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Annex I Expert Group on the United Nations Framwork Convention on Climate Change

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FOREWORD

This Working Paper is one of a series of eighteen studies carried out under the project: "Policies and Measures for Possible Common Action". The project was carried out by the OECD, together with the International Energy Agency, in 1996 and 1997 for the Annex I Expert Group on the United Nations Framework Convention on Climate Change (UNFCCC). The goal of the project was to assess a range of cost-effective greenhouse gas mitigation policies and measures for countries and Parties listed in Annex I to the UNFCCC. The eighteen working papers have been made widely available as analytical input to negotiations under the UNFCCC Ad hoc Group on the Berlin Mandate. The working papers may also provide input to national decision making processes on greenhouse gas mitigation policies. The measures analysed do not necessarily represent policy preferences of Annex I Parties.

The project benefited greatly from substantial input from delegates. Three successive chairmen of the Annex I Expert Group provided outstanding leadership for the project: Doug Russell (Canada); Ross Glasgow (Canada); and Ian Pickard (United Kingdom). The work was supervised by Jan Corfee Morlot (OECD). Fiona Mullins (OECD) drafted the initial framework which was used to structure the eighteen working papers

The Annex I Parties or countries referred to in this document refer to those listed in Annex I to the UNFCCC: Australia, Austria, Belarus, Belgium, Bulgaria, Canada, Czechoslovakia (now Czech Republic and Slovakia), Denmark, the European Community, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Latvia, Lithuania, Luxembourg, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russian Federation, Spain, Sweden, Switzerland, Turkey, Ukraine, United Kingdom and United States. Where this document refers to "countries" or "governments" it is also intended to include "regional economic organisations," if appropriate.

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EXECUTIVE SUMMARY

The objective of this study on *Taxation (carbon/energy)* is to analyse the feasibility of applying such taxation at a common level within Annex I countries drawing from existing experience with taxes implemented to reduce energy-related CO_2 emissions, as well as from a range of available modelling and policy studies.

Context

In most OECD Member countries, almost all forms of energy are taxed to varying degrees, not primarily for greenhouse gas purposes, but to raise government revenues or to internalize other externalities. In fact, there is often an almost inverse relationship between fossil energy price levels, including taxes and subsidies, and their carbon content, i.e., fossil fuels with higher carbon content have lower end-use prices than those with lower carbon content. On a sectoral basis, industrial energy use is generally subject to a low level of taxation, whereas transportation fuels are usually heavily taxed, although with some disparity across countries. There is currently little commonality in the level of final-energy pricing, nor is there any commonality in the energy resources and fuel mixes among Annex I Parties.

Five countries (Denmark, Finland, the Netherlands, Norway and Sweden) have adopted carbon/energy taxes which generally include some rebates or exemptions for industry on competitiveness grounds, or alternative measures to achieve similar objectives. At least two other countries have considered modest carbon/energy taxes (Australia and the United States), but those proposals were not accepted. New Zealand has decided that a carbon tax will be introduced in 1997 if emissions are not on track to achieve existing targets, but is also examining alternative approaches such as tradeable permits.

The European Union is in the process of considering a proposal for a common carbon/energy tax put forward by the European Commission.

Policy objectives

The principal policy objective of taxing carbon and/or energy is to provide incentives to reduce CO_2 emissions, whether through fuel switching, energy conservation, or modal shifts, especially in a context of relatively low energy prices.

Taxes on carbon/energy also help reduce other environmental externalities. Studies for specific countries indicate that the secondary benefits achieved through reductions in other environmental impacts could offset part of the social cost of taxes, as estimated in these studies. In some cases, however, countries have already taken independent steps to abate other environmental impacts, therefore secondary benefits may not always be significant.

Revenues from carbon/energy taxation can be used to reduce other taxes that are viewed as introducing high distortions on the economy, and help achieve other policy objectives.

Approach and methodology

This study relies on modelling literature (IPCC Working Group III and other specific studies, when appropriate), as well as on current carbon and/or energy taxation policies that have been introduced to limit CO_2 emissions, including implementation issues, recycling schemes and differentiated sectoral approaches. When possible, lessons are also drawn from pending or rejected proposals for carbon/energy taxation.

A key methodological problem arises from the difference between taxes that have been implemented and modelling approaches to carbon/energy taxation, in particular when looking at common taxation across countries or regions. Implemented taxes are introduced as part of policy packages to reduce energy-related CO_2 emissions. These take into account sectoral differences, through differentiated tax levels, exemptions, or subsidies for energy efficiency improvements. Most modelling studies, however, look at a single-level tax as the only instrument to abate emissions.

In studies based on global economic models, the tax should be considered a proxy for the marginal cost of reduction. As such, these studies often provide results that apply to all greenhouse gas reduction strategies: some of their results are not specific to taxation as a tool to reduce emissions. In theory, any difference in marginal costs of reduction across regions entails that similar reductions can be achieved in a more economically efficient fashion by equalizing the marginal cost of reduction, represented by a common tax. It is not at all clear that cost and greenhouse gas potential estimates from such studies can be used to compare unilateral and common actions, given the complexity of real taxation schemes, as illustrated by current experience.

Furthermore, studies of unilateral taxation fail to describe what actions are taken by other Annex I Parties to limit their emissions. This and the previous points lead to the conclusion that it is not possible to provide a full quantified comparison of unilateral versus common taxation.

This study does not address issues related to equity, a potentially key element in the design of and agreement on common carbon/energy taxation.

Description of measure(s)

The study looks at taxes based on the carbon and/or energy content of different fuels, from carbon taxes to energy taxes. As an illustration, restructuring *existing* energy taxes applied to all fossil fuels, based on their carbon/energy content would contribute to significant CO_2 reductions. This, however, is not a straightforward option, since existing taxes have been introduced for (fiscal, environmental and other) purposes that cannot be discarded.

The schemes adopted for recycling tax revenues are crucial for the analysis of the economic impacts of carbon/energy taxes. Among others, the study looks at the opportunity of using tax revenues to finance carbon/energy efficiency improvements in sectors where the increase in energy expenditures would be most damaging, e.g. due to rigidities in the capital stock. It also touches on the possibility of coupling carbon taxation with carbon sequestration.

Different national circumstances, e.g. with respect to the level of economic development, the availability of energy resources and end-use energy prices, are potential barriers to implementation of a single carbon/energy tax as a measure for common action at the moment. A less ambitious suggestion would be to agree on pricing as an instrument to reduce energy-related CO_2 emissions in the long run, such as an agreement to keep domestic fossil fuel/energy prices from declining in real terms. However, further analysis would be needed to look at implementation issues related to such an option.

Rationale for common action

The rationale for common action is based on theoretical and empirical analyses which find that a more cost-effective outcome in aggregate economic terms would be obtained if all participating countries would equalize their marginal cost of reduction, represented by a tax in modelling studies.

An agreement to introduce price signals on carbon/energy would make such policy more effective than if it were adopted unilaterally. It may also help avoid establishing complex border tax adjustments between participating countries, although border tax adjustments might still have to be implemented for trade with other regions (pending their being legally and technically feasible).

A widely-agreed price signal on CO_2 emissions could create a significant market for lower-carbon technologies. This could result in cost reductions for such technologies, through economies of scale enabled by sales on a larger market than in the case of unilateral action, without picking “winners and losers”.

In practice, a number of implementation issues stand in the way of adopting a common taxation, starting with sectoral differences within countries, and different levels in energy pricing (see the experience of the carbon/energy tax proposed by the European Commission). When common taxation is considered, a flexible approach, e.g. relying on phased-in price increases, or a broad agreement on the need to reflect the cost of climate change in energy prices, may alleviate some implementation problems at the national level (e.g., the need for exemptions on competitiveness grounds).

Possible participants and vehicles for action

The question of possible adoption of carbon/energy taxes either at a national or some common level among Annex I Parties must be addressed on the background of current energy policies. Countries with economies in transition are still trying to reduce subsidies and achieve pricing at marginal production cost for all end-use sectors. Raising prices to cover production costs should already contribute to reducing energy-related CO_2 emissions. Real carbon/energy taxes, to be applied on top of the marginal cost of production, are not likely to be a priority for those countries before marginal cost pricing is achieved, i.e., subsidies are removed.

Greenhouse gas reduction potential

General modelling results

Modelling studies typically evaluate the impact of reaching different limitation and reduction objectives through the use of carbon and/or energy taxation. These target-based studies suggest that the potential for abating CO_2 emissions from energy use through carbon/energy taxation is in general high in the long term. Modelling results confirm the economic intuition that CO_2 emission reductions are obtained more effectively with carbon taxation than with carbon/energy or energy taxation. These results are produced under specific assumptions, such as optimizing behaviour by all agents in the economy.

Price instruments, if applied coherently over the long-run, do provide a signal to abate the energy intensity of production and consumption. It can be said that current modelling approaches tend to underestimate the adaptive behavior of producers and consumers over the long run in response to steady changes in price signals, because global economic models underestimate the innovative techological responses, and phenomena such as economies of scale and learning curves, which could increase the reduction potential of a given tax level.

Economic and technology-based models both indicate that the marginal reduction cost to achieve a similar reduction objective would vary across countries, a conclusion that is consistent with different national circumstances. Because of differences in marginal cost of reduction, global economic models arrive at the conclusion that equalizing marginal reduction costs, e.g. through a common tax level, would minimize the aggregate GDP cost, or that a higher reduction potential could be achieved at the same overall GDP cost. Again, this conclusion illustrates a general economic principle that applies to all policies and measures able to equalize marginal reduction costs across all greenhouse gases and sectors.

Results for the short and medium term indicate that energy users would respond to a price signal over time by reducing emissions, although simple utility and production functions do not adequately render the existing rigidities of certain demand categories, or the lead time necessary for adjustment. Energy use in transportation, already highly taxed for fiscal reasons in most Annex I countries, would not respond significantly without the introduction of new technologies and changes in infrastructure, since alternative means of delivering mobility or fueling most transport modes are not readily available. This suggests the need for progressive introduction of taxes, instead of a strong signal at the outset.

In general, given shortcomings inherent in model-based analyses, results included in this study are mainly indicative of some of the effects of carbon/energy taxes on the overall economy.

Carbon leakage

Carbon leakage takes place when reduction strategies pursued in one region entail an increase in emissions in another region. The IPCC Second Assessment Report suggests that estimates of leakage range from negligible to almost 100 per cent, for some specific activities. Carbon leakages can take place through two channels: the loss of comparative advantage from adopting a tax, resulting in increased production of energy-intensive goods elsewhere, and the effect of lower demand for fossil fuels on world energy markets.

As for the effects on comparative advantage, if there were a common action to introduce price signals, there would be less opportunity to re-locate production in a country with similar levels of economic development. For countries trading mostly outside Annex I, however, emission reductions achieved at home may be offset by an increase in emissions outside the region. Although energy expenditures amount to a relatively low per centage of GDP within OECD economies (between three and 11 per cent on a purchasing power parity basis, with a 5.8 per cent average for OECD as a whole), energy-intensive industries would still lose competitiveness, all other things being equal, if other trade partners were not to adopt similar carbon/energy taxes.

With regards to energy markets, it can be argued that common action to reduce energy-related emissions within Annex I, if not achieved through absorption or carbon removal, will entail a decrease in global energy demand, lower international prices and spur emissions outside the region. However, this effect is not specific to a tax. A similar drop in energy price will occur whatever policies and measures are used to obtain similar energy-related CO_2 reductions, insofar as they reduce the demand for tradable fossil-fuel based energy.

Economic effects (costs and benefits)

For the most part, economic effects of carbon/energy taxation are derived from macro-economic modelling approaches. As mentioned in the section on "approach and methodology", a number of limitations apply to such modelling results. Among others, these models can only confirm the theoretical economic superiority of a single price signal to achieve an overall reduction objective within a group of countries, compared with unilateral taxation policies to achieve such reductions on a country-by-country basis. In that respect, this study does not shed any new light on the economic benefits of using a common price signal.

Short-term economic impacts are assessed with so-called macro-econometric models, which account for unemployment and other market disequilibria. Longer-run economic impacts are generally estimated with computable general equilibrium models, assuming that all markets operate efficiently. These economic models, *in general*, do not account for sectoral differences, especially with respect to the degree of elasticity in response to price signals over different time frames.

Another shortcoming of most macro-economic analyses is that they do not take into account a "no-regrets" potential and existing market barriers to energy efficiency improvements. A tax would provide a powerful signal for more cost-effective energy choices. In that respect, computable general equilibrium models probably overestimate the cost impacts of carbon/energy taxation. On the other hand, the assumption of cost-minimizing behaviour in such models may exaggerate the adaptability of economic agents in responding to changes in energy prices.

According to many of these models, as summarized in IPCC, the aggregate economic cost of stabilization at current levels in two decades would be in the order of magnitude of 1 per cent of gross domestic product in the final year, with potentially significant differences across countries. These same modelling results also suggest that such differences in GDP losses could be reduced by equalizing marginal reduction cost, for example with a common price signal.

Distribution issues

In introducing a new carbon/energy tax, distribution issues constitute a principal point of contention. Absent massive CO_2 offset options, a tax on carbon/energy would particularly affect the fossil fuel sector, as well as energy intensive industries. It is important to note that *any* policy aimed at reducing fossil fuel consumption would have a similar effect on the energy extraction and refining industry. Still, experience shows that the point where the tax is applied (at the mine mouth or at the utility busbar) affects the perception of costs among agents, and their support or opposition to the tax.

In terms of effects on different income groups, a carbon/energy tax, absent any compensating measures, could be regressive, with differences across countries coming from, among others, the reliance on personal vehicles, and the total energy mix in households energy consumption. Tax policies can be adapted to offset the regressivity of a carbon/energy tax.

Recycling options

National experiences with new carbon/energy taxes show practical ways to recycle tax revenues to alleviate the more negative effects of the tax on low-income groups. In most cases, the carbon/energy taxes have been introduced as part of a fiscal reform, aiming to lower taxes on capital and labour, while reducing energy-related externalities.

Modelling studies focused on short to medium term effects show that a low carbon tax, if properly recycled to reduce more distortionary existing taxes may result in a net macro-economic gain, i.e., an economic dividend in addition to the environmental dividend. Employers' paid social security contributions could be reduced to foster employment; the tax can also be recycled into investment tax credits, with positive effects on GDP, or to reduce government deficit.

There is not, however, a consensus on the existence of a double-dividend. For instance, macro-economic models accounting for unemployment find that recycling tax revenues through lower employers' paid social security contributions could offset the negative effect of the tax on GDP, through higher employment. Computable general equilibrium models which generally ignore unemployment find that recycling carbon/energy tax revenues would not offset the distortionary impact of a carbon/energy tax.

Carbon/energy tax revenues can be used to finance energy-efficiency improvements in an interim period, an option currently implemented in some European countries. Such measures contribute to minimize the increase in energy costs for energy-intensive activities, through a lowering of their carbon-intensity. Funding of research and development for low carbon/energy technologies could also be envisioned. If not introduced temporarily, such policies ought to be carefully monitored to ensure that they do not introduce permanent distortions in energy choices.

Carbon sequestration as a joint-policy tool

This study briefly explores the possibility of offering a choice between paying a carbon tax or sequestering carbon through afforestation measures, when sequestration can be achieved at a lower cost per avoided ton of CO_2. Another option would be to use forestry measures to enhance the effectiveness of a carbon tax, through the recycling of tax revenues as an incentive payment for carbon sequestering. Such schemes would introduce some additional complexity; they would require further analysis especially if they are to be considered as an instrument to be used in conjunction with common taxation.

Feasibility

Any taxation scheme agreed at some international level would have to deal with most implementation issues experienced in setting carbon/energy taxation at the national level.

Experience shows that even "modest" homogeneous taxes on carbon and energy may be difficult to introduce in some Annex I countries, even when exemptions are granted, and other economic policy objectives could be obtained with the tax. The cost of an increase in taxation, directly perceptible by economic agents, does trigger significant political opposition, but this is not unique for taxation instruments. Exemptions for exporting industries, differentiated tax rates across agents, phased-in taxes and various recycling options are possible instruments to overcome some of the political barriers to taxation at the country-level, although they may lower the efficiency of the tax. On the other hand, the relative effectiveness of cross-cutting instruments, such as taxation, may help to overcome implementation obstacles.

In general, barriers to the implementation of a single uniform tax stem from national differences in energy mix and pricing, from sectoral differences in energy-use, and from distribution issues. End-uses such as transportation, where taxes are already high in most countries, could absorb a modest price increase from a carbon/energy tax in those countries. Other sectors like industry and power generation are constrained in the near term by the lifetime of their physical capital. Different tax levels across activities and users, where risks of tax evasion were low, have been used in some instances. The progressive introduction of carbon/energy taxes, and a clear schedule for their evolution over time would help minimize the cost of reducing long-term CO_2 emissions. In some cases, existing taxes were replaced by taxes based on the carbon/energy content of the fuel, and increased on that basis afterwards.

A common approach to taxation might help reduce the opposition to a tax on competitiveness grounds. However, this is not the case for all Annex I countries, because not all Annex I countries primarily trade with other Annex I countries. For that matter, changes in competitiveness would not be similar for all Annex I countries. This issue is linked to the deliberations of the World Trade Organization on the possibility to introduce border tax adjustments on embodied carbon and energy, as well as on the practicality and effectiveness of such adjustments.

The ongoing discussion within the European Union on proposals by the European Commission for a EU-wide carbon/energy tax shows the difficulty of obtaining an agreement on common taxation, also when significant flexibility for member States to reach a uniform tax level in the future is provided.

In addition to domestic implementation issues, countries may be reluctant to introduce a tax at a rate that will be set at some international level, which would take away their control over revenues of the common tax. The European Union member States agreed to follow the approach of using minimum levels of excise duties, which is already in place for mineral oils, to overcome this problem.

