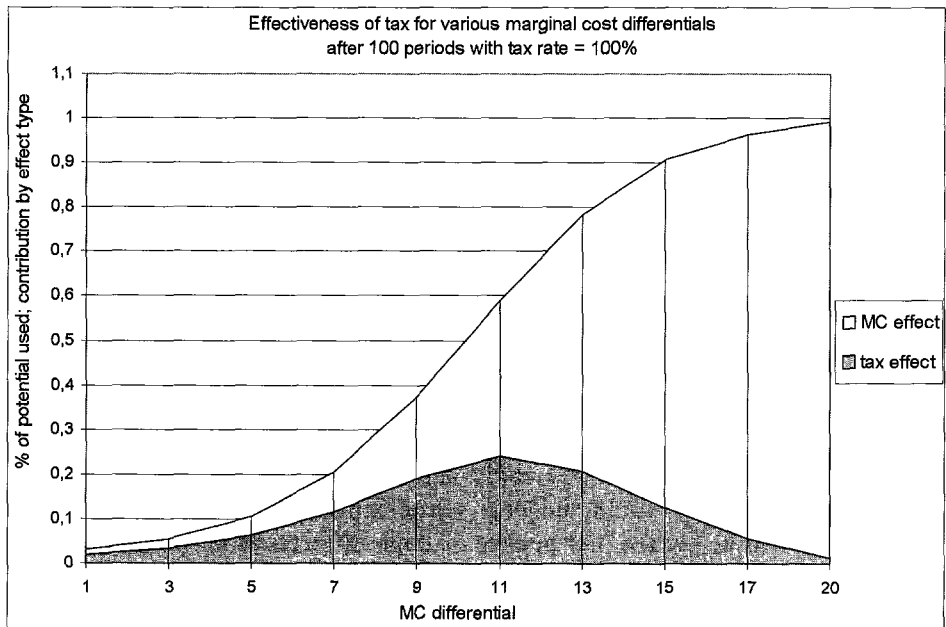


Figure 5. *The contribution sensitivity of taxes in relation to pre-existing cost differentials.*

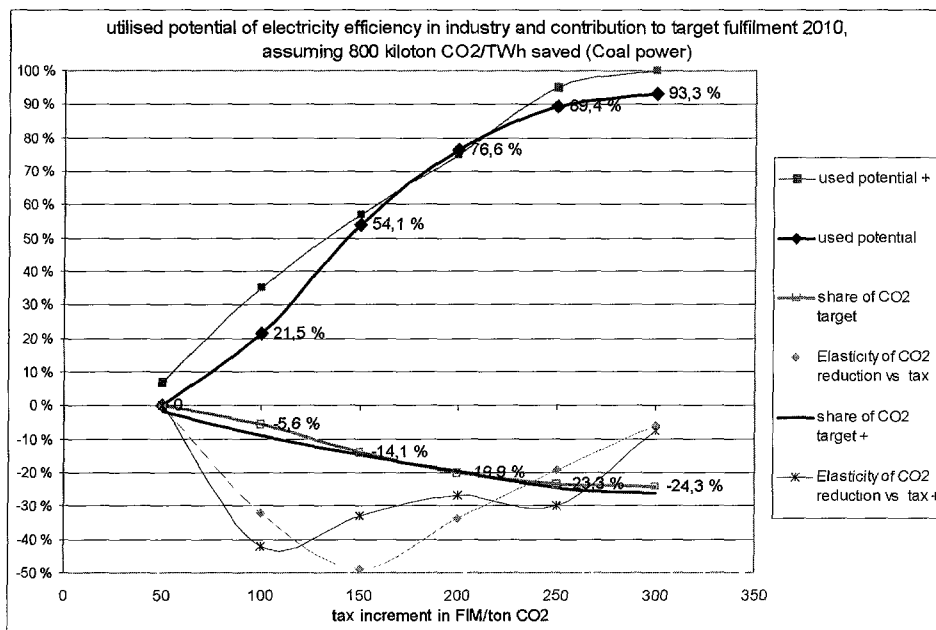


Figure 6. The penetration of efficiency for various tax levels and the emission implications.

Figure 6 shows an example derived from the EFOM based study of 1999 (Lehtilä and Tuhkanen, 1999a). To achieve a use of 60% of the potential a 200 FIM/tonCO₂ tax increment would be needed, while at an increment of 100 FIM/tonCO₂ only 13% is utilised¹⁵. This is mirrored in the elasticity of the tax, which reaches -30% (at 150 FIM) after which it gets less effective, but beyond 200 FIM a new peak occurs. Beyond 250 FIM the elasticity and hence the effectiveness of the tax reduces sharply. The latter effect can be regarded as empirical support for the theoretical curve shown in figure 5.

The graph in figure 6 demonstrates that it is possible that in solution area (in this case efficiency) more than one local optimum may exist. In principle this can also occur when involving more solution areas as well as macro economic criteria. Important is the message that in case of various local optima, it does not make sense to try to find solutions in between these alternatives, at least not from an economic point of view. One either makes very local trade-offs or jumps to another local optimum (implying another combination of solution types).

¹⁵ . The CO₂ tax applied here is not exactly the same as the current existing taxation system.

The interesting challenge is to achieve the elasticity of 30% earlier (and preferably have a higher maximum elasticity), which would allow the authorities to apply lower tax increments¹⁶. The impact of almost immediate maximum elasticity is demonstrated by the other set of lines in figure 6 referring to a hypothetical policy programme in which taxes are accompanied by supporting measures that reduce marginal cost of efficiency measures (potential +).

3.5 Connecting instruments to measures

3.5.1 Introduction

The whole incitement process of instruments targeting at measures is more fuzzy than one tends to think. For a start there is already existing policy¹⁷ (environmental and otherwise) and various new instruments may be introduced, while existing ones may be reinforced or sometimes abolished. The various possibilities are shown in figure 7. A carbon tax for example can incite several measures, such as fuel substitution, fuel efficiency improvements, and adaptation in the product mix (skipping 'dirty' products). However, these various measures also influence each other in terms of responsiveness and total potential. Improvement of fuel efficiency reduces the demand for a substitute fuel. By changing the product structure a company may be able to avoid efficiency investments altogether.

Usually not only taxes are applied, but also other instruments. If for example subsidies on renewables are high, it may constitute a disincentive to invest (more) in energy efficiency. On the other hand if R&DD&D support enables earlier introduction of more efficient technologies, the incentive from a carbon tax gets enhanced (see 3.4). A third source of uncertainties is the ultimate impact on emission levels. If the resulting distribution of measures taken is otherwise than expected, emission reduction are almost certainly different as well. Another kind of uncertainty concerns possible variations in key economic variables, either international, national or sector specific.

¹⁶ . Even though revenue recycling is envisaged, lower taxation is still favourable.

¹⁷ . The interaction effect with existing policy coincides only partially with the so-called tax interaction effect (see for example Goulder et al, 1999)

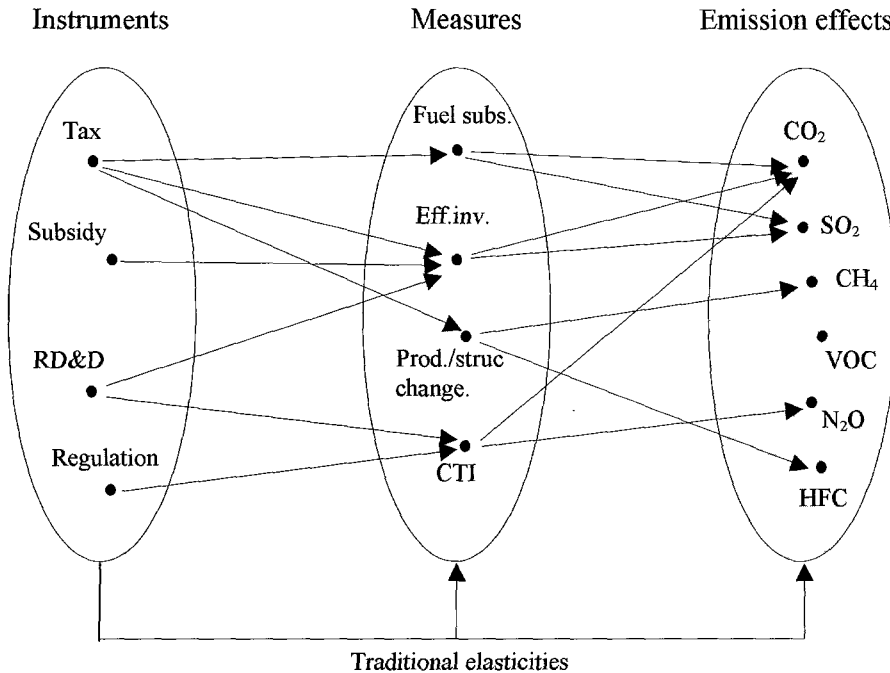


Figure 7. Connecting instruments with measure responsiveness and emission reductions.

If the impact of taxation is assessed by means of EFOM the post-tax marginal prices of energy use options and energy savings options are decisive on what efforts are activated¹⁸. Furthermore, EFOM takes interaction effects between measures into account, e.g. the remaining scope for fuel switching is lowered if some (extra) energy happens to be applied. Also rigidities due to lifetime of the capital stock and regulations that influence upper or lower bounds in the energy system are taken care of in EFOM.

EFOM assumes rational and totally informed agents in all sectors, while total demand per kind of energy use (heat, drive power, light, etc.) is given apart from efficiency measures. This means that induced (feedback) effects on total energy demand are left out, while profitable potentials for saving, fuel switching and renewables are as quickly exploited as system conditions allow. In a macro-economic model in fact only the differences in levels for macro-economic key

¹⁸. One has to take care of a proper and sufficiently detailed specification of the baseline tax and subsidy situation in EFOM, in order to simulate the correct tax based incremental changes in prices.

variables and emissions for scenarios with and without instruments are calculated; while as opposed to EFOM only very generic efforts regarding efficiency, substitution and abatement can be taken into account. So, in a macro-economic model conditionality and upper and lower bounds are neglected. On the other hand feedback from induced effects is taken into account (though the comprehensiveness of the pictured effects depends on the kind of model). Competition for investment funding depending on productivity differentials can be taken in to account, induced effects from increased or lowered demand for various products will be reflected in any macro-model. However, learning effects both in production and consumption are hardly taken up so far. Endogenising learning with respect to environmental technology has received attention (e.g. Seebregts et al 1999; Buonanno et al, 1999; Katsoulacos, 1997), but is still detached from other more general technology growth models. As regards 'learning' in consumption, sociologic (e.g. Bourdieu, 1979; Spaargaren, 1997) or social-psychological (Fisbein and Ajzen, 1975; Antonides et al, 1996) studies have been undertaken, but nothing substantive in economics¹⁹.