In practice, questions such as the exchange rates to be used for translating the common tax, the rules for its evolution given differences in exchange rates, inflation, and reduction levels achieved in participating countries, would require careful attention for the tax to be able to provide a steady price signal for energy choices.

The question whether to levy a carbon/energy tax at the level of producers or consumers will also require careful attention.

Time period

The purpose of a carbon/energy tax is to provide a steady price signal over time, so as to move away from carbon-intensive energy choices. Such a price-driven shift can only happen in the medium to long-term, due to the rate of capital stock turnover and existing infrastructures. This explains why in most cases, carbon/energy taxes are used as one instrument in a much broader package of policies aimed at reducing greenhouse gas emissions.

Taxes could be designed so as to best exploit different lifetime of capital stocks across sectors, e.g. through taxes that are phased-in at different rates. This would minimize the transitional costs of a tax. Any early retirement of existing equipment, which may be necessary to achieve national targets for reductions, comes with an opportunity cost. Providing temporary subsidies for energy efficiency improvements, e.g. through recycling of tax revenues, would help reduce such opportunity costs.

Impacts on other countries

Two issues could be considered: leakages (positive and negative) and border tax adjustments.

Leakages

Any reduction in fossil fuel demand to reduce CO_2 emissions in Annex I would entail a decrease in international prices of carbon-based fuels, beneficial to the rest of the world as a whole; carbon/energy taxation would also have that effect. Moreover, countries competing internationally with industries from with Parties with carbon/energy taxes would be granted a competitive advantage from their un-taxed energy, and become more attractive for investment in energy-intensive activities.

On the other hand, they might pay a higher price for imported goods from Annex I Parties implementing the tax, and be affected by other changes in their terms of trade. Modelling analyses disagree on the overall impact on non-participating countries and on their emissions. While their energy use and emissions may increase, their economic growth may be affected positively or negatively (lower exports to Annex I Parties, due to lower demand for fossil energy and possibly slower economic growth). Even the general direction of changes is uncertain, given the different assumptions on terms of trade, trade balances and the substitutability between domestic and imported goods.

Another aspect of leakages that is not studied in the literature is the possibility for non-participating countries to benefit from technological developments taking place in those countries implementing a carbon/energy tax. In the longer run, this spillover effect may help non-participating countries to reduce their energy-related CO_2 emissions (not to mention to have more efficient, competitive industries and economic infrastructure).

Border tax adjustments

In addition to the taxation of fossil fuel and other energy imports, which is common practice, Annex I Parties implementing carbon/energy taxes could decide to introduce border tax adjustments on their imports and exports, related to the embodied carbon/energy, to and from non-participating countries. This hasn't been the case so far, although it was included in the BTU tax proposal of the United States. The World Trade Organisation has yet to provide a definitive answer on this question.

If participating countries were to tax imports from non-participating countries to assure fair competition on their domestic market, they would affect the export revenues of non-participating countries. A careful analysis of embodied carbon in imports from non-Annex I Parties would be necessary to obtain an order of magnitude for the effect of a border tax adjustment on imports. The administrative requirements and technical practicality of border tax adjustments may be the greatest barriers to their implementation.

1. INTRODUCTION

Objective of carbon/energy taxation

The principal reason for carbon/energy taxation is to increase prices according to the energy and/or carbon content of different fuel sources. Such price change encourages shifts in carbon/energy intensive activities without dictating what those shifts should be or how rapidly they should take place, and provides incentives for, *inter alia*, the development and penetration of more energy efficient or cleaner technologies. Carbon and energy taxes also have an informational value if they are applied with an aim to reduce externalities; i.e., they send price signals to consumers which better internalize certain external costs.

In the case of a carbon tax, the price-signal is straightforwardly applied on the carbon content of the fuel alone, and is mainly aimed at climate change impacts since CO_2 is only a pollutant in the greenhouse gas context. For an energy tax, the purpose may be to tackle broader externalities related to energy use as a whole, which means end-use prices are increased to reduce general energy consumption for a variety of reasons.

So far, energy taxes, applied mostly on gasoline and diesel in transportation, have been used to raise government revenues. They are usually considered to be efficient from a fiscal standpoint. Efficiency in a *fiscal* sense is when a tax raises revenues with as little impact as possible on production or consumption patterns (minimum market distortion, or deadweight losses), which also means they provide a sound revenue base over time. Efficiency in *environmental* terms refers to a policy that induces agents to reduce emissions at the socially optimal level, which can be set through social consensus or scientific measurements. A tax on externalities achieves that goal in the most cost-effective fashion, in theory. However, an environmental tax has potentially opposite fiscal effects since reduced consumption in response to such a tax also erodes the revenue stream, if a stable tax is efficient in reducing emissions. The answer, here, is that the carbon/energy tax can be increased to reach some equilibrium level in the long term (equilibrium on emission level and budget revenues).

One should distinguish short term and long term price responses: a tax that successfully raises revenues in the short term nonetheless affects energy use and energy choices in the longer run. Second, current energy taxes are disproportionately applied to a single fuel, namely oil in transportation; if such taxes have already contributed to lower the efficiency potential on the use of gasoline in transportation, explaining the short-run inelasticity, this isn't nearly the case in the use of other fuels, or other refined oil products, especially when energy prices are relatively low.

Approach of the study of carbon/energy taxation as a measure for common action

The study looks at taxes based on the carbon and/or energy content of different fuels, from carbon taxes to energy taxes. These include standard energy taxes (e.g. BTU-tax), carbon taxes (Scandinavia), and taxes based on both the carbon and the energy content of the fuels (including the *European Commission tax* *proposal*). Different Annex I countries have a different approach to the use of taxation as a means to induce lower energy consumption and/or carbon content. This study seeks to reflect all these viewpoints. However, discussion is limited to recent energy taxation with an explicit CO_2 dimension.

A taxonomy of energy prices/taxes by fuel shows how disparate price levels per unit of energy depend on the fuel (and the region). For that reason, it is theoretically interesting to consider homogenizing energy tax levels based on the carbon/energy content of different fuels, either according to their carbon content or their energy content. This option is used *only as an illustration* of how existing taxes affect CO_2 emissions from energy use, since existing taxes have been introduced for (fiscal, environmental and other) purposes that cannot be overridden by the CO_2 issue. When looking at tax- restructuring, a sectoral approach should also be adopted, since average fossil fuel prices do not adequately reflect implemented energy pricing policies across sectors.

The schemes adopted for recycling tax revenues are crucial for the analysis of the economic impacts of carbon/energy taxes. Among others, the study looks at the opportunity of using tax revenues to finance carbon/energy efficiency improvements in sectors where the increase in energy expenditures would be most damaging, e.g. due to long lifetime of capital stocks. One should be cautious when considering such options: earmarking for environmental policies can lead to inefficiencies (and is discouraged by a theoretical approach of environmental policy), because spending doesn't necessarily go to the cheapest alternative. Such options should be taken for tools to ease the transition towards less carbon/energy-intensive equipments and uses, rather than as an improvement from a straight tax, recycled through the general budget, considered optimal from a theoretical standpoint. This study also touches on the possibility of coupling carbon taxation with carbon sequestration.

Different national circumstances (economic development, energy resources, energy prices) make it difficult to envisage a single carbon/energy tax as a measure for common action at the moment. A more constructive suggestion would be to agree on pricing as an instrument to reduce energy-related CO_2 emissions in the long run. This study is only able to provide qualitative results on this policy approach, and provide some options for further analysis.

2. NATIONAL/INTERNATIONAL CONTEXTS

Different starting points vis-a-vis carbon/energy taxation

Energy situation among Annex I: key data vis-à-vis carbon/energy taxation

This section is supported by figures (1-6) which cover the following elements related to the context for carbon/energy taxation3:

Figure 1 Indigenous production and final consumption of fossil fuels per capita in Annex I countries for the year 1993 (Note: "toe" stands for "ton of oil equivalent");

Figures 2-3 Fossil energy imports and exports per capita for Annex I countries (1993);

Figure 4 Share of different energy sources in generated electricity (1993);

Figure 5 Carbon price "topography" for OECD regions: Europe, North America, Pacific (1993);

Figure 6 The *ex ante* effect of a US$300/tC tax on 1993 average fuel prices for these regions.

+ HIDDEN CO_2 or greenhouse gas per capita
+ CO_2 or greenhouse gas per GDP
- CO_2 consumption per GJ or TOE of TPES
- CO_2 per kWh of electricity output
+ Energy supply per capita (fossil fuels)
+ Energy imports and exports per capita
+ Carbon price "topography", including taxes: OECD Europe, North America, Pacific (shows a reverse relationship between current energy prices and carbon content, with coal being the less taxed, etc.)

-- Carbon prices versus carbon emissions per unit of GDP (OECD analysis)

+ Another illustration: gasoline prices and taxes in IEA member countries, and comparison with a $100 and $300 carbon taxes. HIDDEN

Before turning to the description of current energy contexts in Annex I Parties, it is worth recalling that action to protect the climate should be taken "on the basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities". The following data sheds some light on the question of differentiation with respect to taxation, across regions as well as fuels.

Figure 1

Indigenous Production and Primary Fossil Fuel Demand per Capita in Annex I Countries, 1993 (Cont.)

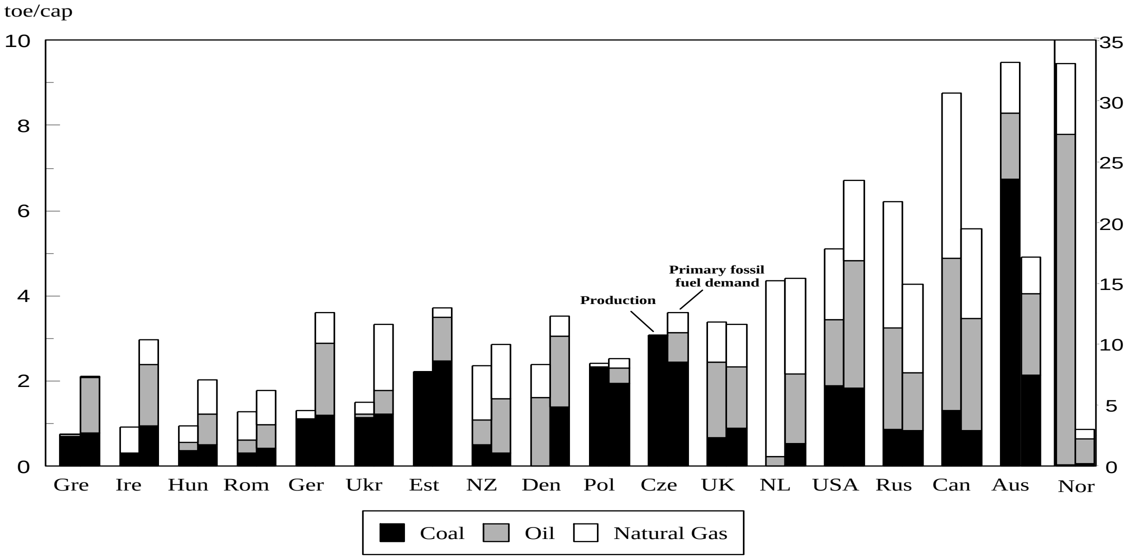


Figure 2

Indigenous Production and Primary Fossil Fuel Demand per Capita in Annex I Countries, 1993 (Cont.)

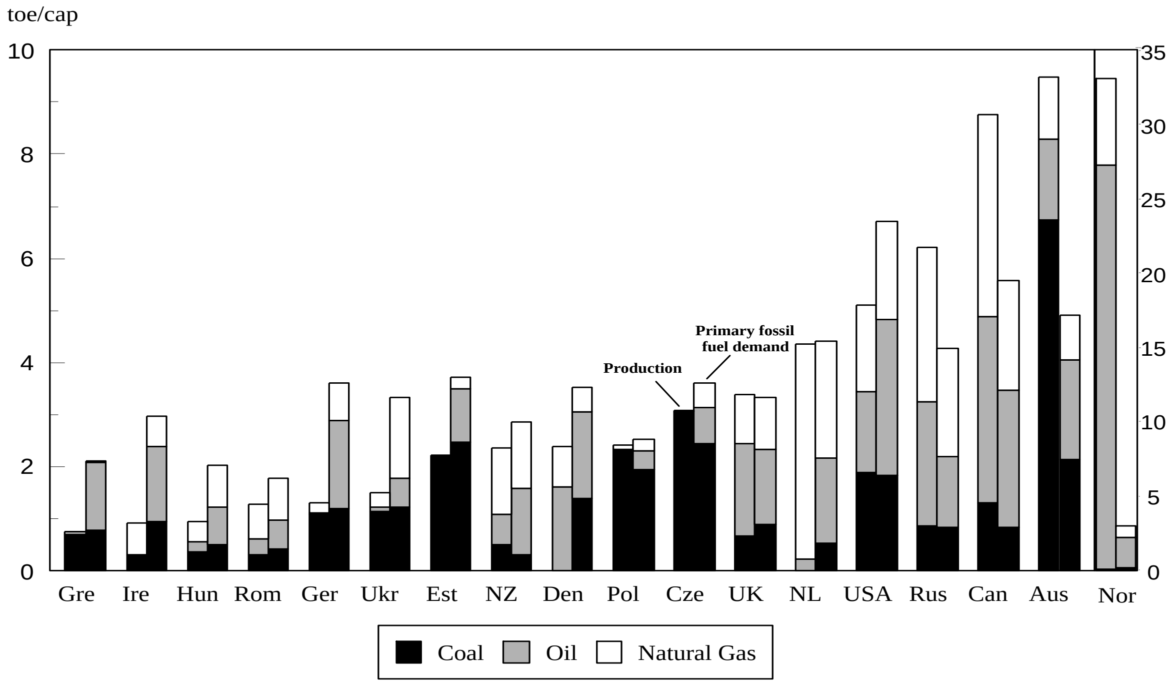


Figure 3

Fossil Fuels Trade per Capita in Annex I Countries, 1993

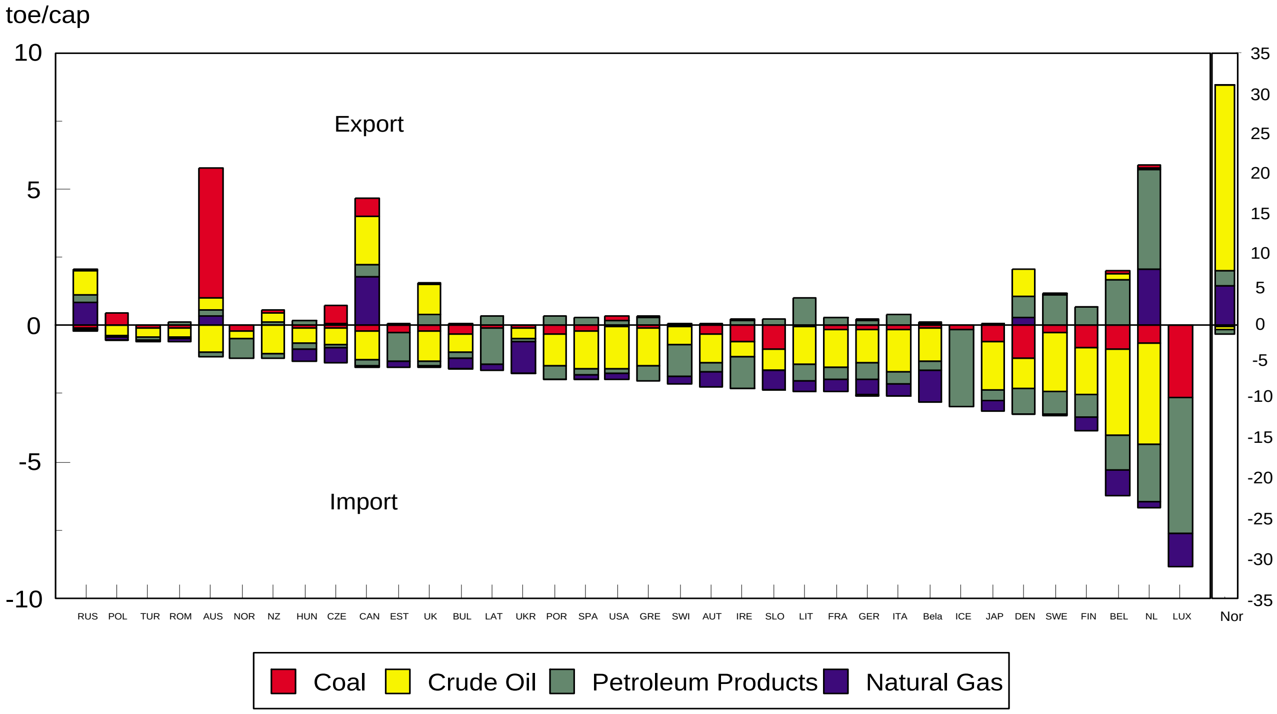


Figure 4

Figure temporarily removed due to technical problem with the file.

Figure 5

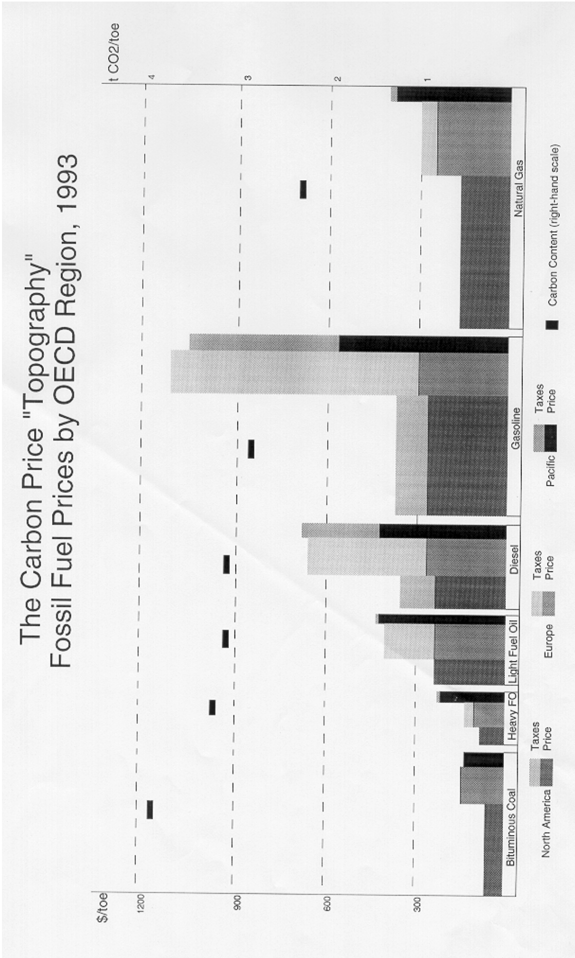
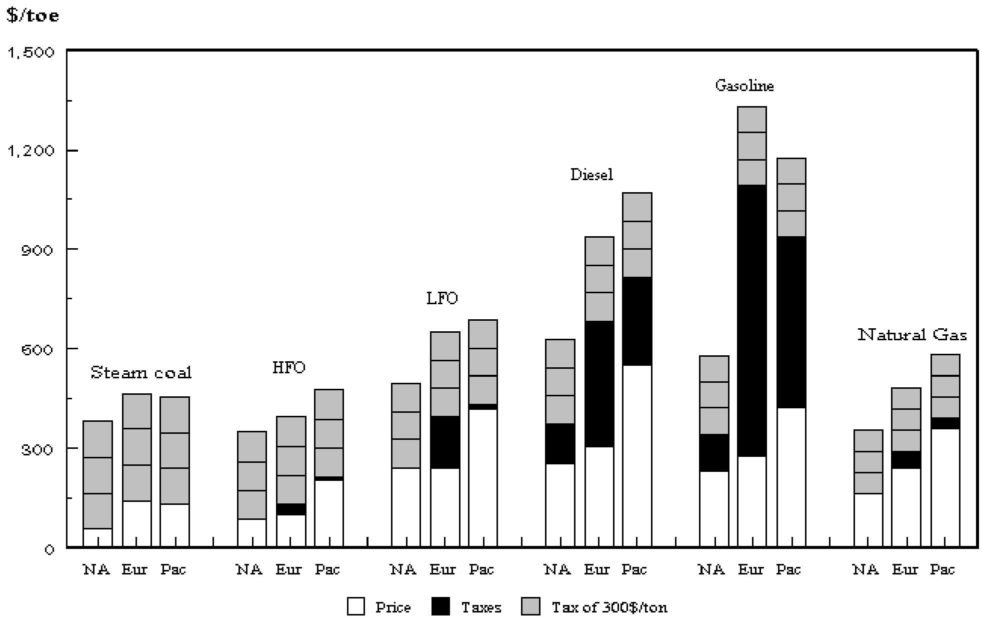

The Carbon Price "Topography"
Fossil Fuel Prices by OECD Region, 1993
$/toe
1200
900
600
300
t CO2/toe
4
3
2
1
Bituminous Coal
Heavy FO
Light Fuel Oil
Diesel
Gasoline
Natural Gas
North America
Taxes
Price
Europe
Taxes
Price
Pacific
Taxes
Price
Carbon Content (right-hand scale)

Figure 6

Prices by Fuel for OECD Regions with a Tax of $300/ton of carbon, 1993



Energy consumers in Annex I countries face very disparate energy price levels, as illustrated by the carbon price topography for OECD regions. It is obvious from this graph that fossil fuels are not taxed according to their carbon content. In other words, when considered in this aggregate fashion, current prices of fossil fuels are not conducive to carbon emission reductions in any region of the OECD. Applying a tax based on the carbon or energy content on top of this price structure would not necessarily succeed in setting a level playing field to foster lower carbon emissions, although it would affect relative prices between coal, fuel oil and natural gas which could lead to more intense competition from the less carbon-intensive of these sources (see section on energy price restructuring). It is noteworthy that gasoline used in transportation, a sector where there is as of now little competition from other fuels, and where long-lived infrastructures play a predominant role in energy use.

Carbon "prices" are not the only drivers for current emission levels; nevertheless, Hoeller and Coppel (1992) emphasize a negative correlation between carbon emissions per unit of GDP and the average price of carbon in OECD Member countries, taking into account the different non-fossil resource base of each country; i.e., high "implicit" carbon prices are generally consistent with a low carbon intensity in the economy. Although it could be argued that national circumstances such as the availability of energy resources, geography, population density, and other institutional and environmental constraints can influence *how energy prices are set*, the classical negative price elasticity of demand remains valid in the case of fossil fuel demand.

A key feature when considering the opportunity to tax energy has to do with the resource base of the economy. Extraction of fossil fuels in Annex I countries vary greatly, with countries like Norway (35 tons of oil equivalent per capita), Australia, Canada, the Russian Federation and the United States extracting more than 5 tons of oil equivalent per capita, and others relying almost exclusively on imports to satisfy their consumption of fossil fuels.

In approaching energy taxation in Annex I Parties, the case of countries with economies in transition needs special attention: although energy prices have been drastically increased following economic reforms, they may not yet reflect marginal production costs. This is largely due to high inflation, the generally high level of subsidies in energy supply activities, and collapsed exchange rates which increase unit price of energy imports. For countries in such a situation, marginal cost pricing seems an appropriate first step before taxes are introduced to internalize the threat of global warming and other local impacts.

This is the energy background on which the design of a carbon/energy tax instrument to reduce greenhouse gas emissions would operate. Certainly, not all countries are equally suited to adapt to a strong price-signal to reduce energy-related emissions.

Energy price restructuring: an illustrative option

The carbon price topography shows a wide disparity in energy prices among Annex I Parties, due to different net-of-tax energy prices, existing taxes and subsidies. Based on this observation, and on the apparent link between implicit carbon prices and carbon intensities in OECD Member countries, Hoeller and Coppel (1992) have analyzed the effects of restructuring current energy taxes to reduce CO_2 emissions. An obvious argument against such restructuring is that existing taxes may already internalize other externalities. Restructuring taxes according to the carbon/energy content only would raise such externalities and lead to social inefficiency. As far as atmospheric pollution is concerned, Hoeller and Coppel stress that the most polluting fuels (heavy fuel oils and coal) face lower prices, suggesting that their environmental impacts are not internalized; this argument, however, omits that governments may rely on other tools to reduce those externalities, that may not necessarily be reflected in fuel prices and taxes.

In spite of these possible critiques to their approach to tax restructuring, their study brings interesting insights into the issue at stake here. Their starting point is the computation of implicit carbon taxes for fossil fuels in OECD Member countries in 1988 (Table 1)

Table 1: Implicit carbon taxes in 1988

($ per ton of carbon)

	Oil and oil products	Gas	Coal	Total
Austria	267	39	0	150
Australia	178	0	0	61
Belgium	162	35	0	86
Canada	108	0	0	52
Denmark	297	110	0	147
Finland	200	0	0	107
France	351	38	0	229
Germany	212	23	0	95
Ireland	277	4	0	139
Italy	317	80	0	223
Japan	130	2	0	75
Netherlands	221	27	0	89
New Zealand	235	0	0	117
Norway	258	0	0	182
Portugal	205	13	0	147
Spain	176	19	0	112
Sweden	268	13	6	214
Switzerland	224	2	18	198
UK	297	0	0	107
US	65	0	0	28

These implicit carbon taxes show disproportionately high taxes applied on oil products (mostly gasoline). On average in OECD Member countries, the implicit carbon tax is US$70, but range from 28 to 229. Rather than re-allocating tax revenues equally across all fuels *and* all countries, Hoeller and Coppel replace existing taxes on oil, gas and coal by the current average implicit carbon tax in each country (right-hand column in the above table). Their simulation is based on a simple energy demand model, without any of the dynamic features of models discussed below.

Such tax re-structuring would lead to an 8 per cent increase in average energy prices in the OECD, with the average price of oil falling by 17 per cent, whereas natural gas and coal prices increase by 17 and 77 per cent, respectively. In this static setting, CO_2 emissions would be 12 per cent lower if energy taxes were allocated according to the carbon content of fuels.

Another detrimental effect of current energy tax structures is that a carbon tax would have a low effect on already high oil prices, so that substitution may theoretically benefit oil rather than gas, whereas gas has a lower carbon content. A more detailed analysis of the markets on which oil and coal products actually compete would be needed to see if prices for these end-uses are indeed as different as the average numbers shown above.

This illustrative analysis provides an interesting message with respect to the effects of carbon/energy taxes applied on top of existing taxes: although they would reduce emissions, they may not do so in the most cost-effective fashion, since existing taxes, if somewhat restructured to better account for carbon/energy content, would reduce CO_2 emissions without increasing tax receipts. Therefore, some rationalization of existing taxes across fuels and by types of end-use may be worth considering before applying new taxes.

Overview of experience with "carbon/energy taxes" as instruments to reduce CO_2 emissions

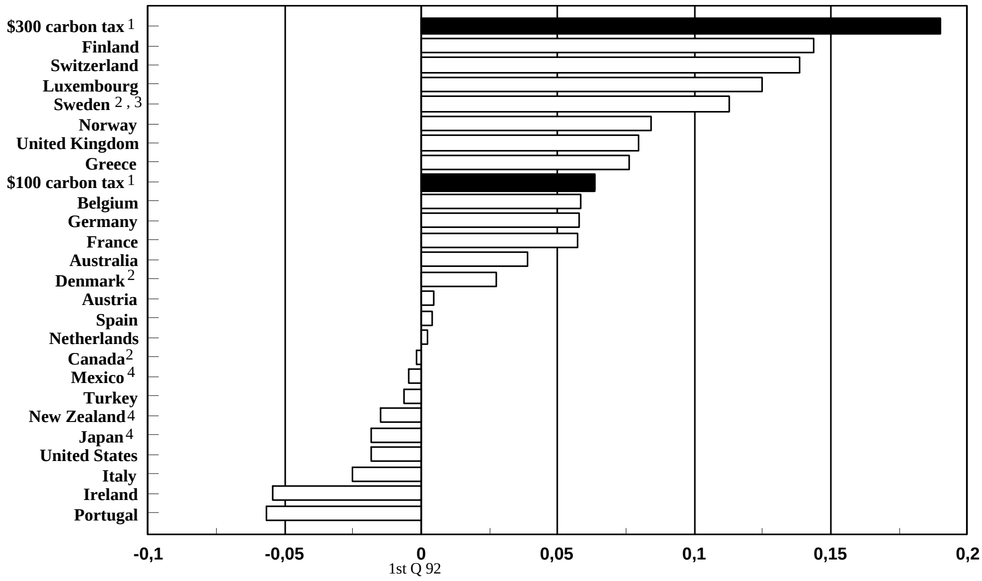
At first, it may seem artificial to focus our analysis on the price signal introduced by carbon/energy taxes, rather than on other pre-existing energy taxes: both introduce an incentive to reduce energy consumption and therefore to lower related CO_2 emissions. Interestingly, some OECD Member countries have increased *gasoline* tax levels (generally the most heavily-taxed energy source) by orders of magnitude comparable or higher than a $100 carbon-tax over the last few years (see Figure 7). These tax increases result either from "real" carbon taxation, or a decrease in the net-of-tax price of gasoline, which provided a means to raise government revenues without inflationary consequences. These increases in tax levels also illustrate the attractiveness of taxes on transportation fuels to raise revenues (*fiscal* efficiency), because demand for such fuels is quite inelastic in the short run.

However, it should be recognized that carbon/energy taxes, if applied consistently to all energy sources, provide a precise signal related to the carbon and/or energy content only, whereas other taxes are usually applied on a fuel-by-fuel basis, with quite different *implicit* rates per unit of carbon or energy (as illustrated by the carbon price topography).

Most of all, recently introduced carbon/energy taxes are more relevant to this study, because they provide illustrations of implementation issues related to the use of taxes to reduce greenhouse gas emissions, both at the national and international level.

Figure 7

Real Tax Changes in OECD Countries for Unleaded Premium Gasoline 95 Between 1st Quarter 92 and 4th Quarter 94 (US$/litre)



Notes: 1. IEA model assumption : 100$ or 300$/ton of C
2. Unleaded Regular gasoline 98
3. Data refers to 3rd quarter 92 to 4th quarter 94
4. Unleaded Regular Gasoline

Sources: IEA Databases.

Carbon/energy taxes under consideration and failed proposals

Several Annex I countries have considered carbon/energy taxes to help reduce their CO_2 emissions. These countries made proposals that were dropped after discussion, or considerably down-sized. Others, like the carbon/energy tax proposal made by the European Commission, have undergone several revisions. Other countries, inside the European Union are trying to introduce carbon/energy taxes with an environmental focus (Austria and Belgium). It is difficult to draw any firm conclusion from proposals under discussion, although they indicate what aspects of such taxes make them more or less acceptable in countries.

Australia's "greenhouse levy"

Australia discussed a "greenhouse levy" of approximately US$3.5 per ton of carbon.[4] The tax was proposed as one of a possible set of measures to enhance Australia's greenhouse response. Complementary proposals were also discussed, some of which would have involved spending some of the money raised through the tax on other reduction measures, such as a Sustainable Energy Agency. The levy was set at a modest level, and was discussed as a possible signal for action to increase efficiency and consider less carbon-intensive fuels.

The proposal encountered strong opposition from industry. It was claimed that the levy would reduce profitability for energy intensive industries and might cause some industry to alter investment plans in Australia. The government decided not to proceed with the levy following industry commitments to achieve more significant emission reductions through cooperative approaches.

The US "BTU-tax"

The "BTU tax" proposed by the Administration in 1993 met the same fate. There are a rather wide range of energy taxes and tax expenditure policies in the United States at the state and federal levels of government that fall directly or indirectly on various forms of energy. Nevertheless, most energy sources in the United States remain lightly taxed relative to other OECD Member countries and, like many other countries, those energy taxes that do exist fall most often on end users or consumers of energy. In early 1993, the Clinton Administration proposed a new form of energy tax at the federal level that would have changed this feature of United States energy prices. The BTU tax proposal, although never enacted, would have taxed virtually all forms of fossil fuel energy in the United States and increased energy prices for all end users (consumers and producers). While the total energy tax burden in the United States would have remained below those in Europe (primarily because of the gasoline tax differentials), taxes on some other forms of energy would have been higher. With the exception of a few European countries, the BTU tax would have been one of the only broad-based, inclusive energy taxes in the OECD. Although the BTU tax proposal ultimately never became law, the analytical and political debate accompanying the tax initiative provides important insights to the development of national and international tax policy. We try to summarize these insights below.

Firstly, it is important to note that the BTU-tax did not originate in a debate on environmental or energy policy, but as part of a broader set of concerns involving the budget deficit and macroeconomic

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4. In 1989, the price of steam coal was 63 Australian dollars in 1989 (industry price for one ton of oil equivalent). At today's exchange rate, without accounting for inflation, the greenhouse levy represents a 4.3 per cent increase for coal prices to industry.

performance. For instance, its rate was not fixed based on the expected environmental outcome, but rather on the basis of how much revenues it would bring. Of course, the other benefits of the BTU tax were highlighted (environmental, reducing energy supply risks, etc.) The BTU tax was selected among alternatives because it offered a balanced coverage of all these issues, without affecting one fuel or energy source too specifically. Although a number of exemptions were included in the original scheme, the tax would still achieve environmental goals if implemented.

Where to collect the tax?

A central tension in the design of the BTU tax was where to place the burden for paying the tax in the marketing chain from production to ultimate end user. While the revenue and macroeconomic implications of one collection point over another are fairly minimal, it makes a big difference in the incentives for fuel switching, and ultimately the environmental impact of the tax, as well as the costs of collection and enforcement. The initial BTU proposal imposed the tax at the minemouth for coal, the refinery gate for oil, the pipeline for gas, and at the electric utility for hydro and nuclear generated electricity. By placing the tax "upstream", the intention was to send the price signal as early on in the production chain as possible thereby creating as broad a set of market responses as possible. It could have gone further - very early versions of the tax placed the burden of the tax for oil and gas at the wellhead.

As the debate went on, the tax was shifted further downstream. One important argument was made by the natural gas producers, who stressed that they would not be able to pass on the tax to final consumers under their current fixed-price contracts. Also, the per centage price increase resulting from the tax in the price of coal, for instance, would be greater if the tax is placed at the minemouth before transportation costs have been incurred as compared to placing the tax at the electric utility gate.

At the end, the issue of who pays the tax, which determines the regional and energy-source impacts of the tax, probably dominated the debate much more than the overall cost of the tax to the American economy or competitiveness issues (the low level of the tax would not have raised US energy prices to levels observed in the rest of the OECD Member countries). This national example shows that the *perceived* distributional effects or the "visibility" of the tax, determined by the tax design (energy versus carbon, upstream or downstream...) play a central role in the acceptability of a tax.

New Zealand's "low level carbon charge"

In 1994, New Zealand proposed a package policy of policy measures to address climate change. One of the proposed measures was a carbon charge on energy-related CO_2 emissions. The charge would have been applied at the point of extraction or importation for fossil fuels, with no exemptions. The charge was intended to be revenue neutral, and various revenue recycling options, including income and corporate marginal tax rate reductions, debt reduction and funding high priority expenditure such as energy efficiency programmes. The proposed charge was set at a low level ($NZ10-30/tC, or $US 15-44/tC) in order to stimulate a change in investments toward lower carbon-intensive options while avoiding excessive short-term adjustment costs.

The carbon charge proposal met strong opposition from both within government and from industry. At that time, forest absorption was also projected to increase significantly over the decade to 2000 and net emissions were projected to decrease by 54 per cent, even though energy and industrial process emissions were projected to increase by 18-22 per cent by 2000. In the face of industry opposition, the government decided to pursue a strategy of voluntary agreements with industry to reduce emissions. However, the threat of a carbon charge remains, and a decision on whether to introduce the tax will be made in mid-1997. At that time, New Zealand's progress toward meeting its target of stabilizing net CO_2 emissions will be assessed and if net emissions are not on track, a carbon charge will be introduced in late 1997.