3.5.2 An overview of pro's and con's of instruments

There are no existing tools or comprehensive empirical studies on the basis of which instrument–measure linkages can be specified. There is only a mixture of piecemeal empirical evidence, prior technical-economic knowledge of the problem area and some guidance from firstly EFOM and in second instance the macro-economic models which all can assist to postulate a set of most likely linkages. In table 1 a preliminary overview is given.

¹⁹ . One might argue that the treatment of panel-effects in longitudinal consumer surveys relates to learning in consumption, however the focus has been on neutralising the effects, not on analysing its behavioural backgrounds.

Table 1. Measures, instruments and sectors.

Measures: type	abatement effect	option for:		tertiary			community	
		heavy indu	light indu	services	agriculture	transport	households	services
technical efficiency improvement-equipment	++/+++	XX	X			XX	X	
technical efficiency improvement-buildings	++/+++		X	X				X
good housekeeping	+		X	X	X	X	X	
product mix change	+/++	X	X	?	XX			
logistics and spatial planning	+/++		X			XX	X	
direct abatement (esp. Non CO2 gases)	+++	XX						X
fuel switching (coal -> gas; imports of hydro)	+ ..+++	X				X		
renewables	+++	X			X		X	X
emission permits	(+++)	X				?		
Measures: type	degradability reversability	instruments		refunds & performance		R&D		
		CO2 tax	inv.subsidy	bonus/malus	standards	rewards	info campaign	support
technical efficiency improvement-equipment	-	XX	X	X	X	X		X
technical efficiency improvement-buildings	+	X	X	X	X	X		X
good housekeeping	++	X				X	X	
product mix change	0	X			X			
logistics and spatial planning	0/-	X			X	X		X
direct abatement (esp. Non CO2 gases)	-	XX	X	X	X			X
fuel switching (coal -> gas; imports of hydro)	+	XX						
renewables	-	X	X		(X)			X
emission permits		(X)						?

The judgement of the abatement effect is a mixture of effectiveness per unit of effort and the total long term potential available. The most effective measures, having three plusses in the column 'abatement effect', are usually also the most expensive ones. Though often the initial exploitation of any type of potential starts at low cost levels. Also the ease with which measures can be reversed or can be degraded (e.g. due to neglect) is indicated. Cheap measures are often more easily degradable or reversible. For good housekeeping that is well known and quite obvious. However, in the case of fuel switching and building technology it gets more important. For example, suppose that CO₂ storage develops into a low cost option. It would immediately mean that coal becomes an attractive fuel again. Buildings tend go through an evolution during their lifetime, which often causes a deterioration of the original design qualities, even though at the same time energy saving features are installed as well.

Emission permits can be regarded both as an instrument and as a measure. The creation of property rights including the institutional framework for emission trade could be regarded as the instrument, since it needs initiative and intervention from public agencies. The actual trade of emission permits represents measures taken by emitters. In the USA emission trading for SO₂ has been working successfully, but the importance of transaction cost should not be underestimated as is evident from the differences in use of trade options (Hahn, 1995). The greenhouse gas emission market is larger and more complex (more emitters, more types of emission sources, and international). This calls for caution to draw straight conclusions from earlier examples. It is obvious that the entry threshold of greenhouse gas emission permit trade will be high (e.g. FIELD, 2000). Since the effectiveness of this instrument builds up quite quickly, it is recommendable to take the time for a thorough preparation of the institutional framework. Given the high entry thresholds a good start-up of the permit trade is essential, as initial failures may increase the deterrence for potential traders.

A *tax* stimulates in principle all measures. Various features affecting the effectiveness of taxation were discussed in previous sections. The focus will be here on appropriateness in relation to distinct measures. Recycling of emission taxes is a default assumption. Some measures can also be steered efficiently in other ways. First, the abatement of non-CO₂ gases, which involves a limited number of players and only a few processes, being urban and industrial waste treatment and agriculture. Since there are also other environmental benefits attached to a sustainable approach in waste treatment and given the structure of the problem, a tax might be not very effective or lead to unintended responses. There is already a programme running in Finland aiming at the utilisation of methane from waste deposits. In addition waste can be used as fuel in combined heat and power production. Emissions in agriculture can be partly reduced by altering inputs (food intake), however farmers may have insufficient countervailing power toward fodder producers and hence (only) a tax on emissions at the source does not enable the choice for the least cost solution. For investments in local installations financial assistance may be necessary as well as easy accessible information to make the right choices.

For CO₂ reduction, i.e. fuel switching, renewables and energy efficiency improvement, taxation may be more effective. As a general guideline it holds that the more decision layers are present between the resulting type and volume of energy use and the aspects that influence the choice of type and volume, the higher the likelihood that the effectiveness of the tax is reduced (i.e. less response at a given level of tax after a given period of application). A good example is energy use in service sector buildings. Often the energy management of an office building or a shopping centre is outsourced to a facility management company, which also caters for other facilities (elevators, cleaning, etc.). The users of the building will judge the facilitators' bill based on its overall performance, not only

energy costs. At the same time the actual users (employees, visitors, guests, etc.) mostly have little notion of their impact on the energy use in the building. On the other hand the facilitator may have had not any influence on the design of the building and its energy installation, though the latter allows for larger adaptations in the medium to long term. Furthermore, the party that commissioned the building (let's say the owner) does not need to be the user, while many other notions than sustainable characteristics will have played a role in the design and budgeting of the building. This does not look like a straightforward working market for end-use efficiency (e.g. Janda, 1999; Weber, 1999). The efficiency market characteristics even change significantly when the time perspective changes. An important issue is here whether one should assume these deficiencies as given or not. If the market characteristics are assumed to be malleable through policies, taxation may become much more effective after applying other measures first or alongside the taxation.

In industrial environments usually prevails a much higher cost awareness concerning energy compared to the service sector or households. Therefore, industries are usually more responsive to price increases. However, the reason why the distribution of delays in response can vary and cover long periods, has to do with the competition for scarce resources (time and money) for investment alternatives, the age distribution of the capital stock and the remaining potential for improvements. In expanding markets, the opportunity cost to invest in energy or abatement instead of the core product or process can be high, even if the energy investment is profitable. In contracting markets, cost cutting is important, which to some extent can stimulate energy saving, but for larger investments there may be no money available. Last but not least, if uncertainty increases industries tend to shun larger investments that commit them for a longer time period. All in all it means that – depending on market conditions – taxation may experience more delay in its impact than expected (see also 3.4).

Investment *subsidies* can be justified if there are positive spillover effects from such measures. Spillover effects in this case means that the investor is also creating benefits for other parties inside or outside the same market. For example, early adopters of a measure could be rewarded since they can make a market move, either through setting an example and producing empirical evidence for other potential investors (who consequently have lower information cost) or by inspiring the supplier of energy efficiency technology to lower prices after a few initial sales²⁰.

Instead of a tax collected and subsequently recycled by the government, one can resort to *inner sector funding*, e.g. by means of a *revolving fund* which is built up

²⁰ . Please note that the opposite is equally possible, in case the supplier suspects that the willingness to pay is larger than originally estimated, but one would not expect much difficulty to start up the market in these circumstances.

by a levy on emissions agreed on by all stakeholders in the sector. Initially, the government can supply (temporary) funding to ensure a quick start. From the fund can be borrowed by investors in the sector against an attractive rate. In addition it is possible to differentiate the funding costs by applying benchmarks to stimulate good performance. Furthermore, there needs to be a – somehow binding – target for the sector and a validated monitoring process. This kind of arrangements typically can be part of a voluntary agreement. The advantage for the public authorities is that the costs for the public administration go down, while inside the sector a reasonably efficient allocation mechanism is ensured. A part of the voluntary agreements in the Netherlands and Denmark have features as described above (see Ingerslev, 1999).

Performance standards either refer to emission or efficiency targets (per sector; see also above about revolving funds), or more specifically to minimum standards for equipment and buildings. Generally it holds that the stricter the targets are formulated and the less flexibility the regulatory framework allows, the higher the overall cost will be. Therefore, notably the more detailed kind of performance standards prescribing lower or upper bounds for equipment and buildings risk to create unnecessary extra cost. On the other hand in case of many decision layers and split responsibilities, as in the service sector example above, performance standards can help to create clarity in markets. Given the characteristics discussed above performance standards seem most suited in cases where on the one hand there is a multitude of decision layers, while the involved type of product or process can be well delineated and represents a substantial volume of energy use or emissions.

Real world examples are the EU minimum efficiency standards for refrigerators and the upcoming EU standards for washing machines. Given the still different taxation regimes in EU countries regarding energy and durable consumer goods, union wide standards are at this moment the best feasible alternative. In the USA performance standards have been applied to sales volumes of cars by brand (CAFE). The weighed efficiency of the sales volume should not exceed the standard. According to Greene (1990), the scheme was effective also in comparison with (hypothetical) price measures. Yet, during the nineties it became clear that the increased sales of ‘sports utilities’, which fall outside the regulation, significantly neutralised the gains made for other passenger cars. A third example is the Energy Performance Standard for new buildings in the Netherlands (EPN). As regards separate components there is a freedom of choice²¹, but the entire building design should pass an energy use simulation test. The EPN was meant to be comprehensive and holistic and thereby more flexible. The application is however quite complicated, requiring education to use the concept and the simulation software properly. Since the EPN is updated in line with technical progress (the norm gets tighter over time) it requires continuous

²¹ . There may be other regulation (e.g. safety) limiting choices for materials and equipment.

attention of the regulator supported by background work. So, the application of the standard has non-negligible costs both for the regulator and the building sector.

According to an overall economic assessment (Jeeninga et al, 1999) the EPN does not seem to be very efficient from an economic point of view in comparison with other measures such as stimulating efficiency in the industry. In terms of energy efficiency improvement as such the programme is definitely effective. Furthermore there is in fact a problem in the overall economic evaluation, as it seems that over time home owners have learned to appreciate the quality improvements, and consequently seem to be willing to pay for it. This creates problems in applying a fair comparison of prior and post EPN-situations, since the preference functions of consumers seem to have altered. This hints to a general economic evaluation difficulty for this kind of policies. If the regulator is right that energy efficiency is a *merit good*, it means that consumers (and a part of the companies) is *ex ante* underestimating the welfare gain from such a measure. Hence an increased investment in energy efficiency is regarded as sub-optimal, while *ex post* the increased investment level turns out to be less of a misallocation.