The EC tax proposals: an attempt at common taxation of carbon and energy

The EC proposal for a carbon/energy tax, initiated in 1992, provides another example of what stands in the way of harmonized carbon/energy taxation to reduce greenhouse gas emissions. Originally, the proposal had the following features:

- applied to all energy sources, excluding renewable energy sources. The aim is to abate all externalities related to energy (not just CO_2 emissions), but also to make the proposal more acceptable to those countries where fossil fuels are used in power generation by spreading the cost on all producers across countries;

- based half on the energy content and the carbon dioxide content of energy sources;

- phased-in over time, to avoid a price-shock and provide some adaptation time;

- fiscally neutral, i.e. all revenues raised by the tax ought to be recycled in the economy, the recycling options being left to individual countries. This principle is introduced as a principle to minimize macro-economic costs, and, possibly, to seize on "double-dividend" opportunities;

- the tax is not the unique instrument to reduce emissions in member countries: it is precisely meant to support other policies and measures adopted in individual countries.

The *ex ante* impact on *average prices* for different users in member countries would be as follows:

Industry	
Coal	[63%]
Heavy fuel oil	[39%]
Natural gas	[31%]
Electricity	[15%]
Residential/Commercial	
Heating oil (light fuel oil)	[18%]
Natural gas	[13%]
Electricity	[13%]
Transportation	
Gasoline	[6%]
Diesel	[9%]

Some design issues

The common dimension of the tax, as well as its energy and carbon components, add some complexity to its implementation. In general, the European Community legislation on taxes follows the destination principle: the tax is paid where the product is consumed. The tax is effectively charged when the product is released for consumption. The "release for consumption" differs for each product, depending on the distribution chain.

Electricity provides a good example of the complex arrangements that would be required. First, it is economically sound to apply the tax on inputs used in electricity, for instance, according to their carbon content, so as to induce fossil fuel savings. However, electricity being traded widely, taxing inputs would alter the competitiveness of domestic electricity, both on the domestic market, where it would compete with imports of electricity from countries which don't apply a tax, and on the international market, for the same reason. A tax applied on electricity output would miss on the opportunity to influence producers' choices. An alternative would be to tax imports of electricity on the basis of their fossil fuel input, but this raises some practical issues, and may not be consistent with EU and GATT provisions.

The EC tax could cover about 80 per cent of energy-related CO_2 emissions, with exemptions possibly granted to energy-intensive industries faced with an imbalance in trade with *third countries*, based on a criterion such as energy expenditures as a per centage of the value added of the firm. Investments aimed at improving carbon and energy efficiencies may be eligible for deduction of the tax due. The eligibility criteria for tax deduction would be left entirely to member countries.

Current status

Its adoption by the EU being first conditional on other OECD Member countries taking similar steps, the European Union has not adopted the original proposal. A new proposal has been under discussion, leaving more flexibility through the possibility of zero tax-rates, tax exemptions for industry, and aiming for harmonization in the year 2000. In 1996, the Council asked the Commission to provide a new proposal for a common tax.

Description of carbon/energy taxes implemented in five European countries

Several carbon, energy and carbon/energy taxes have been introduced, or are being discussed within Annex I, as instruments to reduce energy-related CO_2 emissions. For those countries which have introduced such taxes, the following general comments can be made:

- none of the implemented schemes covers all energy uses resulting in CO_2 emissions in a completely homogenous fashion, either on a per unit of energy or per ton of CO_2 basis;

- exemptions and exceptions have been granted to energy-intensive industries or to industries facing acute international competition; electricity, a highly traded commodity, is also granted special treatment,

- carbon/energy taxes are sometimes introduced in place of other taxes on energy, so as to minimize the additional fiscal pressure, while providing a proper signal to reduce CO_2 emissions;

- countries rely on taxes as *one* policy measure *in a package* of measures to achieve their emissions objectives, which accounts for differences among types of energy-users more than a uniform tax would;

- carbon/energy taxes are often part of a more general fiscal reform to solve structural fiscal issues such as high "distortionary" taxes on employment and capital.

- taxes are usually phased-in, providing a period of adaptation and avoiding the negative effect of a "price shock". Tax rates can be adjusted for inflation over time to keep the signal constant in real terms.

This section provides overviews of carbon and energy taxes implemented in Denmark, Finland, the Netherlands, Norway and Sweden.

From the above, it is obvious that the taxation schemes for carbon and energy cannot be summarized in a single figure for each country; indeed, the complexity of each tax "package" makes it difficult to compare them in a straightforward fashion. Rather than providing all the details of implementation, we focus on general features of particular importance in this study. .

Tax base and level

A tax on energy use in the households sector has been in place in **Denmark** since 1977, and was significantly increased in 1986, offsetting the decrease in oil prices. This tax was broadly consistent with the energy content of fuels, with a lower rate on coal. Denmark introduced a CO_2 tax on energy consumption in 1993 as part of a package including various subsidy schemes for promoting means to produce electricity and heat from less carbon-intensive fuels and to increase energy efficiency. For the households sector, a *tranche* of the energy tax was converted into a carbon tax of 100 DK orUS$14.9 /t$CO_2$ (or 54 US$/tC7). Enterprises were also submitted to this tax, with a reimbursement of 50 per cent generally available.

Starting in 1996, a new, more comprehensive, tax scheme was introduced. It consists mainly of three rates:

1. On heavy industry (or industry facing competition): a tax growing from 5 to 25 DK (3.7 US$/t$CO_2$) over 1996-2000. If these firms decide to enter a voluntary agreement to improve their energy efficiency, and if successfully implemented, the effective tax rate is 3 DK per ton of CO_2;

2. Light processes (all not belonging to the above category) face a tax increasing from 50 DK to 90 DK (US$13.4/tCO2) over 1996-2000. Voluntary agreement to improve energy efficiency, if successful, results in a lower rate (68 DK in 2000).

3. Energy use for space heating is taxed at a much higher rate, growing from 200 DK to 600 DK (89 US$/t$CO_2$) over the same period. This tax rate equivalent to the sum of the carbon and energy taxes applied in the households sector in 1996. Note that leaded and unleaded gasoline is not subject to the carbon tax, since it is already heavily taxed. The tax does apply, however, on diesel, but does not bring total taxes on diesel to the level of gasoline.

Finland introduced Europe's first "explicit" carbon tax, imposed on fossil fuels based on their carbon content, starting at a comparatively low level of Mk 6.7 per tonne of CO_2 (US$1.2/t CO_2). The rate was doubled in 1993, to 50 Mk, with a tax differentiation for diesel and gasoline. The effect of this new tax rate on fuel prices was:

- a 1-2 per cent rise in prices of electricity, light fuel oil and natural gas;

- a 5-8 per cent rise in prices of coal, gasoline and heavy fuel oil; and

– a 10 per cent rise in the price of diesel.

At present, the tax is split into a "fiscal" component with tax differentiations for diesel and petrol, a carbon component and an energy component, replacing the pure carbon component (60 per cent of raised revenues through carbon, 40 per cent through the energy component). The energy tax is imposed on all primary energy sources except wood, wind power and waste used for energy production. In 1995, the tax rates were:

– Carbon component: Mk 38.3 Mk per tonne of CO_2 (US$6.8, equivalent to US$25/tC);

– Energy component: Mk 3.5 per Mwh (US$0.62).

The Netherlands have introduced two taxes on energy and carbon. The first tax introduced in 1988 and considerably increased in 1992 (the *environmental tax*), was initially intended to be a single tax for financing environmental policy expenditures. Since July 1992, the tax has been part of general revenue. It is set to achieve revenue requirements based on consumption in the previous year and, since 1992, on *energy and carbon* content (on a 50/50 basis). This tax also covers uranium used in power generation. The level of the environmental tax on gasoline was Dfl 0.0251 per liter, with total taxes amounting to Dfl. 1.565; the price signal is therefore quite small on that particular fuel (the price for a liter of premium unleaded gasoline being around Dfl. 2). For light fuel oil used in industry, total taxes per 1000 liter are Dfl. 142.7, the *environmental* tax being Dfl. 27.5, and the total price *circa* Dfl. 500; the *environmental* tax thus represents a 5 per cent increase to the price for industry. The current tax rates per gigajoule and per tonne of CO_2 amount to Dfl. 0.3906 and Dfl. 5.16 respectively (roughly equal to a total of US$ 3 per barrel of oil equivalent, half on energy and half on carbon content).

An energy regulatory tax *for small consumers* was introduced to help achieve the CO_2 emission target. The tax, commenced on 1 January 1996 is designed to avoid the economic cost of an unilaterally imposed energy tax on industrial energy users competing internationally. The tax applies to:

– natural gas up to a consumption ceiling of 170 000 cubic meters per year,

– low amperage electricity to a ceiling of 50 000 kWh per year,

– mineral oil products which are substitutes for gas (home heating oil, light fuel oil, non-transport applications of liquefied petroleum gas, butane and propane) with ceilings comparable to the ceiling for gas, and restitution above these ceilings.

The energy regulatory tax applies to the gas and electricity use of households and companies; it covers about 40 per cent of non-transport and non-feedstock energy use. The tax on gas will be introduced in three stages with the effect of raising gas prices by 20-25 per cent; electricity prices will rise by about 15 per cent in a single step.

Norway introduced on 1 January 1991, starting at a rate of US$40.1 per ton of CO_2 on gasoline (equivalent to US$ 147/tC). The tax was also applied to diesel, mineral oil, oil and gas used in North Sea extraction activities. As of 1 January 1996, the tax per tonne of CO_2 ranges from US$17 on petroleum coke to US$55.6 on gasoline and on gas use in the North Sea. In real terms, the tax has not changed in the recent years. The above rates should be compared with excise taxes which are equivalent to US$239.6 per tonne of CO_2 on gasoline, US$176 on diesel oil. Oil and gas companies pay the tax on these products, taxes on coke and coal are paid by importers. An SO_2 tax is also applied to mineral oil which, if translated in CO_2 terms is equivalent to a $US 4.2 tax for auto-diesel and light fuel oil. The SO_2 tax increases with the sulphur content and reaches its maximum for heavy fuel oils at a rate equivalent to $US 35/tC.

For mineral oil (heavy fuel oil for industrial use, and light fuel oil for industry and households), the carbon tax has offset a decrease in the excise tax, resulting in a stabilization of prices for these oil products over 1991-1994.

The Norwegian CO_2 tax covers about 60 per cent of all CO_2 emissions.

Sweden passed a bill in 1990 introducing a *carbon tax* and a value added tax on energy, and lowered the existing energy tax, as part of an overall fiscal reform. The original tax amounted to Skr.250 per tonne of CO_2, levied on oil, coal, natural gas, LPG, gasoline, and fuel for domestic air transportation; fuel use for electricity production was exempted. Simultaneously with the introduction of the tax on carbon, general energy taxes of fossil fuels were cut by 25-50 per cent but the net effect of increased carbon and reduced energy taxes was still to be an increase in tax revenues of Skr.3 billion.

In 1993, the carbon tax rate was increased while the tax applied to industry was adjusted down to 25 per cent of the carbon tax paid by other energy users; in addition, the existing *energy* tax on industry (and horticulture) was reduced to 0. The 1993 tax reform brought industrial total energy tax levels down to a much lower level than before the introduction of the carbon tax in 1991. A number of exemptions and ceilings on tax payments also apply (see below on exemptions).

The government recently announced that the CO_2 tax on industry will be raised from Skr.92.5/tCO2 to Skr.185. The current CO_2 tax on services and households will remain at its current level of Skr.370 (US$48/t$CO_2$ or US$176/tC, at 1994 real exchange rate). The tax is automatically adjusted for inflation, so as to provide a steady signal in real terms.

Raised revenues and recycling

What is the gross collected amount of these taxes, before any recycling takes place? This isn't a straightforward question, because several taxes are applied to the same energy sources in these (and other) countries: other environmental taxes (e.g., on SO_2), excises, taxes to finance maintenance strategic reserves, value added tax, to name a few.

In **Denmark**, carbon tax revenues from industry are to be entirely recycled in that sector, through:

1. lower employers' social security contributions, to become the largest recycling item after 3 years;

2. investment grants for energy efficiency improvements, available for four years;

3. a fund for small businesses which receive only a limited share of recycling via reduced social security contributions.

Energy efficiency grants, up to 30 per cent of the initial outlay, are available on a project by project basis, subject to financial criteria to assure that the project is really driven by energy savings considerations, and that its profitability is not such that it would have been implemented anyway (i.e., it is not a "baseline" investment opportunity).

Carbon tax revenues in **Finland** go to the general budget.

The *environmental tax* of **the Netherlands** goes to the general budget. The new *energy regulatory tax* is used to reduce direct taxes paid by households and businesses. The government has decided to recycle revenues back to households through three changes to the personal income tax: a decrease in the rate for the first income bracket (67 per cent of revenue recycled to households), a raise of Dfl. 80 in the tax free allowance (32 per cent of recycled revenue), and a Dfl. 100 raise in the standard deduction for senior citizen (ca. 1 per cent of recycled revenues). Businesses are compensated through a 0.19 per centage points reduction in the rate of the employer's paid social security contribution (ca. 57 per cent of revenues recycled to businesses), a raise of Dfl. 1300 in the standard deduction for small businesses (25 per cent of recycled revenue), and a 3 per centage point reduction in the corporate tax rate over the first 100 000 Guilders of profit (the remaining 18 per cent).

Together, these two taxes represent 2.5 per cent of total tax revenue in the Netherlands (in 1995, the first tax raised Dfl. 1 350 million; after 1998, the *energy regulatory tax* is expected to raise Dfl. 2 100 million, including the increase in value added tax revenues).

Norway uses carbon tax revenues for its general budget. Revenues from the CO_2 tax amounted to more than Nkr. 5 billion in 1993 (about 0.68 per cent of Norway's total tax revenues). However, the carbon taxation was introduced as part of an overall fiscal reform.

Sweden also introduced the carbon tax as part of an overall fiscal reform which shifted tax revenues away from personal income tax (the highest marginal income tax rate being 72 per cent, for revenues above 25 to 30 000 US dollars). As a result of the *whole* reform (including increase in VAT revenues), direct taxes on households and corporations amounted to 21.3 per cent of GDP in 1991, compared with 25.3 per cent in 19898. Total tax revenues from the carbon tax alone amounted to Skr.10.3 billion in 1993, i.e. 2.5 per cent of total central government revenues; other energy taxes contributed Skr.36 billion.

Exemptions

In **Denmark**, an automatic exemption was granted to industry on competitiveness grounds, in the context of a disagreement about the adoption of a common carbon/energy tax in the European Union or OECD. At first, a set of criteria were applied for tax rebates, based on an energy-intensity indicator, roughly equal to the CO_2 tax payments over value added. A progressive refund was obtained automatically, if the carbon levy was more than 1 per cent of value added: between 1 and 2 per cent, 50 per cent of the amount above 1 per cent would be refunded; between 2 and 3 per cent, the refund is 90 per cent of the amount above 3 per cent.

Subsidies for energy audits were also available, and if the recommendations for energy efficiency improvements were followed, a total tax refund was granted (so-called CO_2 subsidy). On the whole, before the new green taxes were introduced, the average carbon tax rate on energy use by industry was DK 35 per tonne of CO_2 (or US$5). It became clear for the Government that the criterion for rebating the tax could easily be manipulated.

This contributed to prompting the new carbon/energy tax package. Under the new tax package, lower rates are granted to "heavy industry", in fact a list of companies either energy-intensive or operating on competitive markets; this was negotiated rather than determined with a single criterion. Firms on this list, and other firms with a ratio of CO_2 tax to value added above 3 per cent are eligible for voluntary agreements, which implies tax rebates *if successfully implemented.*

For trade reasons, electricity is exempt from the CO_2 tax in Denmark; a subsidy to encourage the use of natural gas (and therefore discourage coal) was introduced to compensate the non-taxation of coal as an input to electricity.

In **Finland**, industries are not granted reduced or zero tax rates. Exceptions include products used as raw material in industrial production, or used for air travel and some sea transportation as well. It can be assumed that the low level of the current carbon/energy tax may make it easier for the government not to provide exemptions. Finland may remove its tax on fuels used in electricity due to increased competition from imported electricity and the impossibility to apply a tax on imported electricity.

By design, numerous exemptions from the two taxes apply to industry and households in **the Netherlands**, but these are not defined by branch or industry, but rather based on actual level of energy use. In the case of large-scale natural gas users, the tax per gigajoule of natural gas consumption in excess of 10 million cubic meters is Dfl. 0.16 instead of 0.39. The per gigajoule tax on so-called residual fuels is 0 (residual fuels include: blast furnace gas and other gaseous fuels, the price of which would have increased by about 5 times, absent this "exemption"). Note that the carbon tax component still applies to residual fuels in the 1992 design. In amendments adopted in 1994, further tax relief was granted to producers of residual fuels when those fuels are used where they are produced: the tax on these fuels will be zero until 1 January 1999. It was stressed by the Parliament (its Second Chamber) that the financial margin created by this temporary tax relief would promote investments in energy conservation by the companies concerned.

The *energy regulatory tax* includes a number of exemptions. First, exemptions aimed to increase the environmental efficiency of the tax: district heating is not taxed, natural gas used for power generation is also exempted, so as to foster the penetration of combined heat and power generation. Second, by definition this tax on small scale energy use does not apply to energy use above the defined ceilings (about 60 per cent of non-transport, non-feedstock energy use in the Netherlands). A tax free energy "floor" has been defined for metered energy, set at 800 cubic meters of gas and 800 kWh of electricity use. These floors help reduce the distributive impact of the tax on lower income groups. These floors were defined based on a new state of the art house. About 6 per cent of gas consumers and 5 to 10 per cent of electricity consumers are exempt from the tax.