In various EU countries (Denmark, Italy, the Netherlands) a market for 'green electricity' is or will be established by means of setting a minimum share of renewables based power in the total delivered sales (Meyer, 2000). The system is arranged through a market of tradable certificates. As long as the prescribed minimum share is lower than the share consumers are prepared to pay for, it is an effective instrument to ensure the development of renewable energy options against acceptable cost²². There is however a risk that other options such as energy efficiency improvement may experience competitive impacts on finding investment funding. Moreover, if the minimum share gets too large it starts to create also distortions to consumers. The merit motive, as was mentioned earlier for building performance standards, is not valid here.

Market transformation is a new catch word for instruments that actively try to improve the way policy signals or customer signals are translated into desired quality levels of products and services. In other words it concerns a kind of performance standards embedded in a setting in order to address market imperfections. The most important representative of this approach is the concept of competitive procurement as developed by the Swedish energy agency NUTEK (now STEM). It aims at speeding up market introduction of more energy efficient product versions (e.g. refrigerators). In Finland MOTIVA has experimented with

²² The Dutch Ministry of Economic Affairs (cf. Finnish KTM) commissioned a market potential survey (http://www.minez.nl/energie/fs_energie.htm, 'De Vraag naar Groene Energie', 2000). The survey showed that 45% of the households and 40% of commercial customers was prepared to pay approx. 7% more (households) or approx. 20% more (companies) in order have (some) certified green electricity delivered. This would cover around 15-20% of total power demand.

the approach to facilitate the introduction of high efficiency windows and heat delivery meters (Kasanen et al, 1997). The windows programme had some but not overwhelming success, which can be attributed among others to very modest funding. In the USA a comparable concept called collaborative intervention is tried for compressed air systems, for which large improvements are possible (McKane, 1999). The challenge is to bring the whole chain from design, production, delivery and use together.

Supporting instruments such as information campaigns, research & development and demonstration and dissemination (R&DD&D) are meant to be effectiveness boosters and fit also in a long term view of achieving the policy goals. In the first waves of energy campaigns in the seventies and early eighties information provision was believed to have significant effect in itself. Over time policy makers have learnt to have more modest expectations at this point and became aware of the limited duration of the effect of information provision. Well managed research & development followed by a few realistic demonstration projects usually have lasting and wide spread effects on the uptake of new technology and organisational practices. This is also termed as experience curve based policies (IEA, 2000). The problem is in the selection of the right products and processes, the right level of ambitious targets and a realistic time frame. This needs a carefully built up system of R&D policies, including technology foresight studies and monitoring. Compared to other EU countries Finland has been progressing quite well with such a framework (see the SENSER report prepared for the European Commission, 1998), though it may need adaptation for the needs of climate policy support. Next to voluntary agreements, that serve as clarifying institutional frameworks for better positioning of instruments, it are the R&DD&D activities that can contribute to a reduction of transaction cost of the different types of measures. Intensified R&DD&D seems especially relevant for energy efficiency of equipment and buildings, long term prospects of renewables, some types of direct abatement measures and, the development of credible concepts describing the interaction between economic, technical and social forces in its entirety. Such concepts are indispensable for eventually arriving at a set of policies that are genuinely consistent with moving toward sustainability.

3.6 Summary and concluding remarks

Summarising the above discussion it can be stated that in principle pricing instruments are to be the cornerstone of a climate policy, as they are capable of providing emission reductions at the lowest overall cost to society. It should be clear however, that the sole use of pricing instruments will be less effective in various sectors. In some specific non-CO₂ abatement cases with only a few players a separate programme could be more effective.

The discussion of instruments started from the presumption that the target achievement for 2010 can be judged without extensive regard to the trajectory that is needed after 2010. That is an incorrect assumption, but at this stage it is wise to identify first the best possible instruments and measures for achieving the commitment in 2010, while not forgetting the long term needs. Subsequently, the planned outlook towards 2020 in Phase 2 of the study can assist in identifying instruments and measures that need early action and fit in a no-regret approach. So, next to the policy plan for 2010 it is recommendable to strive for a formulation of a long term strategy, that should at least give clarity on what actions and changes are at least needed and what actions and developments are to be avoided.

Turning back to the challenge of medium term policy package design, during the preparation of a policy to fulfil the Kyoto protocol, it is recommended to find out:

- How voluntary agreements can create an institutional environment which is conducive to achieving the emission targets by the lowest overall cost to society;
- What kind and what intensity of supporting measures (R&DD&D) are needed for a most effective reduction of marginal costs of efficiency and abatement options;
- What is the right timing to introduce taxation given the expected results of R&DD&D activities, how should it build up and what degree of earmarking of recycled tax revenues is recommendable;
- How a national and perhaps Nordic or Baltic trade system can be exploited prior to and as a preparation of a large international trading system;
- How and when can a solid and credible permit trading system be established at the EU level and involving at least the European Annex B countries, in which not only national agencies but also large industries are allowed to trade, and how Finland can contribute to the successful establishment of such a trading system;
- What taxation and regulatory reforms are at least necessary in Finland and other EU member states to prevent serious biases in the permit market or in other company decisions (e.g. concerning location of new investments).

4 A pilot selection system

4.1 Introduction – preliminary targets and criteria

The selection system goes through six main steps as is explained in chapter 2. The first step concerning a scan of available instruments and their appropriateness has been amply treated in chapter 3. In that chapter also hints for instrument combinations (package lay-outs) have been given in relation to inciting particular kind of measures. In the next steps 2 and 3 a preliminary set of instruments and targeted measures are selected. This work proceeds by going back and forth between steps 2 and 3 (combination and dosage, identifying and ranking measures) as is shown in this chapter.

The preliminary reduction target for Finland is estimated at approximately 19 Megaton of CO₂ equivalent in 2010 (Lehtilä and Tuhkanen, 1999a). The emission level in 1990 is currently rated at 72 Megaton (UNFCCC, 1999). Within the EU burden sharing framework Finland agreed to have in 2010 an emission level that should not exceed the 1990 level. The 19 Megaton is very much a *preliminary* figure, as there are several things to be cleared. The baseline may undergo changes which can result in a change of the central target figure as well as in the uncertainty margins that are applied around the central target²³.

Next the selection criteria for measures have to be selected and specified. Relevant dimensions to be represented are:

1. cost;
2. total potential contribution to target;
3. implementation time;
4. side effects (positive and negative);
5. reversibility and degradability;
6. command over results.

The appropriateness of the criteria depends on the way one wishes to optimise the policy package and the focal area and gravity points of the policy objectives. Preferably the entire problem space is covered. The criteria should allow for consistent ranking procedures, consequently, some effects such as on landscape can be mentioned but are hard to assess at the global level of the present assessment²⁴. Furthermore, by varying the level of detail of the criteria, one

²³ . During final editing stages the figure was already established to be approximately 15 Megaton.

²⁴ . For almost all effects qualitative rating systems can be developed e.g. with the aid of Delphi-survey techniques. Such applications are usually of little use at the global (generic) level of the present study

already adds or reduces weight to specific parts of the problem. The following list gives a fairly broad picture. As costs, both in terms of initial outlays and for the society at large are important, several criteria cover different interpretations of costs. The answering of several of the criteria may require substantial research input. In itself the cost of information or the time lags involved can be a reason to skip a criterion or to resort to simpler methods to attribute a score.

Criteria used in the pre-selection and selection

1. Private direct cost per unit of CO₂ equivalent saved
2. Social (national) cost per unit of CO₂ equivalent saved ²⁵
3. Total (technical) potential of CO₂ equivalents to be saved
4. Expected share of potential actually to be exhausted (given the assumed cost level)
5. Time frame of implementation (this is closely related to criterion 4)
6. Other environmental impacts
7. Other impacts (social, economic or technical spin-offs, cultural)
8. Initial implementation (organisation) costs of measure
9. Continued (repetitive) organisation costs of measure
10. Dependency on changes in institutions, regulations, behaviour, management practices, etc.
11. Number of actors involved (bargaining vs. anonymous market)
12. Compliance likelihood (can affect organisational costs, see 8,9)
13. Reversibility and degradability of saved CO₂ equivalents

The criteria that are printed italic have been used in the preliminary assessment discussed below in section 4.2.

4.2 Available options and initial ranking

Table 2 shows what measures are available in Finland, their potential, costs, side effects, ease of implementation, etc. Information comes primarily from Lehtilä and Tuhkanen (1999a), Lehtilä (2000), Savolainen et al (2000). Additional information is used from Beeldman et al (1999), Honkatukia (2000), Kettunen (2000), Kemfert (2000), Hansen and Larsen (1999). In some cases deviations from the base source are applied. For example, various efficiency measures will

²⁵ . In the first selection rounds this refers only to first order obvious costs not covered by private investors, such as R&D support and programme cost; interaction effects with other measures and higher order effects in the economy can be included after model simulations.

show a large spread when the actual efficiency level of a company is taken into account, hence a part of cheapest options will even have a lower unit cost than the assumed average. Similarly, a large range of estimates exists for permit prices. Application of ceilings throughout the EU will lower the permit price. As regards import of electricity the extra cost should be small, given the way the Nordic electricity market operates. Nevertheless, if there would be a systematic attempt to use the trade option more extensively, it can be expected that prices go up. Therefore a small increment is assumed for the average. High increments would be irrelevant.

Highlights to table 2

Emission permits are kept apart in this list as it is not a domestic measure. Big potentials can be found in: fuel switching for electricity generation, industrial energy efficiency improvements, and direct abatement of non-CO₂ gases. Additionally interesting are power imports, energy efficiency in buildings and improvement of conversion efficiency in power stations and refineries. Typically difficult is the transport sector, of which the reduction potential is small compared to the volume of fuel consumption. It should be noted that in table 2 the reduction potential of international transport (sea and air) is not included as these emission sources are outside the first commitment period of the Kyoto Protocol.

The potential of product mix change is very hard to assess and therefore only mentioned pro forma in the table. An increasing number of industries around the world and also in Finland is building long term strategies in which sustainability is a core element (Kettunen, 2000; Price-Waterhouse Coopers, 1999/2000). This will inevitably affect their product mix. A more tangible and directly relevant version of product mix adaptation is the offering of 'green electricity' (see 3.5.2).

Table 2. Overview of available measures.