The main argument for these exemptions was that Dutch companies which operate on the international market don't have the opportunity to pass on price increases to their international consumers, Dutch firms being price-takers rather than price-makers. A second argument behind the design of the set "floors" has to do with the distributive impacts of a tax applied homogeneously, regardless of the share of energy expenditures in households income, and of the adoption of very efficient energy use practices.

In **Norway**, the CO_2 tax only covers 60 per cent of energy-related emissions. Onshore use of natural gas is not taxed. For mineral oil, the pulp and paper, and fish meal industries pay half the rate. Air service, shipping coastal freight transportation, coastal fishing in distant water and the supply fleet in the North Sea are also exempted. Coal and coke, when used as reducing agent and feedstock, and in the cement and leca industries are not taxed. Concern for competitiveness has been a major factor in determining what exemptions should be granted. In the particular case of Norway, we find a direct illustration of how a concern for CO_2 leakage has led to exemptions: the taxation of fuels for fishing in distant waters, aviation and shipping could have very little incentive effects on energy use since it is easy to tank in other countries.

Sweden introduced exemptions from the carbon tax for industrial use, as well as for the electric power sector. For any single company, there would be a ceiling on the total amount of *energy* taxes to be paid.

During 1991, this ceiling was 1.7 per cent of the value of manufactured products; over 1992-94, it was brought down to 1.2 per cent. It should have been eliminated by January 1995. This exemption rule ran into the same evasion problem as in Denmark, with firms isolating their most energy-intensive activities and being granted exemption on that basis. Additional to the tax evasion problem, the exemption was granted on a company-by-company and on basis (not on an industry branch basis), and had to be renewed every year by the government, which represented an impractical and expensive scheme.

We also noted that the carbon tax rate was 25 per cent that of other energy users, except for the carbon tax paid on gasoline and diesel for transportation by industry; the previous existing energy tax, however, was reduced to zero in 1993. Starting 1996, the carbon tax rate should be 50 per cent that of other users.

Electric power generation is exempted from the carbon tax; a government task force has studied the consequences of introducing such a carbon tax (Skr.80, or US$10.4/t$CO_2$) on electricity, and a new taxation system for power plants and heat plants. The issue of possible imports on non-taxed electricity was raised, and this question is still under consideration.

Biomass use in power generation, as a renewable energy source, is not subject to carbon and energy taxes, and a limited subsidy was introduced for investments in plants using biofuels.

Sequestration, and other greenhouse gases

Sequestration and carbon taxes

Taxation of carbon and sequestration of carbon through forestry measures are usually handled separately. Recently, the Working Group on CO_2 policy of the government of New Zealand has been considering an incentive payment for carbon absorption under an economic instrument (tax or tradeable permit system). What could be the role of forestry options in a carbon/energy taxation scheme?

First, one has to recognize that excluding options that would reduce emissions at a lower cost than a tax reduces the cost-effectiveness of the taxation scheme. If a forestry option is available to capture carbon *permanently* at unit cost X, and if the tax applied on energy use is Y, with Y being greater than X, then, ideally the carbon tax should encourage this forestry measure so as to produce a cost-effective outcome for overall reductions. For instance, an energy consumer could get a rebate on its carbon tax by proving that it contributed to absorbing the equivalent amount of carbon with forestry measures. A signal for the cost of absorbing carbon would still be passed on to the final consumer, with the same effect as a standard carbon tax, only lower than the carbon tax set by the government, in this example. Coupling taxation with forestry measures moves in the direction of a system of tradeable permits of CO_2 emission emissions.

The IPCC Second Assessment Report shows that options for carbon sequestration are generally under US$100/tC, sometimes as low as 1 to US$6/tC within the Annex I "region". These are static estimates that depend on available land, and correspond to a special set of forestry options; they would have to be considered with respect to their total capacity, to see how much they could contribute in reducing emissions. For example, what could be their contribution to stabilize emissions in a given country?[9]

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9 . A recent study explores the cost of a strategy to permanently sequester up to all CO_2 emissions from the transport sector, finding that the marginal cost would be low, within the IPCC range quoted here (BTCE, 1996).

Such a scheme would raise some practical implementation issues:

- the level of carbon tax revenues would become uncertain, as it may be difficult to assess *ex ante* both how many agents would turn to forestry measures to avoid paying taxes, and what the total potential for carbon sequestration at a given cost (below the level of the implemented tax) may be;

- a monitoring mechanism ought to be created for forestry measures, to assure that volumes of sequestered carbon do correspond to carbon tax rebates, and that sequestered carbon remains so “permanently”. Another option is to require landowners to pay the tax or hold emission “permits” upon release of the carbon at harvest;

- the potentially perverse incentive effects for existing landowners to remove forests in order to replant in a high growth rate species to earn the credit.

There may be some macro-economic effects as well, if forestry measures become more profitable than agricultural options and compete for the same land. Those effects would also have to be assessed carefully.

From an institutional standpoint, it is worth stressing that Ministries of Finance may not be used to deal with such “offsetting” mechanisms where a whole different expertise is required.

Other greenhouse gases: is taxation feasible?

None of the implemented taxation schemes cover other greenhouse gases10. The number of gases as well as the variety of sources and the difficult monitoring of emissions help explain why taxation in the context of global warming currently focuses on energy-related CO_2 emissions: those emissions can be easily estimated from quantities of fossil fuel used, and those fuels can be taxed accordingly. In principle, taxes on other emissions would also achieve efficient reductions; for instances, taxes could be used to help foster research for substitutes (in the case of HFCs), by creating a market for substitutes with less radiative forcing. This would require careful analysis of substitutes as they are being put on the market to determine whether their radiative forcing is indeed lower, and whether a tax should be applied or not, depending on its global warming potential or another such indicator of radiative forcing. If practicable at all, such a scheme may indeed require common implementation to avoid smuggling from regions where such taxes are not applied. This question would require further analysis.

Expected contribution to greenhouse gas reductions

The complexity of the above schemes, with numerous exemptions affecting the price signal of taxes, makes it difficult to assess what would be their effect on energy-related CO_2 emissions and on the economy. Still, some analyses of expected impacts are available.

Denmark has estimated the effect of its new carbon/energy tax scheme, taking into account the recycling of tax revenues through lower social security contributions and investment grants to promote energy efficiency11. The tax, along with other measures such as subsidies for energy efficiency improvements, would provide a 4.7 per cent reduction in CO_2 emissions from 1988 levels in the year 2000. The relative high tax on space heating would have a modest effect, whereas subsidies have a key role in providing emission reductions.

The results on the macro-economy underline the difficulty of assessing the economic impacts of such a complex scheme. With respect to costs for industry *before recycling*, the tax burden accounts for less than 0.5 per cent of total labor cost; over five years, such a fluctuation is modest compared with what variations in exchange rates, prices and wage rises may bring about. Recycling basically reduces the overall cost to zero, with lower labor cost and investment grants bringing about a 0.5 per cent reduction in cost. Investment grants for energy efficiency improvements mean increased administrative costs in industry, but lower energy costs, and a potential improvement in competitiveness. The net effect on employment would be modest but positive (+2000), as a result of:

- a negative effect of the tax in some sectors;
- a positive effect of recycling through lower social security contributions;
- a positive effect from the investment grants;
- a positive effect through the substitution of labor and capital for energy (uncertain).

The Netherlands expect that their new *regulatory energy tax* will contribute a total CO_2 emission reduction on the order of 1.7 to 2.7 million tonnes per year in 2000 or 1.5 per cent of total emissions in this country; CO_2 emissions from the groups targeted by the tax are projected to decline by about 5 per cent12. This emphasizes that the tax is not indeed the only tool applied to reduce CO_2 emissions from these sectors. No information was available on what might have been the effects of the *environmental tax*, in the last three years. Note that by design, the level of this tax cannot be predicted, since it is based on revenue requirements for the overall budget.

Norway has tried to estimate the effects of its CO_2 tax for the first three years of its implementation (1991-1993). The results apply to only parts of total CO_2 emissions covered by the tax. They are based on a detailed sector-by-sector analysis which highlights the difficulty of assessing the relative contribution of prices, trade conditions, general technical improvements, regulations, and changes in industry structure in the observed changes in CO_2 emissions. One conclusion is that the CO_2 tax has probably had some effect on emissions form mobile sources in the households sector and from stationary sources. The total effect varies between three and four per cent over the period; the price of fuel oil and gasoline increased by 11-17 per cent and 9-11 per cent respectively, as a result of the CO_2 tax. The implied price elasticity of oil demand ranges from 0.17 to 0.44, in line with conventional numbers, although maybe on the high side for such short term responses.

Sweden - Given the combination of the carbon and energy taxes, and their evolution over the past years, the analysis of their impacts on overall energy consumption and resulting carbon dioxide emissions proves difficult. A few observations can be made.[13] First, the removal of the energy tax on industry in 1993 was followed by a 20 per cent increase in heavy fuel oils consumption over the first six months of the year, compared to the same period the previous year (this is however partly explained by a surge in economic growth); the sales of light fuel oil decreased by about 8 per cent. In the paper and pulp industry (which represents about 40 per cent of final energy consumption by industry in Sweden), the increase in HFO demand was 30 per cent, with a corresponding decrease in the use of wood for energy. This demonstrates, if needed, that industry fuel choices are influenced by prices, and suggests that taxes have an impact on energy consumption.

13. Ministry of the Environment and Natural Resources (1994).

In the district heating sector, where the carbon tax was raised from Skr.250 to Skr.320 in 1993, demand for carbon tax-free wood fuels increased by 30 per cent. For other sectors, the effect of price changes introduced by the carbon and energy taxes on energy demand and CO_2 emissions are less clear.

Main lessons from the current experience and design issues are summarized in Section 5

Carbon/energy taxation: from "theory" to practice

Current experience with carbon/energy taxes offers insights into implementation issues and design of taxes to reduce CO_2 emissions. They do not, however, give a clear picture on the possible contribution of carbon/energy taxation to reduction in energy-related CO_2 emissions.

For this analysis of taxation as a policy for common action, we need to draw on quantitative analyses describing the effects of various carbon/energy taxes on CO_2 emissions and the economy. These results should, however, be treated as incomplete illustrations of the potential effects of carbon/energy taxes to reduce greenhouse gas emissions, especially with respect to the impacts of such taxes on technological change in the long run.

Another key element to keep in mind is that current experience shows it is unlikely that taxation would be adopted as the only tool to address this issue. At the moment, countries which have implemented taxes hope they will contribute to only part of their overall emission objectives. It is important to remember that other measures could supplement taxes, which may improve its efficiency or lower its overall cost. Although we touch upon the issue of accompanying measures, most estimates rely on a single tax to achieve emission reductions.

4. SUMMARY OF ANALYTICAL RESULTS: NATIONAL AND INTERNATIONAL MEASURES

The first section of this chapter addresses the impacts of various carbon/energy taxation schemes studied in the literature, with regard to *national* effects of such taxes. The second section considers the effects of the use of carbon/energy taxation as a possible policy tool for common action. Both sections rely heavily on modelling results. We have included brief overviews of what different approaches can and cannot provide.

Effects of carbon/energy taxation at the national level

This section will consider analytical results of a range of possible taxation schemes (BTU, EC proposal, carbon taxes for various regions of the world), possible options for recycling, such as *financing of energy efficiency improvements* (Goto, for Japan, and EC study).

Overview of modelling results on carbon, carbon/energy and energy taxes

In this section, we rely on the available literature covering various taxation of carbon/energy with insights on national differences. To the extent that it is possible, we try to draw on similar studies for various countries or regions, in order to avoid differences coming from the use of different models or approaches. We rely on the IPCC Working Group III Chapter 9 (*A review of mitigation cost studies*). In some cases, we chose to use studies that shed some light on specific measures included in the scope of this study. It wasn't possible to rely only on IPCC material, nor was it possible to synthesize all available literature on carbon/energy taxation.

We consider carbon taxes, carbon/energy taxes, and energy taxes, with a focus on reduction levels obtained with various tax levels, over various time horizons, for different countries. Macro-economic costs, when relevant, are addressed in this section as well.

We look at three variation of carbon/energy taxation:

- Carbon taxes. It is not always possible to find homogeneous studies looking at the same tax level; considering taxes necessary to achieve a similar reduction objective then provides another useful angle for comparison;
- Carbon/energy taxes (EC proposal, and other derived studies);
- Energy taxes ("BTU-tax").

In a final section, we provide some comparative results of the three kinds of taxes.

Limitations of various modelling approaches to assess the effects of carbon taxes

The results reported in this study are based on four general categories of models:

- Computable general equilibrium (national and global);
- Macro-econometric analysis (mostly national and regional);
- Technology-oriented models, based on linear programming (national);
- Energy models (global; partial equilibrium models).

Most of the analysis on international taxation schemes rely on the first two types of models. These typically take a highly aggregated view of different energy sectors and end-uses. **The "optimal taxation" solution these models generate is therefore robust in macro-economic terms, i.e., estimated *economy- wide* GDP effects. These models do not account for sectoral differences, especially with respect to rigidities and costs at the micro-level**. In designing taxation policies in the real world, as shown by experience to date, these sectoral differences in adaptability, and therefore micro-economic impacts, are extremely important, if not determinant in the policy chosen. Of course, such effects become even more difficult to assess when longer time frames are considered.

We summarize below the main features, strengths and weaknesses of these approaches. The reader should keep in mind that **these comments apply to all the modelling results reported below**.

<u>Computable general equilibrium models</u>
Key features and assumptions

- Markets, and the economy as a whole, reach equilibrium (supply=demand) through price adjustments
- Markets work efficiently

Strengths

- Produce economically-consistent scenarios over long run time horizons, with complete economic interactions among sectors
- Assess economy-wide GDP cost of reduction strategies, including trade effects

Weaknesses

- Energy end-use and technology are described through simplified production and consumption functions, even for sectors as different as private transportation and electricity production.
- Markets are assumed to operate efficiently; any departure from baseline entails a cost.
- Usually ignore transition costs, by assuming malleability of capital stocks and optimal decision-making
- No or little statistical basis (models usually calibrated on a single year)
- Technology is exogenous; economies of scale, and other increasing returns of adoption induced by the price signal cannot be rendered.
- Do not always account for resource depletion
- Rely on "closure rules" (e.g. evolution of government deficit) with unclear influence on results, including trade, investment and debt.
- Poor description of investment behavior as well as households energy use and choices.

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Macro-econometric neo-keynesian models
Key features and assumptions
- Forecasting tools based on short to medium term (10-15 years)
- The economy is not necessarily in equilibrium: "structural" unemployment is possible
- Monopolistic competition ("mark-up" pricing, as opposed to marginal cost pricing)
- Household behavior based on elasticities rather than utility functions

Strengths
- Strong statistical basis
- Key output include impact of policy measures on prices, investment, employment, as well as GDP.
- Best suited to look at "double-dividend" issues

Weaknesses
- Financial flows as opposed to physical flows
- Technology based on econometric analysis, little physical realism
- Econometric analysis may not be valid to estimate the effects of unprecedented *policy* changes, especially for longer time frames

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Technology models
Key features and assumptions
- Country-specific technology databases on different components of the energy system (cost, age, lifetime)
- Optimization of energy-environment systems under a set of user-determined constraints
- Indicate what technology can contribute to meet a certain set of constraints

Strengths
- Technological detail
- Constraints can be directly applied to reflect real world constraints of energy choices

Weaknesses
- Assume agents respond perfectly to prices, leading to "technology optimism"
- Do not represent feedbacks of different energy choices to the rest of the economy (investment, increase in energy prices, etc.)

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Energy Models (partial equilibrium)
Key features and assumptions
- Project energy demand based on econometric analysis and exogenous economic growth scenarios
- Solve market equilibria for energy at regional and/or global level

Strengths
- Coherent global energy picture; energy detail (from primary to final energy, or energy service)
- Amenable to sensitivity analyses

Weaknesses
- No coherence-check on the underlying growth scenario
- Econometric analysis may not be valid for long-term projections
- No feedback on the economy

Carbon taxes

Studies on the effects of carbon taxes range from standard energy modelling, short-term macro-economic analysis, to long-term computable general equilibrium analysis and technology optimization. It may be useful to distinguish the approaches when reporting results, even for what appear to be comparable scenarios.

Essentially two approaches can be used to present the results: from CO_2 reduction objectives to taxes necessary to achieve that level of reduction, or use “standard” tax rates (US$50, US$100) and compare their effects across studies. We chose to focus on reduction objectives, because the review of the literature of the EC tax proposal offers a way to compare effects of a single tax over different countries and region.

Note, however, that the carbon tax level necessary to achieve given reduction objectives (say, from 1990 levels) is heavily dependent on what emissions would be without the tax, i.e. the level of emissions in the business as usual scenario. Because baseline scenarios are unlikely to be similar across different models, comparing tax levels or GNP costs is all the more difficult.

In brief, the following results should be treated with extreme care.

When introducing a carbon tax, it is important to assess how much it can contribute to reduce emissions, and what the economic effects might be, over different time horizons.

EPRI (1994) has conducted a macro-econometric analysis of the effects of a US$100 carbon tax, to be introduced progressively, and unilaterally by the US over the 1995-2000 period. Although the study does not focus on stabilization, such a tax would stabilize US emissions at 1993 levels to the year 2000. Important macro-economic dimensions in the short-run include:

- inflation, as the increase in energy prices is passed on to other sectors of the economy. The EPRI study assumes that the tax is fully passed on to consumers in the form of higher prices.
- investment: largely determined by interest rates level, but also by changes in demand for particular goods (fossil energy, electricity, etc.)
- trade: since the United States is an importer of energy, a domestic tax on energy products is likely to affect its trade balance. Imports of other products can be altered through income effects. Exports, in turn, may suffer from an increase in prices, compensated or aggravated by exchange rates variations.
- unemployment: unemployment levels are altered by the change in production levels of specific sectors of the economy.
- government deficit: the EPRI results quoted here assume that revenues from the tax are recycled through lump-sum reductions in personal income taxes, through a reduction in average personal income tax rates. There is therefore no change in the government deficit from the baseline scenario to the US$100/tC scenario.

Table 2 provides key result for the year 2000, when the carbon tax reaches US$100/tC, 2005 and 2010. Note that emissions for the two latter time-horizons would be above 1993 levels.

Table 2: Macro-economic Impacts of a $100 Carbon Tax (US)

Changes from baseline

	2000	2005	2010
Real GDP (%))	-0.7	-1.8	-2.3
GDP price deflator - inflation (%)	2.3	3.4	3.9
Consumption (%)	-0.3	-1.4	-1.9
Investment (%) - business	-2.5	-4.1	-4.6
- residential	-2.3	-2.9	-3.2
Imports (%)	-1.2	-2.7	-2.9

Net trade (1987 US$ Billions)	7.8	15.7	10.1
Unemployment rate (% points)	0.11	0.22	0.18

What is noteworthy from these results is that they indicate an increasing GDP loss for a stabilized tax after the year 2000. To some extent this follows the aggravation of investment, as a larger share of income goes to the payment of energy expenditures, and less to savings. These GDP results beyond 2000 are typically higher than those provided by computable general equilibrium models, or partial equilibrium models (see below). Among many other factors, the econometric nature of the model used here assumes less flexibility over the longer run, since it is based on past observations; the phased-in $100 tax described in this scenario does differ from past experience with changes in energy prices. It would benefit from a clear announcement about its future level, enabling energy consumers to adapt efficiently when choosing energy-using equipment for the future.

DRI conducted a similar analysis for Canada, comparing the economic impacts of a tax and that of another policy package, including improved energy efficiency.[14] A tax of Can$150/tC would have to be phased in over the 1992-2000 period in order to stabilize energy-related CO_2 emissions; in this scenario, the tax is kept constant in real terms after 2000, which is not enough to stabilize emissions in the following decade. Real GDP be 1.6 per cent lower in the year 2000 compared with its baseline level, and 1.0 per cent lower in 2010.

The Energy Modelling Forum has conducted a comparative analysis of carbon taxes and GDP costs associated with given reduction levels for the United States, which we report in Table 3 (IPCC, 1996). The time horizon considered here is 2010, and that taxes are implemented from 1990 on. Twenty years should allow for most of the capital stock to turn over, although power generation, buildings and transportation infrastructure have typically longer lifetimes.

Table 3: Comparison of Carbon Taxes and GDP Losses in 2010 (US)

	Carbon Tax *($ per ton of C)*		GDP Loss *(% of GDP)*		
	Stabilization	- 20%	Stabilization	- 20%	
CRTM	150	260	.2	1.0	Disaggregated economic equilibrium
DGEM	20	50	.6	1.7	Disaggregated economic equilibrium
ERM	70	160	.4	1.1	Energy-sector equilibrium
Fossil 2	80	250	.2	1.4	Energy-sector equilibrium
Gemini	120	330			Energy-sector equilibrium
Global 2100	110	240	.7	1.5	Aggregate economic equilibrium
Global Macro	20	130			Energy-sector equilibrium
Goulder	20	50	.3	1.2	Disaggregated economic equilibrium
GREEN	80	170	.2	.9	Disaggregated economic equilibrium
MWC	70	180	.5	1.1	Energy-sector equilibrium

14. DRI (1993).

Two remarks can be made at the outset:

1. *carbon taxes* to achieve similar reduction objectives vary greatly across models, from US$20/tC (DGEM) to US$150/tC (CRTM). Differences can be explained by:

   – differences in baseline emissions; indeed, DGEM projects low growth in emissions over the two coming decades;

   – differences in treatment of capital stocks: DGEM assumes the perfect malleability of capital across sectors at all period, an assumption certainly is not valid in the short run. This is equivalent to assuming that a change in relative prices shifts capital from, say, iron and steel, to services, without loss of total capital, all other things being equal;

   – specification of agents' ability to allocate their resources efficiently over time. Models such as Global 2100, DGEM assume perfect foresight: consumers allocate their resources on consumption and savings so as to maximize their utility (or welfare) over time. Other models, such as GREEN and CRTM assume agents are myopic, and base their decision on current relative prices;

   – whether revenues are recycled in the economy or not (partial equilibrium models do not always account for increased tax revenues).

2. *Aggregate macro-economic costs* are small at the end of the period, even for a 20 per cent reduction (from .9 per cent of GDP to 1.7 per cent). When translated into the reduction of the GDP *growth rate* over the period, assuming a baseline growth of 2 per cent without the tax, a 20 per cent reduction would imply a GDP growth of 1.91 per cent, based on the result provided This is well within the range of usual uncertainty in short-term forecasts of GDP growth.

When looking out over longer time frames, top-down models find that the cost to stabilize or reduce emissions tend to increase *when expressed in per centages of GDP*. The obvious reason is to be found in the baseline CO_2 emission growth: none of the models assume that emissions from fossil fuels will stabilize during the next century. The tax itself, however, can be stabilized when *carbon-free backstop technologies* substitute for fossil fuels.[15] Montgomery (1993), summarizing EMF results, shows that GDP losses would grow from 1.25 per cent in 2010 to 2 per cent in the year 2050 in order to stabilize energy-related CO_2 emissions at 80 per cent of their 1990 levels from 2010 on.

In the case where *backstop technologies* provide a ceiling to the tax, it should be noted that their cost remains independent from the size of their market: technology assumptions are exogenous in all the above top-down models. Increased competition, the scale of the market for carbon-free technologies, and the long-term certainty for such a market in these stabilization scenarios should have some impact on the cost of these technologies. Although economies of scale and monopolistic competition are widespread notions among top-down modelers, the general equilibrium nature of their models makes it difficult, if possible at

15. A *backstop technology* is an energy technology which can supply unlimited quantities of energy at a constant marginal cost. It can be carbon-based,in the case of synthetic oil or gas produced from shale oil, tar sands, etc., or carbon-free: nuclear fission and fusion, solar, wind, geothermal, tidal, etc. This is largely a theoretical notin, since, for instance, the cost of inputs used in the production of such energy may well change over time, affecting the marginal production cost.

all, to incorporate these features. In all, the assumption that technology is given, and that a long-term steady or increasing price-signal will not affect the development of alternatives to fossil fuels greatly determines the estimates of the long-term costs of reducing CO_2 emissions with a carbon tax.

Norway, a sizeable fossil energy producer and exporter, and one of the countries who has implemented a carbon tax, has looked carefully at the impacts of a tax on its economy in the medium to long-run. The scenario analysis summarized here focuses on a domestic tax on carbon emissions. The model used for this analysis is a computable general equilibrium, with parameters estimated econometrically.[16] Table 4 presents changes in macro-economic variables in the year 2020 in a stabilization scenario. The tax level required to stabilize emissions would be US$55/t$CO_2$ (US$200/tC).

Table 4: CO_2 stabilization scenario at 1989 levels (Norway)

Changes in macro-economic variables in 2020

GDP	-0.5%
Import	0.1%
Export	-1.9%
Consumption	1.2%
Gross investment	-1.6%
Capital stock	-0.4%

In comparison with the United States studies quoted above, one can be surprised at the comparable level of GDP loss (0.5 per cent in 2020) to achieve stabilization, whereas the tax required would be somewhat higher, at US$200/tC. One has to account for different factors: first existing taxes on energy (especially in the transportation sector) are higher in Norway than what they are in the United States. For that reason, a higher additional tax would be required to produce an equivalent price increase in Norway. Second, although the tax is high, it applies to a much less carbon-intensive economy: whereas the higher existing taxes imply that the carbon tax would have more of a distortionary impact, since it is applied to relatively smaller quantity, the overall distortion is less. Last, the high level of the tax can also be explained that Norway is more efficient in its use of carbon: further improvements would require tapping a more expensive potential. Indeed, a simulation from the same model finds that a 35 per cent reduction from 1989 levels in the year 2020 would require a US$2 750 tax per tonne of *carbon*.

Last, but critical point with respect to this scenario: it does not assume that other Annex I countries would conduct similar actions to reduce their emissions. We will see below that the heavy reliance of some countries on fossil-fuel exports make them more vulnerable to policies aimed at reducing energy-related CO_2 emissions.

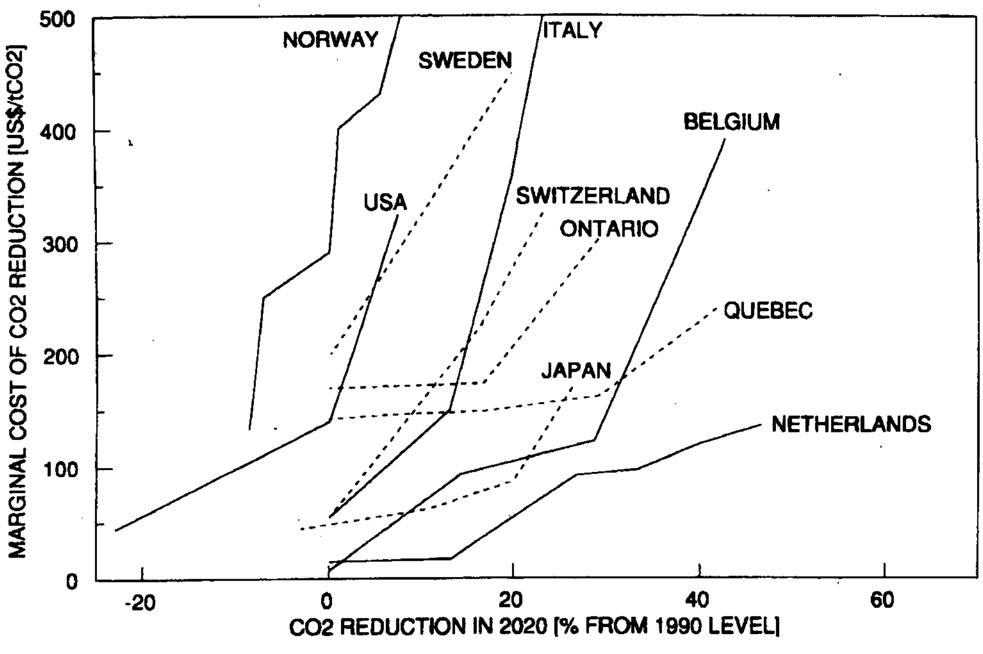
A recent study on the macro-economic and sectoral impacts of carbon taxation in Japan show results that confirm our previous comment on the relation between carbon-intensity, tax levels and GDP costs to achieve a particular constraint. The model used combines a technology-optimization model for energy supply and demand with a dynamic equilibrium model of the economy17. According to this study, a US$200/tC tax would be required to achieve stabilization at 1990 levels over the 1990-2010. The GDP cost of such a strategy would peak at 0.17 per cent in 2000, and average a 0.11 per cent discounted GDP cost. The low carbon-intensity of the Japanese economy explains both the high tax and the low GDP loss when compared with other studies based on general equilibrium assumptions.

16. Johnsen *et al*. (1996).

Technology-optimization models shed a completely different light on the carbon tax issue, because they take into account the differences in dynamics of various energy uses, and describe technology explicitly. The following figure indicates marginal reduction costs for several OECD Member countries and two different regions of Canada; it is based on the MARKAL, a linear-programming dynamic optimization model using country-specific databases on energy supply and demand technologies, as well as their cost18. These marginal cost curves indicate the tax that would have to be applied on energy use to reach different reduction levels in the year 2020. Particularly key in these results is the assumed baseline for energy technology development and use over the projection period.

There are wide variations among countries. Norway, Sweden and Switzerland, with low per capita emission levels, would face the highest marginal reduction cost in order to further reduce their emissions. According to these results, Sweden would have to apply a US$200/tCO2 (US$733/tC) in order to stabilize its emissions at 1990 level in the year 2020. Quebec's marginal cost is also high, but its hydro-electric potential would enable large reductions at a slowly rising marginal cost. As for the Netherlands, the low marginal cost is largely explained by the availability of carbon-storage options. Japan, in this exercise, would further reduce its reliance on fossil fuels by increasing the use of nuclear in the baseline; stabilization of emissions at 1990 level in the year 2020 would require a US$50/t$CO_2$, (or US$183/tC) roughly consistent with the result given by the above-mentioned top-down approach (US$200/tC). In the case of the USA, cheap coal resources favor a high carbon-intensity in the baseline. This high carbon-intensity suggests a high opportunity cost of emission reductions.

Figure 8: Marginal cost of CO_2 emission reduction: results from the Markal model



One of the key messages of that approach is that the marginal cost of reducing CO_2 emissions is not homogeneous across OECD Member countries, a message that remains valid with non-OECD Member countries. This merely reflects the different structure of energy use in those countries, as well as available technologies.

This suggests that the *cost-effective* approach to this issue is to agree on a common tax level, which will set the marginal reduction cost at the same level for all participating countries. On the other hand, this more detailed sectoral analysis shows that a sector-oriented approach may be necessary to fully account for differences across countries.

Carbon/energy taxes

Because carbon/energy taxes have been widely discussed at the European level, we will focus on the European Union in this part, with few comparative results for other parts of the world. In the case of the carbon/energy tax proposal of the EC, fiscal neutrality through carbon tax recycling was recommended, and therefore explicitly simulated in the analyses we quote here. However, we will discuss recycling as a separate issue below.

Because the original EC proposal described the tax evolution over the 1993-2000 period, standard macro-economic models (neo-keynesian) have been used to simulate its short to medium term effects, while other attempts were made to look at the more global impacts of such an option.

The following results cover six European countries (Germany, France, the United Kingdom, Italy, Netherlands and Belgium).[19] It is based on the original proposal of a mixed carbon and energy tax amounting to US$10/barrel of oil equivalent (or ECU 9.37 per ton of CO_2 and 0.70 per gigajoule of energy content). This tax would start at US$3 and be increased by one dollar to the year 2000, where it would reach its target level of US$10. A key element of the results below is that recycling is achieved through reduced social security contributions. For the year 2000, the impacts of such a tax on energy consumption and related CO_2 emissions, with full account taken of changes in GDP, are shown in Table 5.

Table 5: Effects of the EC tax proposal on 6 European countries - Summary results
(per cent changes from baseline, year 2000)

	Ger.	Fra.	UK	Ita.	Neth.	Bel.	EUR-6
Energy Consumption	-3.6	-2.8	-3.5	-5.0	-1.7	-3.6	-3.5
Industry	-4.0	-2.2	-3.5	-5.2	-1.6	-3.1	-3.5
Households	-3.1	-4.0	-4.1	-5.2	-1.4	-4.2	-3.7
CO_2 Emissions	-4.1	-4.7	-4.2	-5.6	-1.9	-5.0	-4.4
Energy intensity	-3.7	-3.3	-4.1	-5.6	-1.8	-4.1	-3.7
GDP	0.22	0.04	-0.42	0.72	-0.16	0.57	0.15

These results would necessitate more comments than allowed for in this study. A few points need mentioning:

- the *generally* positive GDP effect has to be considered in light of the recycling option on lower social security contributions, in a region where unemployment is high. Indeed, employment would be augmented by 0.64 per cent from baseline level in this scenario, hence a positive effect on the economy;

- the tax would successfully reduce the energy intensity of these economies, compared with the baseline, one of the goals of the EC tax;

19. Bossier and Bréchet (1995).

- the tax would reduce the increase from 12 per cent to 8 per cent from 1992 levels. However, except for Belgium, the model used for this analysis does not distinguish different types of fossil fuels, and has to work under the assumption that the fossil-fuel mix remains the same over the period. Fuel switching, a likely solution to CO_2 reduction is therefore not accounted for in these results. This also raises some issues with respect to the ability to describe existing energy taxes applied to different types of fuels.

- the positive GDP effects for some of the sample countries cannot be taken as an evidence that any on carbon/energy, when recycled, would result in GDP gains, since higher taxes would imply a farther departure from baseline conditions.

Although not too far apart from each other, these six countries would undergo different impacts on their economies, with some experiencing a net GDP gain from the EC tax. The study also shows that even though the tax would be implemented by all six countries, they would be affected differently through their trade patterns, a subject which we will discuss below.

While the results reported in the previous section show a macro-economic loss from a *carbon* tax, these results on the EC tax do not mean that the short term effect of the EC tax would be more beneficial. First, the cost of each tax has to be measured with respect to its environmental goal; clearly, the EC tax simulated here would not stabilise emissions, but fuel switching is not made possible in this model; in addition, tax revenues are recycled through a well-identified option with positive GDP effects. For a true comparison of carbon and carbon/energy taxes, GDP effects would have to be compared with similar emission reduction objectives and recycling options, simulated using similar models.

Few studies explore alternative allocations of the tax per carbon and energy content. One such example is provided by Gregory et al. (1992), looking at a US$10 tax per barrel of oil based for 25 per cent on the carbon content, and 75 per cent on the energy content. Not surprisingly, CO_2 emissions would be slightly higher in that case than with the original EC tax, with a higher tax on the carbon content. As is the case when comparing a CO_2 tax with a carbon/energy or an energy tax, other dimensions than CO_2 emission reductions must be invoked in order to favor the alternatives to the carbon tax (energy efficiency, energy security, other environmental impacts, political acceptability for the tax, etc.)

Energy taxes

For a number of reasons related to implementation and distribution of costs, the US Administration put forward a proposal for a "BTU tax", that is a tax on the thermal content of energy. According to modelling studies by both the Department of Energy and the Environmental Protection Agency, the tax would not have stabilized CO_2 energy-related emissions at their 1990 level, but would have achieved about 25 per cent of the necessary reductions.[20] It was studied along with, and selected instead of five other options:

- a carbon tax on the carbon content of the fuel (US$24/tC);
- an at-source *ad valorem* tax on the value of the fuel at the point of extraction;
- and end-use *ad valorem* tax on the value of the fuel at the point of final sale;
- a motor fuels tax on the retail price of gasoline and diesel; and

20. Haspel and Tseng (1993), Shackleton *et al* (1994).

– an oil import fee on the value of imported crude oil and petroleum products (US$9.57).