Measures and first line criteria Type	Incremental cost FIM/ton	potential Mton	Side effects		Adoption speed Years to 50%	Nr. of users	Risk for degradation & reversion
			Environ-ment	Economic			
Efficiency improvement of industrial equipment	0 – 1000	4 ~ 7	+ (TMR↓)	New markets	5	Medium	-
efficiency improvement in buildings	30 – 550	2,5 ~ 5	0	New markets	8	Large	+
good housekeeping	50 – 400	0,5 ~ 1	+ / 0	0	3	Large	++
product mix change	?	?	(TMR↓)	New markets	>2	Medium	0
logistics and spatial planning	0 – 500?	1 ~ 2	+ (space)	location choice	5 ~ 15	Medium	0/-
Transport equipment	0 – 500?	0,1 ~ 0,4	0	?	7	Large	
direct abatement (esp. Non_CO2 gases)	0 – 1000	5 ~ 6	Smell ?	Changes in waste sector	5	Small	-
fuel switching (coal -> gas/biomass; import of hydro; nuclear)	~ 50; 0 - 60 ~ 0; ~ 25	3 ~ 13	Varies; nuclear fuel cycle	Trade balance	5	Small	+
Renewables		0,5 ~ 1	Landscape	New markets	8	Medium	-
TOTAL		20 ~ 40					
emission permits		≥ 50%	0				

*) a part of the separate potentials cannot be freely added, due to interaction effects, the actual figure may be lower than 40 Megaton.

Small - up to 20 companies or agencies represent at least 80% of the potential
 Medium - 20 to 100 companies or agencies represent at least 80% of the potential
 Large - more than 100 companies or agencies needed to reach 80% of potential

All the other measures crudely distinguish by sector, and supply or demand side option.

The exception is emission trade which is accessible for most sectors (except households²⁶). The options are not equally expensive. From a direct cost minimisation viewpoint one should rank by increasing cost, implying the lowest cost options first. However, in every main option there is cost range. So, for quite some options only a part of the potential is achievable against modest cost.

²⁶ . This could be solved by allowing for intermediates, as is now already possible for travellers that want to offset their emissions caused by air travel.

Therefore a first way of ordering options is to rank them by cost level at the median of its potential, which is a first crude approximation of a realistic comparison of direct costs per ton. This is done in table 3 below. Four options seem to be at least for 50% exploitable for less than 100 FIM per ton of abated emission. These four options together have also a substantial potential, being 19 Megaton in the Minimum potential and 40 Megaton for the Maximum potential.

For the minimum potential estimate it means that for fuel switching additional nuclear power is not available, while for permit trading a ceiling of 50% of the reduction target is applied. In the maximum potential case additional nuclear power and unrestricted permit trade are included. Whereas for other options the difficulties to exploit potentials are entirely related to prohibitive high costs, technological uncertainties and minimum development time, the restrictions on permit trade and additional nuclear capacity are rooted in politics. The likelihood of the future existence of these restrictions is intractable. Therefore, for the time being only a likelihood of 50% to each of the events can be applied. Furthermore, by its nature this study is focusing on a (national) economic appraisal for Finland of alternative policy packages to fulfil the obligations stemming from the Kyoto Protocol. Around this focal area of national economic impacts indications will be given of possible significant other effects as well as an indication of the robustness of policy packages. However, the study will *not judge* the other effects and robustness, but only list them in a way that enables policy makers to judge possible trade-offs between national economic costs, possible other impacts and uncertainties.

Table 3. Measures ordered by cost per ton at median potential use.

Instruments and measures <i>Type</i>	Incremental cost			Potential		Side effects		Adoption speed nr. of years to reach 50% Adoption speed	Nr. of users	Risk for degradation or reversion	
	FIM/ton	Min	average	max	Mton	min pot	max pot				Environ- ment
Import (free electricity market)	0	20	30		1,0	2,0	0 (?)	Trade balance	3	Small	+
Fuel switching (coal -> gas/ biomass/nuclear)	10	40	125		3,6	13,0	+	Trade balance	6	Small	+
Direct abatement (esp. Non_CO2 gases)	5	40	1000		5,0	6,0	nuclear fuel cycle smell ?	Changes in waste sector	5	Small	-
Emission permits	30	90	300		9,5	19	0 (?)	Technology transfer ?	3	Large	-
Good housekeeping	50	100	400		0,4	0,8	+0	0 (?)	3	Large	++
Transport equipment	0	100	500		0,1	0,3	0 (?)	?	7	Large	+
Logistics and spatial planning	0	100	500		0,5	1,5	+	location choice	5 ~15	Medium	0/-
Renewables	120	150	180		0,5	1,1	(space)	New markets	8	Medium	-
Conversion efficiency and CHP, fuel cells	60	160	220		1,8	3,8	0 (?)	New markets	6	Small	-
Efficiency improvement of industrial equipment*	0	250	1000		4,0	7,1	+(TMR)	New markets	5	Medium	-
Efficiency improvement in buildings	30	200	550		2,6	4,8	0	New markets	8	Large	0/+
Product mix change	?	?	?		?	?	(TMR)	New markets	>2	Medium	-
TOTAL DOMESTIC					29	60					

4.3 Reassessing the initial ranking – other criteria and synergies

In first instance it looks attractive to focus policy design on the four best rated options, without disabling the remaining options. There are however other criteria that should not be neglected. First there is the uncertainty (and the resulting extra cost) of not achieving the target in the first commitment period. Secondly, the cost minimisation should also consider the long term perspectives. Finally, there can be interactions between measures.

Commitment risk 2010

The three criteria on the right hand side of table 3 represent different aspects of risk of non-achievement. In summary these criteria tell that quick implementation, a small number of parties (actors) and low probabilities for reversion or degradation of abatement make a measure more preferable. Not a single measure in table 3 rates good on all three aspects.

Given the timing of the first commitment period (2008-2012) estimated adoption speeds of more than 6 years up to 50% penetration start to be more risky. Four measures have a risk of working too slow to be a prime policy area, being: building efficiency, renewables (sun, wind), transport equipment, and spatial planning. As regards number of players only permit trade rates unfortunate. The prerequisites for taking part in international emission trade are indeed a source of concern (a hot topic in the United Nations Framework Convention for Climate Change UNFCCC) and indeed the indications are that costs are non-trivial. However, most other measures involve larger number of parties as well, so there is not much choice in this respect. As regards reversibility power imports and in some cases fuel switching bear a risk of being forced to switch to dirtier sources in the long run.

Reconsidering the top four measures it seems that direct abatement measures of non-CO₂ gases can be pursued safely up to a cost level of about 50~60 FIM/ton of CO₂ equivalent. For the other measures further review is needed. Yet, from earlier studies it can be clearly inferred that a part of the fuel switching (e.g. from coal to gas in district heating) seems to be a no regret option as well.

All in all the costs up to 2010 of using the first four options supplemented by those actions from other measure types that are low cost as well will be appreciably cheaper than focusing strongly on renewables, and efficiency in buildings. There are however other criteria to be involved as well, notably risk or robustness of policies (see the 2010 commitment risks above) and the expectations on what is needed after 2010. Furthermore, possible important synergy effects between measures have to be assessed.

Long term trajectory

Table 3 includes indications for the possible presence of (other) environmental and economic effects. The listed environmental effects do not have straight price tags, therefore at this stage of the study in which economically interpretable information is used, they are not used for selection. In the final stage of overall trade-off evaluation they can have a role. The economic side-effects can be turned into quantitative indicators in the initial steps 2 and 3, but will be included in following steps based on background studies. The economic side-effects such as new market opportunities render also a step up to a long term view, which has not been applied so far given the focus on 2010. The prospects are that further substantial reductions of emissions in OECD countries will be required in the

decades after 2010. This relates to the so-called ‘soft-landing’ scenarios from which one can deduct that optimising solely for 2010 will almost certainly create extra adaptation cost later on compared to a cost-effectiveness strategy that aims to optimise over a longer time frame. This issue was already brought up in the conclusions of chapter 3.

Especially in industrial and building applications numerous studies indicate that transaction cost and hence the marginal abatement cost per ton can be brought down significantly. Furthermore, there are long run innovation possibilities enabling significant further reductions of energy intensities. The question becomes how much effort should be invested in R&DD&D and market transformation which does not cause too large extra cost up to 2010 and allows for lower costs in the longer run. Extra private and public cost must be weighed against lower future abatement cost and extra economic opportunities regarding exports. As regards climate policy construction it means that energy efficiency measures (buildings, industry, logistics and transport equipment) have strategic importance even though the contribution for the commitments in 2010 may be not spectacular. R&DD&D and market imperfections can then be focal points of instrument design aiming at a steady transformation. The essence of the evolution in the policy is picture in the scheme below (figure 8).

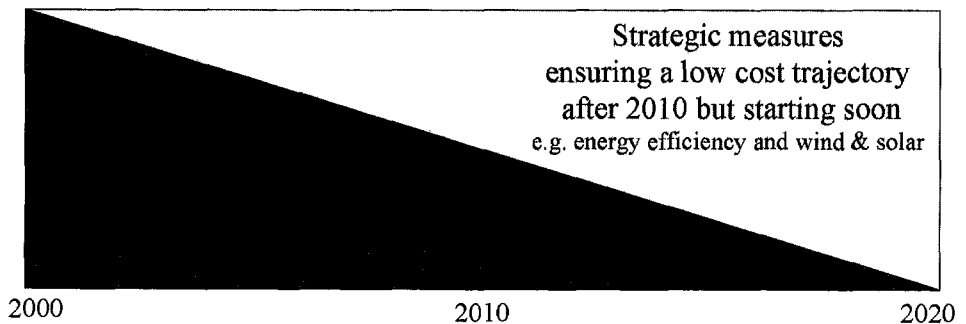


Figure 8. The evolution in the policy mix.

Interaction between instruments and between measures

Interaction between projects can appear both at the input and at the output side. Interaction at the input side for example would be the joint use of the same organisation to implement a measure. It means that the costs decrease per unit of implementation and consequently per unit of CO₂ equivalent saved.

A negative type of interaction at the input side takes place when the necessary institutional context for application of one instrument precludes the use of other

instruments requiring a different institutional environment. Generally spoken *direct limitation* on (company wise) emission levels conflicts with the context necessary for emission trading. Though this is normally quite evident within one sector or policy area such possible conflicts may be overlooked in case distinct but still interacting sectors are involved. Such errors could be partly prevented by analysing clustering phenomena in the economy. This can be done by means of input-output tables

In order to obtain overview one can make use of an interaction matrix. In such a matrix it is indicated whether the interaction is reinforcing (\uparrow) or reducing (\downarrow). An example based on table 3 is shown on the next page. Attributing values to the interaction indicators may require substantial preparatory studies. The present indicators are based on literature and expert judgement. Furthermore, the default assumption is that the indicated strength and even direction of the indicator is rated on the basis of default effort levels for both measures. However, there might be decreasing returns to scale, or more general non-linear relations, including the option that beyond some point the influence switches from positive to negative or vice versa. Measures not necessarily have symmetric relations

Table 4. Interaction between measure.

Affected measure	Affected element	Fuel switching	Conversion Efficiency*	Renewables	Efficiency** in indu & bu	Power trade	Permit trade
Measure 1	Private unit cost		↓	0	0	↑↓	↑↓
Fuel switch	Social unit cost		↓	0	0	↑↓	↑↓
	Potential		↑	0	↓	↑↓^	↑↓#
	Adoption speed		↑	↓	↓	0	0
	Reversion risk		0	0	0	↑	0
Measure 2	Private unit cost	↓		↑	0	↑↓	↑↓
Conversion	Social unit cost	↓		↑	0	↑↓	↑↓
Efficiency	Potential	↑		↓	↓	↑	↑↓#
	Adoption speed	↑		↓	↓	↑	0
	Reversion risk	0		0	0	0	0
Measure 3	Private unit cost	0	0		0***	↑↓	↑↓
Renewables	Social unit cost	0	0		0	↑↓	↑↓
	Potential	↓	↓		↑	↑↓	↑↓#
	Adoption speed	↓	↓		↑	↑↓^^	0
	Reversion risk	0	0		0	0	0
Measure 4	Private unit cost	↑	↑	0		0	↑↓
Efficiency	Social unit cost	↑	↑	0		0	↑↓
Ind/build.	Potential	↓	↓	↑		↓^^^	↑↓#
	Adoption speed	↓	↓	↑		↓	0
	Reversion risk	0	0	0		0	0
Measure 5	Private unit cost	0	0	0	0		0
Power trade	Social unit cost	0	0	0	0		0
	Potential	0	↑	0	↓		↑↓#
	Adoption speed	0	↑	0	↓		0
	Reversion risk	0	0	0	0		0
Measure 6	Private unit cost	0	0	0	0	0	
Permit trade	Social unit cost	0	0	0	0	0	
	Potential	↑↓#	↑↓#	↑↓#	↑↓#	↑↓#	
	Adoption speed	0	0	0	0	0	
	Reversion risk	0	0	0	0	0	

Notes to the table:

*) with the influence of conversion efficiency on fuel switch and vice versa it is assumed that the efficiency for the low emission fuel is improved. If the conversion efficiency of the current (emission intensive fuel) is improved the (effects) arrows would reverse.

**) efficiency in industry or buildings does not affect fuel switch potential if there is still another supply option which is skipped first

***) advanced low energy buildings often integrated the use of solar energy, large scale practice of such designs would lower the still high unit cost of solar

^) depending on prices in other countries there may be a discouragement or an encouragement to apply fuel switching

^^) in a totally free electricity market without environmental quality demands, the potential of renewables becomes smaller, however in case of a quasi green certificate market the opposite could be the case

^^^) substantial amounts of cheap import power would exert the same effect as fuel switching and conversion efficiency improvement

#) here applies a similar effect as in power trade, if the permit price is high compared to large potential of fuel switch options, it may enhance adoption speed and exhaustion of the total potential (this may be the case in Germany), conversely low permit prices will reduce the potential or at least postpone its use. For the same reason one could argue that the unit cost are influenced in this way.

4.4 Fitting instruments to the preferred measures

Given the findings in the previous sectors the question is what instruments will incite efficiently and effectively the four most promising options for 2010 and at the same time enable a good build up of the structural measures that enable much more reduction against reasonable cost after 2010. The list below is based on the discussion in the previous sections and the other background report on costs. In the first place it is looking to lower cost options. In the second place it takes into account significant potentials of which the costs can go down thanks to accompanying measures. Subsequently, taxation can render sufficient stimulus to implement changes. Finally, several regulatory obstacles are mentioned. Some of them may be easy to alleviate, while other obstacles may remain justifiable in relation to other policy requirements.

<u>Intensive up to 2010</u>	<u>Instruments needed</u>
Non-CO2 gases	Specific programme, maybe also surcharges, connects to actions already taken in baseline;
Fuel switching	Pricing of carbon content (taxation), a background study on the leeway in attribution of cost elements to customer types in a free electricity market and heat-power cross-subsidy space in DH systems, R&DD in as far as biomass <i>logistics</i> are a threshold and maybe start-up subsidies for biomass, a background study on an efficient and reasonably fair tax recycling lay-out;
Power trade	Prevent domestic taxation systems that are a disadvantage to credible (clean) power trade, scan legislation and spatial planning regulation on obstacles to the extension of power transmission capacity (either through costs or timing) and if necessary reconsider the conflicting rules;
Permit trade	Experiment with permit trade preferably at Nordic or Baltic level both IET and JI, stimulate the creation of a permit trade system amongst Annex B countries and at least among the European Annex B countries (even if ceilings are to be accepted), study the kind of R&DD&D policies needed to boost technology development and transfer – e.g. as part of sector VA's;

Long run strategicInstruments needed

Efficiency improvements	Study to what extent and how currently perceived marginal costs of in the industry efficiency can be reduced, subsequently start up or intensify R&DD&D actions for promising applications as well as market transformation actions in case of significant imperfections – both actions in VA frameworks, with some delay the pricing of carbon can be introduced (this needs balancing with the timing for fuel switching and the permit trade experiments)
Efficiency improvements in the built environment	Study to what extent and how currently perceived marginal cost of efficiency can be reduced, subsequently start up or intensify R&DD&D actions for promising applications as well as market transformation actions in case of significant imperfections – both actions in VA frameworks, the pricing of carbon is introduced here through the energy conversion sector, co-ordinate with actions in spatial planning e.g. through umbrella VA's ²⁷ ,
Conversion efficiency	on the one hand carbon taxation will enhance this, while R&DD support will be needed to cut very risky parts of development projects, co-operation with industries and institutes at EU scale is preferable
Renewables (solar, wind)	set a lower bound for installed capacity which ensures no serious competition with other options – possibly in connection with a green certificate market, survey willingness to pay for 'green energy' for several customer types, clarify spatial planning regulation and landscape issues for wind power, aim at integration of solar energy options in the built environment - notably new buildings, improve regulatory options for small scale supplies to the public grid
Transport equipment	in addition to international agreements with the car industry concerning fuel efficiency national measures are needed to ensure that the <i>actual fleet development</i> is at least as good as the international agreement aims at (e.g. purchase tax differentiation based on fuel

²⁷ . For example in the Netherlands next to building performance standards also area performance standards (for newly built areas) are introduced. It also connects to a EU project on systematic sustainable renovation practices in which Finland (VTT) takes part as well.

efficiency), continue experiments with low carbon options in public transport aiming at cost effectiveness

Transport and space stimulate and support RD&D in sustainable logistics, prevent urban sprawl, match urban extension with easy accessible public transport, promote biking and develop safe bicycle-infrastructure in cities

At this point we have proceeded up to step 3 of the evaluation process as pictured in figure 2. So far it has been a mixture of qualitative and fairly simple quantitative methods. The further iterations steps 2 and 3 and subsequently in step 4 and 5 are necessarily more quantitative oriented. The next paragraph will give an introduction to methods to be used in the further quantitative assessment. The results used in the analysis are of purely of educational nature and should therefore not be regarded real results for Finnish national or private cost levels.

4.5 Towards a quantitative treatment²⁸

4.5.1 Instrument incitement

The actual incitement level of an instrument cannot be derived straightaway from the comprehensive marginal cost curve of the total emission reduction potential (see fig. 4 in this report and fig 3.1 in Kemppi and Pohjola, 2000).

The standard textbook idea is that the incited reduction effort is determined by the intersection of the tax level (a horizontal line in fig. 4 and a vertical line in fig. 3.1 in Kemppi and Pohjola, 2000) and the marginal cost curve of emission reduction. There are two sources for deviation of this result. First, there are scale economies active at the side of policy programme supply and investment assessment. The policy makers and the measure implementor are facing not one overall curve as in the textbook case, but a multitude of curves, (at least) one for each measure type. This is pictured in figure 9 below. As a result there will be tendency to focus on measures that a priori have larger potentials at reasonable cost in order to reduce failure risks and high overhead cost.

²⁸ . This chapter discusses the points of departure and the results of preliminary exercises for modelling instrument incitement and package evaluation. Annex 2 gives an account of the model types implemented.

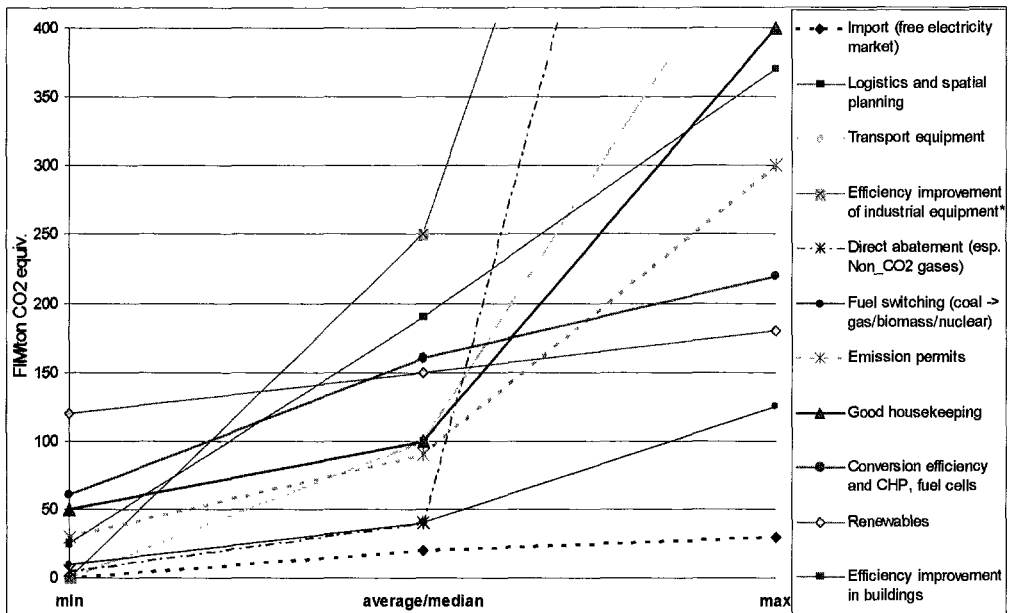


Figure 9. Stylised marginal cost curves (only lowest cost, median potential and maximum of table 3).