In this proposal, the BTU tax was set at US$0.257/.599 per million Btu, the second higher rate applying to oil products.[21] It was assessed along with other taxes on energy with the primary goal of reducing the government deficit; here, environment and other energy goals achieved through the tax were considered "secondary", but nonetheless assessed carefully. The BTU tax would have reduced emissions by 1.4 to 2.1 per cent from baseline levels (equivalent to 21 to 31 million tons of carbon in the year 2000). By comparison, the carbon tax would have achieved a 1.3 per cent to 2.5 per cent reduction in the year 2000. That tax, however, would have hit coal-rich regions of the United States in a disproportionate fashion, one reason why the BTU tax was eventually selected by the Administration.

The aggregate economic impacts of the BTU tax would have been modest, under the studied recycling scheme, that is, reduction of the government deficit. Under baseline monetary policy, real GDP falls progressively over the entire period compared to the base case, declining by almost .3 per cent by the year 2000. With monetary accommodation, interest rates would be lowered, which would spur investment, and return GDP to the approximate level forecast without the tax by the year 2000, according to the EPA study.

In case an energy tax similar to the BTU-tax would have to be used as the single tool to stabilize CO_2 emissions in the United States, the monetary accommodation may not be able to compensate other detrimental macro- economic effects on the economy.

Comparison: Greenhouse gas reduction potential and overall GDP costs

The above set of results, from various types of analyses, provide a general idea of the effects of taxes on energy-related CO_2 emissions. Different approaches used, as well as weaknesses in each approach, make any conclusion on the overall cost and on the reduction potential quite tentative. Nevertheless, these modelling studies tell us that:

- carbon taxes, carbon/energy taxes and energy taxes would lead to CO_2 emission reductions, even when set at a modest level;

- the economic cost would be higher in the short term than in the medium to long term, due to the lead-time for the economy to adapt to the new set of relative prices;

- high carbon/energy taxes do not necessarily imply a high macro-economic cost;

- the level of overall energy efficiency and the initial carbon intensity of the economy affects the marginal cost of emission reductions (tax level to reach a certain objective); a key element in that respect is the set of technologies available in the different countries.

21. The *higher* rate is equivalent to 0.44 ECU/GJ, that is lower than the *energy* component of the EC tax proposal (0.71 ECU/GJ). For information, a carbon tax, in order to bring the same government revenues than the BTU-tax would have to be set at US$22 per hort ton of carbon (US$24/tC).

As for the efficacy of carbon taxes versus carbon/energy or energy taxes, the modelling studies quoted in the IPCC Working Group III Report confirm the theoretical result that a carbon tax would achieve higher CO_2 emission reductions than other energy taxes set at the same level.[22]

Two dimensions are missing from the above analyses: technological change induced by a new set of relative prices, and the so-called "no-regrets" potential, which could contribute as much 10-30 per cent reduction in greenhouse gas emissions from the baseline (IPCC, 1996) where distortions and barriers are prevalent in energy markets. In a context of low energy prices, there is little incentive to search for energy efficiency improvements; the role of the tax would be to foster the adoption of cost-effective energy efficiency options through market mechanisms.

The technology dimension of the above modelling approaches must be addressed when considering the assessment of the effects of carbon/energy taxes on GDP and greenhouse gas emissions. Since technology is given and exogenous, and not explicitly represented as a product of the economy, the dynamic effects of a carbon tax on research and development on energy efficiency, and the prospect for gains in competitiveness arising through technological advances are overlooked. This is an important when considering the economic cost and benefits from taking unilateral actions to reduce greenhouse gas emissions from energy use by a wide and disparate range of sectors and activities. Although technology-optimization models offer a detailed approach of what technology could contribute to reduce national emissions under a certain constraint on emissions, the general absence of a feedback on the economy and on trade prohibits drawing too robust conclusions on the technology dimension of this issue.

Recycling schemes

The current experience shows that recycling can play a key role in assuring:

- the credibility of a tax by demonstrating that the carbon/energy tax is not a new means to raise revenues under the disguise of environmental policy;

- the political practicality of a carbon/energy tax, since recycling's primary objective is to offset the negative macro-economic effect of the tax.

Including recycling options in the tax proposal is not a necessary condition to the successful introduction of a carbon/energy tax; in some instances, new taxes were substituted for existing taxes and will only *gradually* provide a signal on the carbon and energy content of energy use, the ultimate goal of the tax.

The economic modelling literature has remained mostly focused on macro-economic recycling, rather than on recycling aiming to help achieve the environmental goals of carbon/energy taxes. We start by reviewing the results on the former, then show examples of results on recycling through investment on energy efficiency improvements, as announced above.

Macro-economic recycling: the search for a double-dividend

The possibility of recycling the revenues of carbon taxes through a reduction of other taxes has been studied both in theoretical setting and applied numerical models (computable general equilibrium and macro-econometric models). This has been the central focus of work done for the European Commission,

22. See IPCC (1996) Table 9.1.2.1.4.1.

because of the fiscal neutrality principle of the EC tax proposal. The relatively high level of unemployment in member countries, combined with high taxes applied to labour, suggested recycling carbon/energy tax revenues through a lowering of employer's paid social security contributions, to foster employment. This also comes at a time where other taxes are already high and cannot easily be increased.

The argument behind the choice for lower labour taxes is the high distortion they introduce in the price of that factor. Lowering these taxes might therefore benefit the economy, provided other taxes are raised in a less distortionary fashion. On this point, general equilibrium analysis suggests that a carbon tax would not be less distortionary, since it would be applied on a productive input. If one sets aside the environment dividend, a carbon/energy tax could therefore be expected to involve net costs if introduced to an already "efficient" tax system.[23] That approach, however, usually omits the possibility of structural unemployment, assuming that labor markets are in equilibrium.

Some applied modelling analyses find that there would be a "double dividend" from recycling carbon/energy tax revenues through lower labor (first the environmental dividend, second the economic dividend). As for the EC tax, the above-mentioned results display net GDP gains for some countries in the EU, from recycling revenues through lower labor taxes. In brief, a lower tax on labor, reflected in a lower labor price induces an increase in employment which in turn increasing production and consumption. In the set of models quoted here, much more complex mechanisms are also simulated, which we need not get into here. Note that *not all* countries would see a net increase in their GDP from the EC tax under this recycling scheme (the United Kingdom and the Netherlands), even if all countries would record a net increase in employment levels.

A similar study was conducted for the United States, looking at other options for recycling with a carbon tax growing from 15 to US$40/tC over the 1990-2010 period:[24]

- the default assumption is that of "lump-sum" tax cuts, meaning an overall decrease in taxes on households to exactly offset carbon tax revenues;
- revenues raising: the carbon tax would be used to lower the government deficit, i.e., would not be recycled directly through the economy;
- personal income tax cuts;
- corporate income tax cuts;
- payroll tax cuts (employee only, employers only, or both);
- investment tax credit.

All models find that in the case of the US, recycling through investment tax credit would best foster economic growth (from a zero net GDP cost to a 1.67 per cent increase from the baseline). Other schemes would provide either slight improvements or losses from the default option.

These results should be considered illustrative only, since they rely on simple assumptions on the substitutability among factors (capital, energy, labor and materials), the magnitude of which depends on

23. Goulder (1995).

24. Shackleton *et al*. (1993).

what observations are available. Such observations may not cover the price changes envisioned by the carbon/energy taxes tested in these models. Although oil shocks have provided such observations for oil and other energy products, their effects are not strictly comparable to what the effect of a carbon/energy tax might be. Differences include: revenues raised and re-distributed domestically, a long-term price signal provided to agents, as opposed to the “surprise” of oil price increases.

Even if one accepts the evidence from neo-keynesian analyses on the existence of a double dividend, modelers have not tested whether there is still a double-dividend from recycling, e.g. through lower labor taxes, when tighter energy-related greenhouse gas constraints, i.e., higher taxes are applied.

Last but not least, it ought to be stressed that the existence of a double dividend, if any, calls for improving the tax system, and is largely independent from the issue of carbon/energy taxation.

Financing energy efficiency improvements

Financing energy efficiency improvements with carbon/energy tax revenues is one form of what is known as earmarking. Theoretical and practical arguments against earmarking include the following:[25]

- if the tax is fixed at such a rate that it should lead to the required level of CO_2 emissions reduction, earmarking the revenues for expenditures that would further reduce the targeted emissions would be inefficient. If, on the other hand, it is not possible to fix the tax at the required level, then earmarking would help achieve the reduction target;

- as the share of earmarked funds rises, government may find themselves no longer able to set priorities over time. Conversely, the earmarking of the tax need not extend indefinitely, but be limited to a transition period;

- if a fixed share of revenues are earmarked for energy/environment programmes, as revenues vary, so will the financing for such programmes, which cannot be consistent with cost-benefit analysis of these programmes. In the case of energy-related CO_2 emissions, if tax revenues increase, this also indicates an increase in emissions, and also a need to improve energy efficiency further to achieve an emission target; if, in turn, revenues are reduced, this indicates a favorable emission reduction. Last, but not least, earmarked funds need not be a share of total revenues, but could be a portion of total revenues. Given short-term rigidities in energy systems, total tax revenues from carbon/energy taxes can be estimated with enough certainty.

Carbon/energy taxes could generate sizeable revenues, part of which could be allocated to help finance energy efficiency improvements and smooth the transition towards internalization of the greenhouse effect. It is also a way to show that taxes are not raised for budgetary reasons. Denmark has taken such an approach, with a four-year “transitionary” programme of energy efficiency grants to industry. After four years, raised revenues are almost entirely recycled through lower social security contributions by employers.

There is little literature on such schemes, because an appropriate treatment of this question demands an assessment of an economy's untapped energy efficiency potential, as well as some knowledge as to how

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25. OECD (1996).

economic agents choose to invest in energy efficient products or equipments.[26] Existing market barriers to cost-effective energy efficiency improvements also need assessing.

Goto (1995) provides an estimate of how such recycling could help mitigate some of the negative distributive impacts of a carbon tax on the Japanese economy. The author starts from the observation that industry requires a two to three-year pay-back period for energy-efficiency investments, due to risk considerations. He then translates the apparently inefficient diffusion of more energy efficient technologies by a pay-back period of five years for such investments. Agents are supposed to replace their equipment at the end of its lifetime, regardless of their cost-effectiveness; if a more efficient technology is available then, the government provides a subsidy on this technology to foster its adoption. New technologies are applied only in selected sectors (steel, chemical industry and transportation). A simulation is performed under this set of assumption, and determines the new tax level necessary to achieve the stabilization of energy-related CO_2 emissions at 1990 levels in 2000 and thereafter.

The tax level would be reduced by 20 per cent, to US$160 instead of US$200/tC (see above results). When compared to the scenario without energy efficiency investment, industry would greatly reduce its loss of value added (by about US$155 billion). The total subsidy would amount to US$12.5, but result in an overall GNP increase of US$67 billion. This suggests that such a subsidy scheme should be adopted regardless of the carbon tax. However, the tax helps preventing the rebound effect: without the carbon tax, a decrease in energy demand would lower end-use energy prices, which would partly offset *ex ante* reduction in energy consumption. In brief, financing energy efficiency improvements and the price-signal of a carbon-energy tax are complementary to achieve the desired emission target.

The European Commission ran similar scenarios for six of its member countries.[27] This exercise is somewhat more limited since it does not assume a wide-ranging carbon/energy tax, but an energy tax raised on households energy use only, recycled to foster energy efficiency improvements in industry and household sectors. Households reduce their emissions in response to the price signal, and adopt “best available technologies”; industry reduces its emissions through two types of government aid. These scenarios rely on detailed estimates of energy efficiency potentials for specific industries at the national level; they rely on a macro-econometric neo-keynesian model for each country.

Two mechanisms are explored to improve energy efficiency:

- i a subsidy, limited to 40 per cent of investment outlays in best available technologies (industry and households), or

- ii a lower interest rate on loans for such investment in the industrial sector.

These two scenarios are not completely comparable, because the energy tax increase on households is not the same in both (5 per cent in *i.*, 1.5 per cent in *ii.*) If we focus on economic and environmental effects of these scenarios, the subsidy scheme i. offers a better coverage of total energy demand, and therefore brings more important reductions than *ii*. In the year 2005, scenario *i*. brings about a 6.7 per cent reduction in total energy demand, whereas *ii*. has a more limited impact (-1.3 per cent). Not all of the difference can be attributed to the respective policies, since part of the reduction in energy demand in *i*. is due to negative “income effect”, with GDP being somewhat lower in the first scenario (-0.1 per cent from

26. In other words, this means bridging the gap between so-called *bottom-up* and *top-down* approaches, a yet unresolved methodologivcal problem.

27. Bossier *et al*. (1995)

the baseline versus -0.03 per cent in *ii*.) For comparison, the EC tax would bring about a 7.2 per cent reduction in energy-related emissions.

Those scenarios indicate that earmarking for energy efficiency improvements can achieve reductions that would otherwise necessitate much higher taxes. This result is mostly valid in the short to medium term, where technology is given. In the longer term, the effect of a higher price signal on technology development may supersede the energy efficiency uptake encouraged by the subsidy schemes.

Another option to recycle carbon/energy tax revenues to directly contribute to greenhouse gas reductions would be to finance the uptake of renewable energy sources, or finance research and development programmes to address the longer-run. Renewable energy use could be funded over a limited period of time, so as to increase the scale of production, and lower the unit cost, without creating a long-lasting distortion, or "picking winners". In principle, an appropriate mix of market mechanisms and setting long-term policy objectives should be sought.

Contribution to other policy goals (other than through recycling schemes)

It is commonly argued that a tax on carbon/energy would also achieve other environmental goals, the benefits of which may be significant in some instances. The issue of internalization of external costs is covered in another study (full cost pricing, under economic instruments), but is worth quoting some work that has been done along the lines of so-called secondary-benefits of carbon taxation. These are called secondary benefits because the primary benefit of a carbon tax is to reduce CO_2 emissions; reductions in other external costs are only a joint-product, secondary to the main objective.

Statistics Norway has conducted many analyses on the effects of various carbon tax policies on Norway's other emissions, and the associated economic benefits, which are summarized in the table below. Table 6 indicates both the macro-economic cost from a carbon tax, as well as the environmental benefits, estimated in dollars per reduced ton of carbon, for 10 different studies. Note that underlying assumptions, end year, modelling approaches and scenarios (unilateral or common stabilization strategies) vary from one study to another. In each study, an estimate of the cost of reduced pollution and reduced traffic is provided.

Table 6: Secondary benefits of carbon taxes and GDP costs - selected results for Norway

Study	Loss in GDP US$/tC	Environmental benefit US$/tC	Benefit from reduced traffic US$/tC	Total for "secondary benefits"	End Year
1	**2**	179	309	**489**	2000
2	**177**	52	74	**126**	2010
3	**795**	306	392	**698**	2000
4	**897**	151	228	**379**	2000
5	**1974**	169	255	**424**	2025
6	**2757**	184	828	**1012**	2030
7	**3634**	138	228	**366**	2030
8	**5974**	213	365	**578**	2030
9	**8219**	222	256	**478**	2000
10	**37672**	1426	1630	**3056**	2000

* Ratio of total economic cost divided by total carbon emission reduction.

The above results show that for Norway, the secondary benefits can be of the same order of magnitude than total macro-economic cost. The effects of the carbon tax, in addition to climate stabilization, would be direct benefits that may offset part of the cost for CO_2 reduction. Note that the environmental benefits are not “recycled”, nor fed into the model. More careful review of the underlying scenarios and assumptions would be necessary to provide further elaboration on these results.

Distributive effects[28]

Distributive effects represent the most delicate issue when introducing a new tax. This remains the case for carbon/energy taxes. Although the aggregate macro-economic cost of such taxes can be modest, some sectors or income groups are more likely to suffer than others from carbon/energy taxation schemes. Additional insights can be gained from analyses of distributive impacts, especially when looking at the differentiated regional impacts within countries: they provide a “reduced version” of what the effects of a common taxation at an international level would imply across countries.

There is a significant shortcoming to associating all distributive effects reported below to a carbon/energy tax: any instrument, or policy package, aimed at decreasing the consumption of fossil fuels will have detrimental effects on sectors such as coal mining, oil and gas extraction, refining, fossil fuel-based power generation, etc. Precisely, the theoretical argument in favor of a tax instead of relying on command-and-control measures lay in its ability to best allocate the efforts across agents, and provide reductions in the most cost-effective fashion.

Distributive impacts of carbon taxes can be envisioned along three dimensions:

- income groups,
- sectors, and
- regions (e.g. for the United States and Canada).

Countries with carbon/energy taxes have sometimes introduced recycling schemes to offset the negative distribution effects of new taxes. Governments have experience with such measures that go far beyond that of taxation policies, e.g. employment policies to absorb the extra workforce from declining industries, and could not be covered in this study. This remains mostly an issue to be solved at the national level.

Income groups

This section reports the results of income distributional studies of carbon taxes in developed countries. The following figure presents estimates of the income distributional impacts of a $100 per ton carbon tax imposed in the United States based upon the 1991 Poterba study. The estimates assume that the tax is fully passed through to customers in the form of higher fuel prices. The added cost that each income group bears thus depends upon its energy expenditures. This study illustrates the difference the definition of income makes in assessing the regressivity of the carbon tax. The study calculates global warming response costs as a per centage of both *per capita* income, the traditional measure, and *per capita*

28. This section includes text of the OECD report: *Climate Change, economic instruments and income distribution* (1995).