A second source of deviation comes on top of the aforementioned one. This concerns the actual specification of the capital stock of the potential investors. There will be spread in the energy efficiency of the capital stock (and consequently variation in the impact of taxation on unit cost) and the age distribution of the capital stock will vary. Furthermore, product differentiation may lead to small differences in price elasticities of demand for end products. All in all it implies that for each reduction option a company specific marginal cost curve could be drawn and consequently there is a substantial spread around the average marginal cost levels depicted in the 'textbook' curves as in figure 4. Now it will be obvious that application of a tax in reality will only cause a part of the indicated potential to be realised. For the economy as a whole one could think of an order of magnitude of 60% to 80%, but in some sectors such as transport and buildings it looks like the figure is lower.

Summarising, the incitement level of a measure due to the application of an instrument depends on:

- Marginal cost differential between current state and increased emission reduction efforts with and without incentive (from instrument);

- The efficiency level of the sector and its variation inside the sector;
- Significance of low unit cost of final product (demand elasticities);
- Age distribution of the capital stock
- Time lapse between installation of instrument and impact monitoring moment

One way to picture this process of instrument effectiveness is by means of a discrete choice model in which the arguments of the main function have latent variables. Another approach is by means of dynamic substitution models (see also Marchetti and Nakicenovic, 1979; Uytterlinde et al, 1999). The example model used in this study states that the progress of the market share (penetration) is steered by the internal rate of return (IRR) and by the extent of succeeded and remaining penetration in the previous period ($P(t)$ and $(1 - P(t))$). Furthermore, the effectiveness with which the influence is communicated, is taken into consideration.

Even though discrete choice models have been used a lot in economics (e.g. in transport and consumer purchases), there is a preference to use in this study the second type of model. This approach has been used several times to describe technology change in case of generations or waves of newly introduced technologies. It responds also better to synergy phenomena between options.

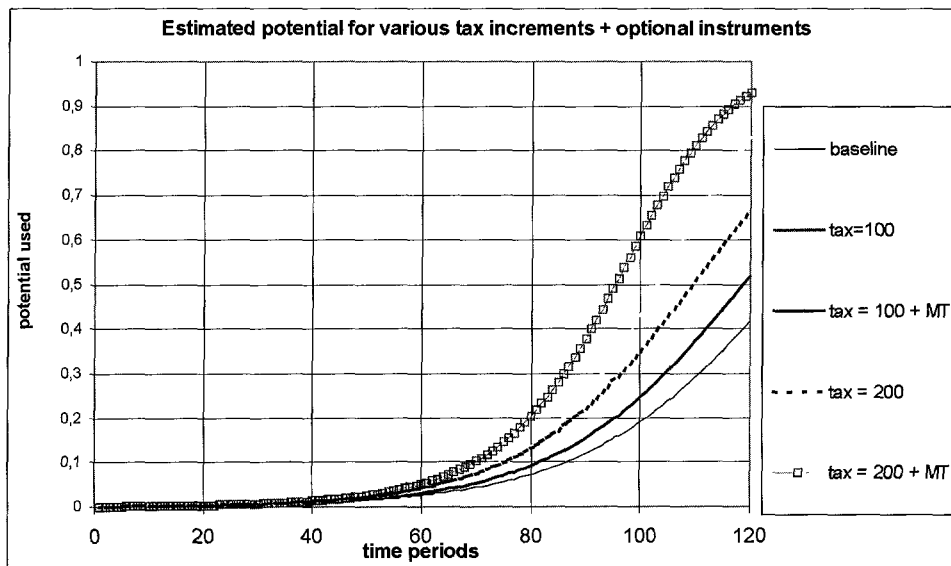


Figure 10. Penetration curve based on Appendix equations 6-10, with one alternative.

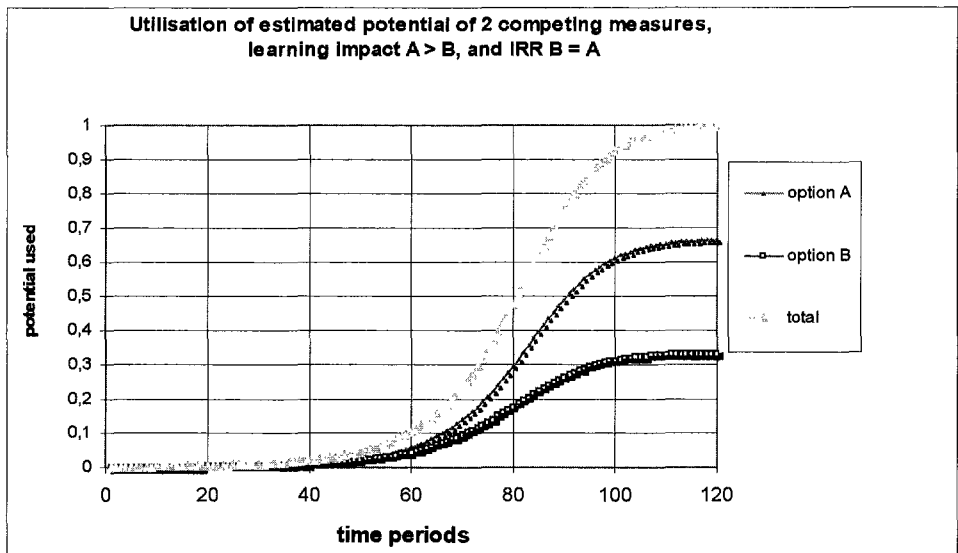


Figure 11. Penetration curve, with two lasting alternatives.

4.5.2 Package evaluation

Applying several possible measure packages to different scenarios results in a shortlist of most attractive packages (steps 4 and 5 in figure 2 of chapter 2). These packages can now be simulated in economic and ecological models, in order to obtain a better founded ranking. The KESSU-EFOM linkage will provide a medium term evaluation of the net economic cost to Finland. Finally, a risk and uncertainty analysis can be performed. First, it can be studied what is the likelihood that environmental targets are not met and/or total socio-economic cost is higher than expected for a given scenario-package combination. Subsequently, it can be analysed what package seems to have the overall best score in different scenarios (step 6 in figure 2). A final ranking could then be made based on a multi-criteria analysis (MCA) or by means of hierarchical goal programming possibly as a subset of the MCA.

Depending on the thoroughness of the information the ratings of the projects can be ordered using quantitative or qualitative data analysis techniques. Items 1 – 7 are distinct final impacts²⁹, the items 8-13 say something about the likelihood of the results of items 1 – 7 or give some intermediate impacts. The information of items 8 – 13 can be used to filter the ratings of items 1 – 7.

²⁹ . The numbering refers to the 13 criteria mentioned in section 4.1.

In the current example it is assumed that only one scenario is applied. In principle it is possible to apply various scenarios. This means the entire sequence has to be repeated for each scenario. From a cost and duration perspective it might be wise to wait with the application of scenarios until the package evaluation phase. It would mean that at the individual policy area level a business as usual + perhaps very likely new developments and policies are added. Please note that measures and measure packages should not be confused with scenarios.

A simple example

For two not entirely hypothetical instruments an example exercise has been made. The two options are a programme that relies mainly on taxation (including recycling of the tax revenues) and a programme that uses taxation in combination with efforts to reduce the market imperfections. The programmes are evaluated on social unit cost, private unit cost, exploited emission potential, other environmental effects and other effects (other policy areas). The costs are expressed in FIM/ton, the potential in tons CO₂ equivalent, the other effects get a rating from -5 (very damaging impact) to +5 (very beneficial impact).

For the 'tax only' programme a CO₂ tax of 250 FIM per ton is assumed, while for a 'tax + transparency' programme a tax of 150 FIM per ton is applied. However, in the latter programme substantial extra government expenditures are geared towards initiatives and instruments that reduce the market imperfections and hence the transaction cost. In both cases a net investment effect (slightly positive) and a tax interaction effect (negative) will occur. For the 'tax only' programme the net investment effect amounts to +0.2% of GDP in 2010, while the tax interaction effect is rated at -0.9% of GDP in 2010. For the 'tax + transparency' programme it is simply assumed that the effects are 0.6 (150/250) times the size of the effects of the 'tax only' programme. In addition the 'tax + transparency' programme needs government spending on for the supporting activities, this effect is set at -0.25% of GDP in 2010. The Finnish GDP in 2010 is rated at 1050 billion FIM (in 2000 prices). The reduced amount of emissions is 22 Megaton.

The assumptions result in ex post private unit costs of 318 and 191 FIM/ton for 'tax only' and 'tax + transparency' respectively, while the ex post social cost are rated at 318 and 305 FIM/ton. As regards other items it is assumed that the 'tax only' programme causes less disturbance in the overall government programme and consequently has a better rating on 'other effects'. On the other hand the active market transformation policy in the second package is assumed to cause positive spill-over effects to other environmental problems (side-effects of more environmental technology development). Therefore this package gets a better rating on that issue.

The rating is transformed into index figures, for which the default option is set to 100. Three weighing options were used. One with equal weights (33,3%) for commercial sectors, ministries and the citizen (tax payer), one with 80% weight

for the commercial sector and one with 80% weight for the citizen (tax payer). For each of the stakeholder types different priorities are attached to the criteria. The default option is defined as the 'tax only' option with equal weights for all stakeholders.. The MCA evaluation results are summarised in the table below. For all parties the alternative is better than the default. However, the relative differences indicate that the citizens dislike the 'tax only' option as it incurs most probably higher taxation. In the alternative programme the difference between private cost and social cost (i.e. transfers at the expense of the tax payer) temperate the positive rating of the lowered overall cost. The specification of the function implies that social cost is more decisive than private cost, therefore the commercial ratings start at a higher level. This shows the preliminary character of the application. Scaling is one of the issues to be dealt with.

MCA example ratings	Tax only	Tax + market transformation
Average	100	136
Commercial primacy	236 (100)	281 (122)
Citizens primacy	82 (100)	118 (144)

This is only a temporary implementation of the system. In practice more instruments will be used (see the sector programmes of the ministries and also the instrument overviews in Hildén et al (1999). The handling of larger packages will be dealt with in Phase 2.

The influence attributed to social unit cost is somewhat larger than for private unit cost. However, in case of a big difference between the two, a significant correction takes place in order to indicate that the instrument is expected to cause substantial redistribution effects and hence in a comprehensive model analysis the net benefits may turn out to be smaller.

The results can also be displayed graphically, representing 'decision space'.. This is done in figure 12 below. Social cost and private cost levels are varied from 100 to 500 FIM (in steps of 10 FIM, hence the numbering 1-40 along the x- and y-axis). Other items are held constant. The colours in the plane refer to ranges of MCA ratings. The default programme is indicated by a white dot just on the border of the dark and light area in the plane. The alternative programme implies a moving up along private cost axis with only a modest move in social cost. The picture shows that the light area is most decisive. Moving into the dark part means lousy solutions, while it requires quite low ex post unit cost to get beyond the 150 rating. Please note that changing other circumstances would involve the drawing of a new plane which may be higher, lower or intersect with the current one. If the different items, that are held constant here, are not totally independent from the cost levels and each other, one needs to redraw the plane being the

synthesis of planes under varying conditions. This could cause more irregularities in the plane.

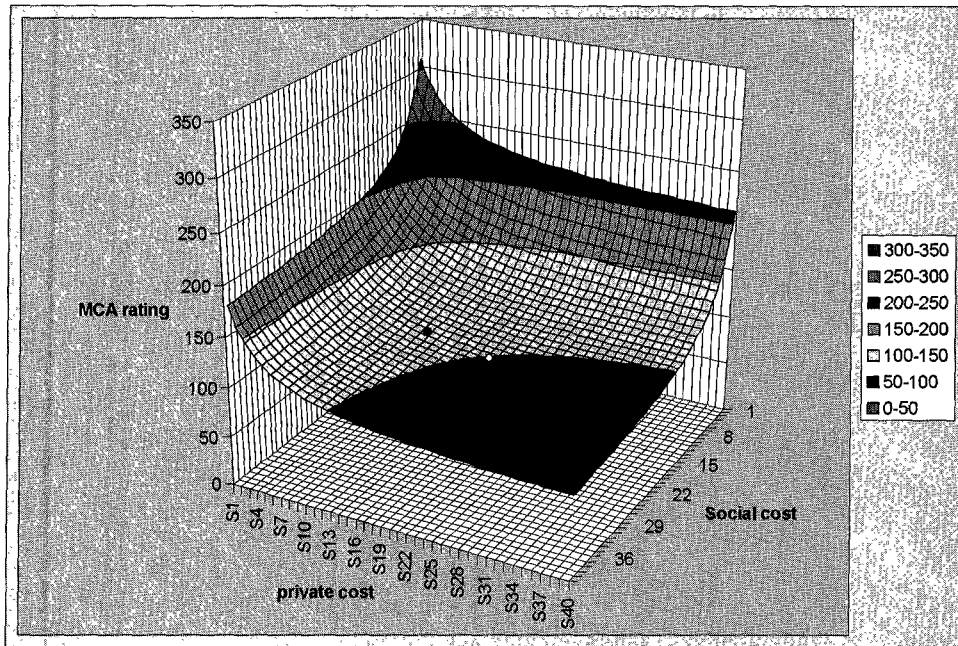


Figure 12. Example of MCA decision space - trade-off between social and private unit costs, other items held constant.

5 Conclusions

Process in addition to analysis

This report discussed the evaluation of climate policy options. The discussion touched not only upon the analysis of the economic merits of various instruments and measures, but also stressed the importance of a *well defined evaluation process*. In order to prevent problems in later stages of the decision making it is important that the evaluation process is:

- Clear and tractable
- Consequent
- Comprehensive
- Involving all stakeholder groups

Modelling compromises and decision support tools

The problematic ability of currently available analytical tools to connect instruments to measures calls for a combined use of macro-economic and specific energy models. It also necessitates an iterative procedure to achieve credible social-economic optima, given the pre-specified objectives. Around a core system of linked energy-economic models a evaluation support system (e.g. based on multi-criteria analysis) can assist to clarify the trade-offs to be made in the prime stages (when selecting instruments) and in the final stages (when comparing policy packages on their overall performance).

Prioritising instruments

Market based instruments (taxes, tradable permits) are recommended to be the cornerstone in policy design. To avoid extra burdens in the economy a *tax recycling programme* should come alongside the taxation. However, *market imperfections will require the use of additional instruments*, such as RD&D and market transformation and occasionally performance standards in order to make markets more responsive for price instruments. The correction of market imperfections can also imply a stepwise introduction of market based instruments, e.g. with low taxes in initial stages.

Voluntary agreements can function as clarifying and negotiation cost reducing frameworks in which the default mix, as just indicated, is tailored to the specific situation of sectors. For example, in sectors exposed to foreign competition it should be tried to *avoid regulatory competition (dis)advantages*. Instead, concertation throughout the EU is recommendable.

Background questions

Turning back to the challenge of medium term policy package design, during the preparation of a policy to fulfil the Kyoto protocol, it is recommended to find out:

- How voluntary agreements can create an institutional environment which is conducive to achieving the emission targets by the lowest overall cost to society;
- What kind and what intensity of supporting measures (R&DD&D) are needed for a most effective reduction of marginal costs of efficiency and abatement options;
- What is the right timing to introduce taxation given the expected results of R&DD&D activities, how should it build up and what degree of earmarking of recycled tax revenues is recommendable;
- How a national and perhaps Nordic or Baltic trade system can be exploited prior to and as a preparation of a large international trading system;
- How and when can a solid and credible permit trading system be established at the EU level and involving at least the European Annex B countries, in which not only national agencies but also large industries are allowed to trade, and how Finland can contribute to the successful establishment of such a trading system;
- What taxation and regulatory reforms are at least necessary in Finland and other EU member states to prevent serious biases in the permit market or in other company decisions (e.g. concerning location of new investments).

Preliminary order of measures and instruments required for their incitement

Please note that the list below is preliminary and is very likely to see some changes, either due to model assessment results and/or due to political developments (e.g. success or failure of COP6 and feasibility of permit trade).

Intensive up to 2010*Non-CO2 gases*

Specific programme, maybe also surcharges, connects to actions already taken in baseline;

Fuel switching

Pricing of carbon content (taxation), a background study on the leeway in attribution of cost elements to customer types in a free electricity market and heat-power cross-subsidy space in DH systems, R&DD in as far as biomass *logistics* are a threshold and maybe start-up subsidies for biomass, a background study on an efficient and reasonably fair tax recycling lay-out;

Power trade

Prevent domestic taxation systems that are a disadvantage to credible (clean) power trade, scan legislation and spatial planning regulation on obstacles to the extension of power transmission capacity (either through costs or timing) and if necessary reconsider the conflicting rules;

Permit trade

Experiment with permit trade preferably at Nordic or Baltic level both IET and JI, stimulate the creation of a permit trade system amongst Annex B countries and at least among the European Annex B countries (even if ceilings are to be accepted), study the kind of R&DD&D policies needed to boost technology development and transfer – e.g. as part of sector VA's;

Long run strategic*Efficiency improvements in the industry*

Study to what extent and how currently perceived marginal costs of in the industry efficiency can be reduced, subsequently start up or intensify R&DD&D actions for promising applications as well as market transformation actions in case of significant imperfections – both actions in VA frameworks, with some delay the pricing of carbon can be introduced (this needs balancing with the timing for fuel switching and the permit trade experiments).

Efficiency improvements in the built environment

Study to what extent and how currently perceived marginal costs of efficiency can be reduced, subsequently start up or intensify R&DD&D actions for promising applications as well as market transformation actions in case of significant imperfections – both actions in VA frameworks, the pricing of carbon is introduced here through the energy conversion sector, co-ordinate with actions in spatial planning e.g. through so-called umbrella VA's.

Conversion efficiency

On the one hand carbon taxation will enhance this, while R&DD support will be needed to cut very risky parts of development projects, co-operation with industries and institutes at EU scale is preferable.

Renewables (solar, wind)

Set a lower bound for installed capacity which ensures no serious competition with other options (possibly in connection with a green certificate market), survey willingness to pay for green energy for several customer types, clarify spatial planning regulation and landscape issues for wind power, aim at integration of solar energy options in the built environment – notably new buildings, improve regulatory options for small scale supplies to the public grid.

Transport equipment

In addition to international agreements with the car industry concerning fuel efficiency national measures are needed to ensure that the *actual fleet development* is at least as good as the international agreement aims at (e.g. purchase tax differentiation based on fuel efficiency), continue experiments with low carbon options in public transport aiming at cost effectiveness.

Transport and space

Stimulate and support RD&D in sustainable logistics, prevent urban sprawl, match urban extension with easy accessible public transport, promote biking and develop safe bicycle-infrastructure in cities.

APPENDIX 1

IMPLEMENTED CLIMATE POLICY RELEVANT INSTRUMENTS IN FINLAND

Taxation

Carbon tax	<p>base rate is 102 FIM / ton CO₂, for natural gas it is 50% of this tariff, while peat gets a separate treatment resulting effectively in approximately 25% of the tariff applied to coal and oil products.</p> <p>a separate treatment has been arranged for electricity production. There is a taxation on electricity sales. For all biomass power units, for peat power units under 40 MW, for hydro units up to 1MW, for wind power and for blast furnace gas there is a subsidy per kWh just as large as the electricity tax per kWh. For industry, electricity tax is 40% lower than for other users.</p>
Motor fuels	<p>there is quite a high excise duty on motorfuels (approximately 14x the level of carbon tax for gasoline and about 6x for diesel).</p>
Car purchase tax	<p>depending on pre-tax price of car and depending on cylinder content for motorbikes. There are reduction possibilities for low emission vehicles.</p>
Subsidies	<p>for investment in biomass based energy systems</p> <p>for investment in energy saving equipment</p> <p>for support for energy scans in companies and buildings.</p> <p>the entire amount of subsidies relating to getting the energy efficiency markets and renewables markets going (thus apart from those in relation to electricity tax) is rather small compared to for example Sweden, Denmark and the Netherlands.</p>
Voluntary agreements	<p>for several sectors VA's for energy saving have been drawn up between the Ministry of Trade</p>

and Industry (KTM) and companies from those sectors, also a framework arrangement with municipalities has been made. In the industry 75% of the consumption is involved, whereas the same share applies for electric power production. For district heat it is 51% and for other sectors such as transport and real estate considerably lower. The agreements are indeed not much more than frameworks, that contribute to more clarity regarding options and also support for energy scans is connected to these frameworks. Furthermore, it includes a fairly light minimum requirement for annual reporting of progress of the partners.

R&D programmes

there is and has been a series of programmes concerning technology development notably regarding energy conversion, biomass, and industrial end use efficiency. Next to that also some efforts for buildings, transport and behaviour. In addition R&D funding is obtained from the EU programmes and from the Nordic Council programme.

Awareness, dissemination, etc.

the energy agency MOTIVA provides next to assistance in some of the subsidy schemes (notably the energy scans) quite some information through web site approachable data bases, courses, experiments, and monitoring and progress reports.

APPENDIX 2

Towards a quantitative treatment

Instrument incitement

Summarising, the incitement level of a measure due to the application of an instrument depends on:

- Marginal cost differential between current state and increased emission reduction efforts with and without incentive (*from instrument*);
- The efficiency level of the sector and its variation inside the sector;
- Significance of low unit cost of final product (demand elasticities);
- Age distribution of the capital stock
- Time lapse between installation of instrument and impact monitoring moment

This enables us to represent incitement formally as follows:

$$P(M_{b,t+\delta} \geq L_{a,t} | I_{a,t} = N) = f(MC_{Mb,t}, \delta, dY_t, VK_t, \varepsilon_{p,e,t}, E_{z,t}) \quad (1)$$

$$MC_{Mb,t} = f(L_{z,t}, \sum_{t_0-t} \{R\&D_t\}, T) \quad (2)$$

The first equation states in general terms that the conditional probability that the measure efforts exceeds a default level at time t while the instrument impulse achieves level N at time t , than the probability is function of the marginal cost differential, the time lapse since the instrument is working, the economic growth of the sectors subject to the instrument, the vintage distribution of the capital stock (potential for renewal), the price elasticity of the demand for end products of the sector and the emission level of the sector. The marginal cost differential between continuation or renewal will depend on the default developments, the intensity of the incentive (tax), the R&D intensity and the efforts to reduce market imperfections This is reflected in second example equation.

P	Probability (if stochastic function) or Penetration (if penetration function)
M	Measure (investment leading to reduction of nn Megaton CO ₂ eq.)
L	default Level of efficiency/abatement investment (in that sector)
I	Instrument impulse (subsidy %, tax rate, ceiling, etc.)
IRR	Internal Rate of Return
MC	Marginal Cost differential between target measure and default
dY	economic growth (in that sector)
VK	Vintage distribution of the capital stock (in that sector)
E	Level of Emissions (in that sector)
R&D	Investments in relevant R&D

ε_p	price elasticity of end product of sector
δ	time lapse effect since installation of instrument
T	expenditures on market Transformation (networking)

One way to picture this process of instrument effectiveness is by means of a discrete choice model in which the arguments of the main function have latent variables (see for example Maddala, 1983).

The discrete choice model as tried out for this study looks as follows:

$$P(M) = e^{a \cdot \text{tax} + b \cdot \text{MC} + c \cdot \delta} / (1 + e^{a \cdot \text{tax} + b \cdot \text{MC} + c \cdot \delta}) \quad (3)$$

$$\text{MC} = m \cdot (1 + \Delta \text{MC})^{\text{R\&D}} \quad (4)$$

$$\delta = d_t \cdot (t - t_0)^{\text{VK}} \quad (5)$$

An example of the application of the discrete choice model is shown in figure 10.

Another approach is by means of dynamic substitution models follows (see also Marchetti and Nakicenovic, 1979; Uytterlinde et al, 1999).

The example of the predator-prey models applied here looks as:

$$P(t+1) = P(t) + a \cdot \text{IRR} \cdot P(t) \cdot (1 - P(t)) \quad (6)$$

$$\text{IRR} = f(\text{MC}, \text{tax rate}, \text{market interest}) \quad (7)$$

$$a = (\text{MC}^* - \text{MC}, \text{RD\&D}, t) \quad (8)$$

$$a = A_0 + b \cdot t \quad (9)$$

$$b = f(\text{RD\&D}) \quad (10)$$

This model states that the progress of the market share (penetration) is steered by the internal rate of return (IRR) and by the extent of succeeded and remaining penetration in the previous period ($P(t)$ and $(1 - P(t))$). Furthermore, coefficient a represents effectiveness with which the influence is communicated. This coefficient is here further explained by a constant and learning part (equation 9 and 10).

In case of more than one alternative the equations get slightly more complicated, but not essentially different than in equations 5 to 10. This would alter in case long range perspectives are applied in which market shares of the alternatives can change including the earlier built up shares of other alternatives. Even though discrete choice models have been used a lot in economics (e.g. in transport and

consumer purchases), there is a preference to use in this study the second type of model. This approach has been used several times to describe technology change in case of generations or waves of newly introduced technologies. It responds also better to synergy phenomena between options.

Package evaluation

Applying several possible measure packages to different scenarios results in a shortlist of most attractive packages (steps 4 and 5 in figure 2 of chapter 2). These packages can now be simulated in economic and ecological models, in order to obtain a better founded ranking. The KESSU-EFOM linkage will provide a medium term evaluation of the net economic cost to Finland. Finally, a risk and uncertainty analysis can be performed. First, it can be studied what is the likelihood that environmental targets are not met and/or total socio-economic cost higher than expected for a given scenario-package combination. Subsequently, it can be analysed what package seems to have the overall best score in different scenarios (step 6 in figure 2). A final ranking could then be made based on a multi-criteria analysis (MCA) or by means of hierarchical goal programming possibly as a subset of the MCA.

Depending on the thoroughness of the information the ratings of the projects can be ordered using quantitative or qualitative data analysis techniques. Items 1 – 7 are distinct final impacts³⁰, the items 8-13 say something about the likelihood of the results of items 1 – 7 or give some intermediate impacts. The information of item 8 – 13 can be used to filter the ratings of items 1 – 7. From the filtering develops a new set of scores for items 1 – 7. Subsequently, by applying a weighing procedure an overall ranking can be produced. The procedure is described formally as follows:

definitions

Policy area:	p
Measure in policy area p):	m_p
Score on individual criterion j for measure m :	$s_{mp}(c_j)$
Filtered score, by using criteria $i+1$ to j to filter criteria 1 to i :	$fs_{mp}(c_i)$
A filter function g_i for filtering the score of main criterion i : $g_i(s_{mp}(c_{i+1}) \dots s_{mp}(c_j))$	
Aggregate score, weighed sum over criteria 1 to i :	S_{mp}
A transformation function to infer a total rating from the different criterion ratings	Γ
Weight for main criterion i of actor k :	w_{ik}

³⁰ . The numbering refers to the 13 criteria mentioned in section 4.1

Action 1:

attribute scores for each criterion with respect to the measures under scrutiny, i.e

$$s_{mp}(c_i) = x,$$

whereas, depending on the nature of the criterion and the available data,

$$x \in \mathbb{R} \text{ or } x \in \{X_1, X_2, \dots, X_n \} \text{ or } x \in [X_{\min}; X_{\max}] \quad (11)$$

Action 2:

Use the scores for likelihood and intermediate ratings to filter main scores, i.e

$$fs_{mp}(c_i) = g_i(s_{mp}(c_{i+1}), \dots, s_{mp}(c_j)) \quad (12)$$

whereas g is a function attributing a score to criterion i , possible functional forms will be discussed later.

Action 3:

Determine the weighed sum of the remaining filtered scores per measure

$$S_{mp} = \sum_i \sum_k \{w_{ik} \cdot (fs_{mp}(c_i))\} \quad (13a)$$

or

$$S_{mp} = \Gamma(w_{ik} \cdot (fs_{mp}(c_i))) \quad (13b)$$

whereas Γ is a function transforming the individual scores per criterion into an overall rating for an instrument, possible functional forms will be discussed later.

Whereas we a priori assume that actors have equal importance unless otherwise indicated explicitly, so for $\forall_{i,k}$

$$w_{ik} = w_{ik+1} \quad (14)$$

Alternative bases for determining the relative importance of actors, could be for example the relative sizes of ownership (as with share holders) or the number of (predetermined) voting rights, the area of land touched, the volume of the population represented, etc.

In the above example is assumed that only one scenario is applied. In principle it is possible to apply various scenarios. This means the entire sequence has to be repeated for each scenario. From a cost and duration perspective it might be wise to wait with the application of scenarios until the package evaluation phase. It would mean that at the individual policy area level a business as usual + perhaps

very likely new developments and policies are added. Please note that measures and measure packages should not be confused with scenarios.

A simple example

For two not entirely hypothetical instruments an example exercise has been made. The two options are a programme that relies mainly on taxation (including recycling of the tax revenues) and a programme that uses taxation in combination with efforts to reduce the market imperfections. The programmes are evaluated on social unit cost, private unit cost, exploited emission potential, other environmental effects and other effects (other policy areas). The costs are expressed in FIM/ton, the potential in tons CO₂ equivalent, the other effects get a rating from -5 (very damaging impact) to +5 (very beneficial impact).

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The rating used is based on an application of equation 13, which is finally normalised to an index, for which the default option is set to 100. Three weighing options were used. One with equal weights (33,3%) for commercial sectors, ministries and the citizen (tax payer), one with 80% weight for the commercial sector and one with 80% weight for the citizen (tax payer). For each of the stakeholder types different priorities are attached to the criteria. The default option is defined as the 'tax only' option with equal weights for all stakeholders..

The MCA evaluation results are summarised in the table below. For all parties the alternative is better than the default. However the relative differences, indicate that the citizens dislike the ‘tax only’ option as it incurs most probably higher taxation. Yet, in the alternative programme the difference between private cost and social cost (i.e. transfers at the expense of the tax payer) temperate the positive rating of the lowered overall cost. The specification of the function implies that social cost are more decisive than private cost, therefore the commercial ratings start at a higher level. This shows the preliminary character of the application. Scaling is one of the issues to be dealt with.

MCA example ratings	Tax only	Tax + market transformation
Average	100	136
Commercial primacy	236 (100)	281 (122)
Citizens primacy	82 (100)	118 (144)

In the example function (13) was implemented as follows:

$$S_{mp} = \Gamma [w_{ik} \cdot (fs_{mp}(c_i))] \quad (15)$$

where $i = 1, \dots, 6$; $k = 1,2,3$; $m = 1, 2$

$$cw_i = w_{ik} \cdot w_k (fs_{mp}(c_i)) \quad (16)$$

$$S_{mp} = \{(cw_3 \cdot cw_4)^{10/cw2} + 0,75 * (cw_3 \cdot cw_4)^{10/cw1}\} (1+cw_5/10 + cw_6/10) \quad (17)$$

This is only a temporary implementation of the function. In practice more instruments will be used (see the sector programmes of the ministries and also the instrument overviews in Hildén et al (1999). The handling of larger packages will be dealt with in Phase 2.

The influence attributed to social unit cost is somewhat larger than for private unit cost. However, in case of a big difference between the two, a significant correction takes place in order to indicate that the instrument is expected to cause substantial redistribution effects and hence in a comprehensive model analysis the net benefits may turn out to be smaller.

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