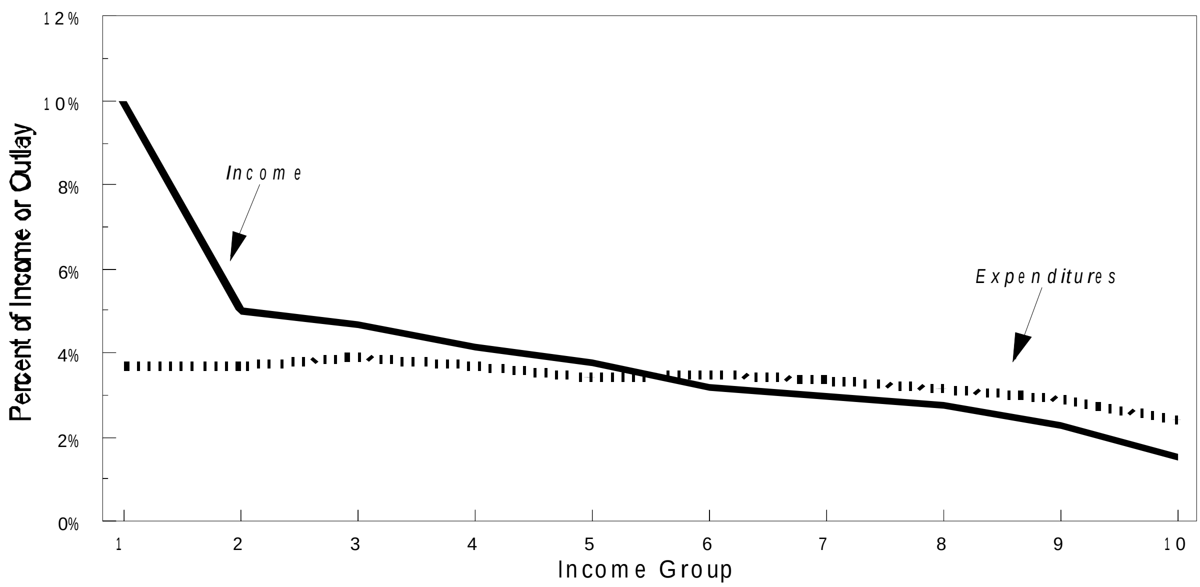
expenditures, which is intended to measure expected *lifetime* income (see Figure 9). The latter is less influenced by stochastic loss of income, e.g. from temporary unemployment, hence it is a more steady indicator of the economic position of households. The patterns are regressive in such studies (*i.e.*, greater costs as a per centage of income for lower income groups) using both measures, although the degree of regressivity is much smaller when expenditures are used. The difference in measured impact is particularly dramatic for the lowest income group. For the lowest group, the costs of a $100 per ton carbon tax are projected to be more than 10 per cent of income, but only 3.7 per cent of expenditures.

Table 7: Summary of empirical studies of the income distributionalimpacts of a national carbon tax

Reference	Country	Model	Results
Bull *et al*. (1993)	United States	General equilibrium	Proportional
DeWitt *et al*. (1991)	United States	Partial equilibrium	Regressive
Jorgenson *et al*. (1992)	United States	General equilibrium	Varies by welfare function
Poterba (1991)	United States	Partial equilibrium	Regressive
Schillo *et al*. (1992)	United States	Simulation	Regressive
Pearson (1992)	European	Partial equilibrium	Regressive
Pearson and Smith (1991)	European	Partial equilibrium	Varies by country

Source: IPCC (1996, chapter 11)

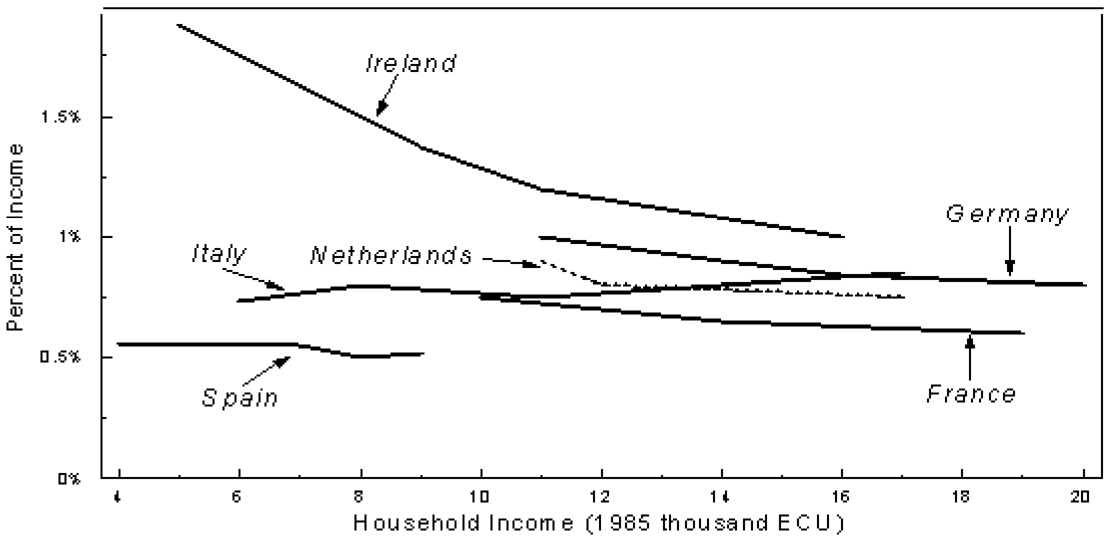
Figure 9: Income distribution impacts of a $100 per ton carbon tax in the United States



Source: Poterba (1991).

Figure 10 shows the distributive results in six European countries of a carbon and energy tax proposal equivalent to $10 per barrel of oil. (The EC proposal is a combination of a tax on the carbon content of fossil fuels and a tax on all non-renewable forms of energy.) The estimates in Figure 4 relate to the direct fuel expenditures by household and do not include the indirect effects of the tax as a result of taxes borne initially by industrial taxpayers. The pattern is very different in the various countries. The tax would clearly be regressive in Ireland, suggesting a pattern similar to that in the United States based on income rather than expenditures. (The researchers find a similar pattern in a separate study on the United Kingdom.) However, in the other five countries, the per centage burden of carbon tax payments for household energy use is only weakly related to income, if at all.

Figure 10: Income distribution impacts of a carbon tax in six European countries

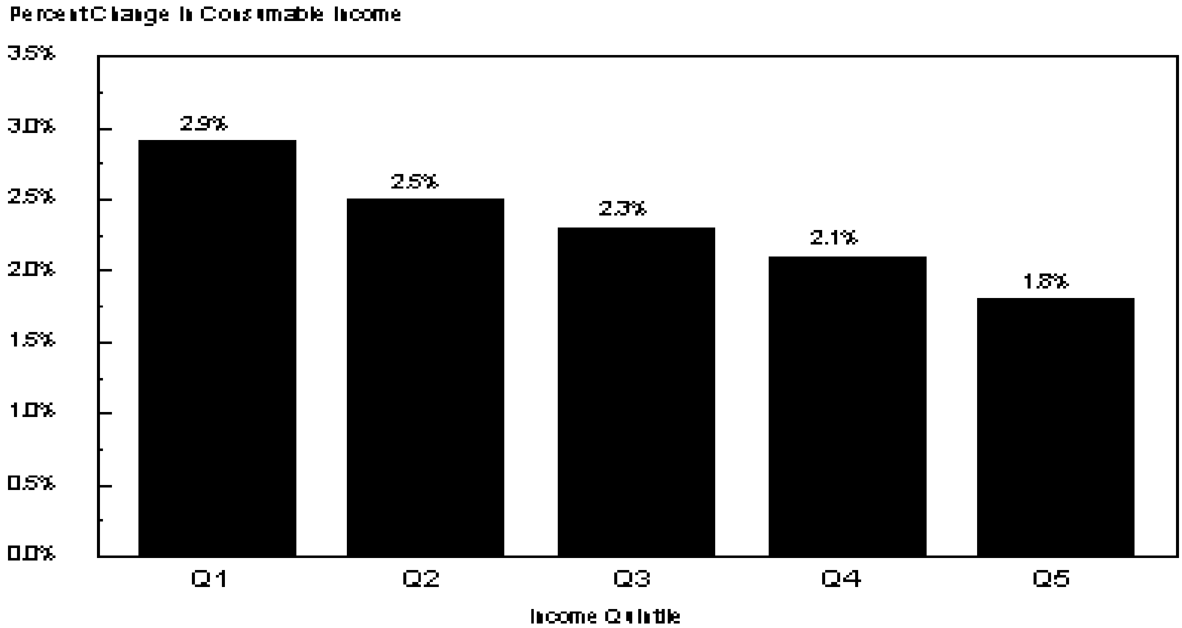


Source: Pearson and Smith (1991).

The authors note that the less regressive pattern in these other countries reflects both differences in energy spending as well as differences in the consumption of fuels with high carbon content. One important difference relates to patterns of automobile ownership. Automobile ownership is less prevalent among lower income groups in the other five countries than in the United States or the United Kingdom. As a result, lower income households in the other five countries do not bear added transportation costs due to a carbon tax.

A recent Canadian study by Hamilton and Cameron (1994) assesses the distributional effects of a tax of \$27.70 (Canadian dollars) per tonne of CO_2 emitted (equivalent to a \$101.56 per tonne of carbon in US dollars), the tax estimated to meet the Rio target of stabilizing CO_2 emissions at their 1990 levels by 2000. Although the required tax is estimated using a general equilibrium model, the distributional impacts are based upon a series of partial equilibrium calculations that simulate the short-run effects of the tax. The authors find that the carbon tax would be moderately regressive. Figure 11 shows the results of the simulation in which direct and indirect effects of a unilateral Canadian tax effects are estimated for the five quintile income groups. The per centage burden on households in the lowest income group is 2.9 per cent, compared to 1.8 per cent for households in the highest income group.

Figure 11. Precentage change in consumable income from a carbon tax in Canada, by income quintile



Source: Hamilton and Cameron (1994, Table A2).

Income distribution impacts were also assessed for specific income groups, when selecting a carbon/energy tax in the United States. Since in the United States, the poor generally spend a greater proportion of their income on energy than the rich, all energy taxes are slightly regressive. All the taxes examined lowered the income of the lowest quintile by nearly 1 per cent versus 0.1 per cent for the highest income quintile. When household expenditures, often considered a more reliable indicator of economic well-being, rather than income are used as the basis of comparison, the taxes had an impact for the lowest quintile of about 0.4 per cent per cent, compared with 0.15 per cent for the highest quintile. The carbon and BTU taxes have the smallest impacts on households at all income levels. While these differences across the income distribution are generally small, they are, nonetheless, regressive. The Administration proposed to offset the regressivity of the energy tax by introducing progressive provisions in the larger deficit reduction package being sent to Congress.[29]

Energy sectors

A carbon tax could have dramatically different impacts on different sectors of the economy, particularly energy sectors. The precise impacts on different energy sectors would depend upon their carbon content and on market conditions faced by domestic producers.

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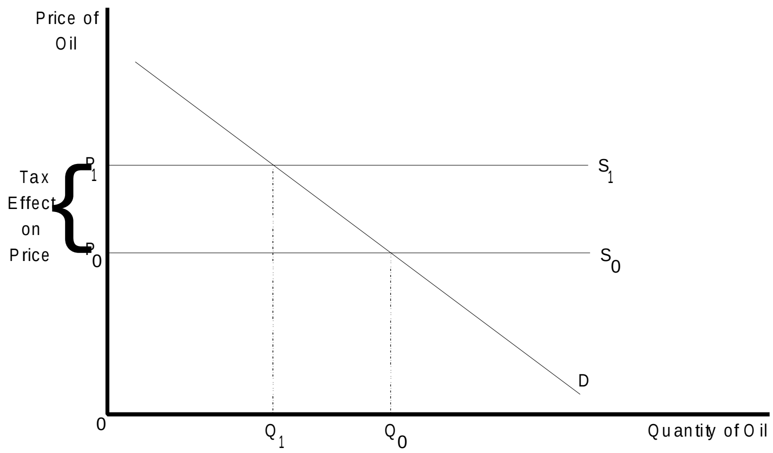
29. The most important program proposed by the Clinton Administration to offset the regressivity of the BTU tax was an increasein the Earned Income Tax Credit (others included expanded funds for the Low Income Energy Assistance Program and increased funds for food stamps). The Earned Income Tax Credit effeictively exempts from income taxation certain portions of income from low earners.

Market Conditions

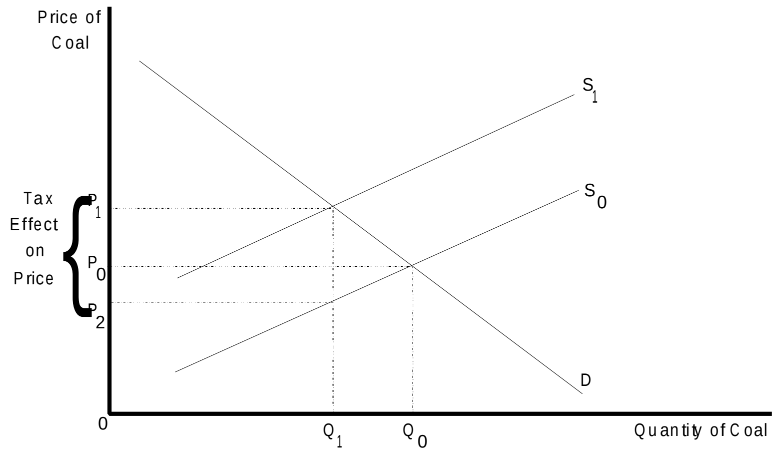
The impacts of a national carbon tax on prices and uses of different fuel would depend in large part on the market conditions faced by domestic producers, particularly whether they operate in international or local markets (Nichols and Harrison, 1991). Oil represents one extreme case, in which the price is set largely by world markets. Domestic producers would sell abroad if the country price fell below the world price, and foreign suppliers would not sell to buyers within a country unless they received the world market price. Thus, the domestic supply curve for oil (assuming the internal market is a relatively small part of the world market) would tend to be perfectly elastic at the world market price (see Figure 12). The effect of a carbon tax would be to shift the supply curve up by an amount equal to the carbon tax times the carbon content of oil (from S0 to S1). Because the supply curve is horizontal, the price rises by the full amount of the tax and customers bear all of the added costs; the supply price net of the tax would remain the same. However, the amount of domestic oil sold would decrease in response to the higher price from Q0 to Q1 with the shift dependent upon the price elasticity of demand for oil.

Figure 12. Illustrative impacts of a carbon tax on the domestic oil market



Energy producers would bear some of the burden of a carbon tax in the form of lower prices if the supply were not completely elastic. Coal fits into this category in many countries. For example, in the United States the relatively high cost of shipping means that there tend to be regional markets for coal. Producers' profits would therefore be affected by a carbon tax. Figure 13 illustrates this case. The initial supply shifts up, from S0 to S1, based upon the impact of the tax. Because the supply curve is not completely elastic, some of the tax is paid by consumers of coal (from P0 to P1) and some of the tax is reflected in a lower price paid to coal producers (from P0 to P2).

Figure 13. Illustrative impacts of a carbn tax on regional coal markets



Empirical Studies

Table 8 shows the estimated effects of a \$100 carbon tax on the prices and uses of fossil fuels in the United States in 2000 as estimated by the United States Congress' Congressional Budget Office (CBO). As expected, the coal industry would be hard hit by a carbon charge. Coal use is projected to decline by 13 per cent from the baseline, a drop that reflects both that coal is the most carbon-intensive fuel and its relative ease of reducing coal generation of electricity. Indeed, the CBO concludes that reducing coal use is a necessary part of any effective CO_2 reduction strategy in the short-run. Thus, a carbon tax may not result in greater reductions in coal than a comparable regulatory strategy. Oil and natural gas face smaller declines with a carbon tax, estimated at 6 per cent and 4 per cent, respectively. Natural gas declines because of the general decline in fossil fuels. The CBO notes that alternative fuels not affected by the carbon tax (*e.g.*, solar) would be likely to expand, although the overall levels are expected to remain small.

Table 8: Estimated effects of a \$100 per ton carbon tax on prices and quantities of fossil fuels in the United States

	Oil	Natural Gas	Coal	All Energy
Price (per cent change)	21	16	161	NA
Quantity (per cent change)	-6	-4	-13	-7

Source: US Congress (1990, p. 28).

Energy taxes

Taxes other than a carbon tax could be used to reduce greenhouse gases. A BTU tax, based on the energy content of primary fuels and including other sources such as nuclear energy and hydropower, would differ in two major ways from a carbon tax (see US Congress, 1990). First, since the BTU tax in the United States would have a base about 15 per cent greater than a carbon tax, it would raise the same revenues with lower average tax rates. Second, because coal has more carbon per unit of energy than the other fuels, a Btu tax would impose less burden on coal than a carbon tax. Table 9 shows the CBO's calculation of the effects of a carbon tax and a Btu tax that would both raise \$15 billion in revenues. A carbon tax would increase the price of coal by \$7.57 per ton; a BTU tax would increase coal price by \$5.13 per ton. Note that the BTU tax would discourage the introduction of forms of energy such as nuclear power and hydropower that do not emit carbon dioxide. Note also that the revenue collected is greatest for oil in both cases, because oil is the dominant source of energy in the United States.

Table 9: Comparison of the effects of a carbon tax and an equivalent BTU tax on fuels

	Oil	Natural Gas	Coal	Other	Total
Carbon tax					
Dollars per ton of carbon	12.51	12.51	12.51	NA	NA
Dollars per million Btus	0.28	0.20	0.35	0.0	NA
Dollars per unit of fuel	1.63	0.20	7.57	0.0	NA
Revenue ($1990 billions)	7.23	2.85	4.92	0.0	15.0
Btu Tax					
Dollars per million Btus	0.23	0.23	0.23	0.23	NA
Dollars per unit of fuel	1.36	0.24	5.13	NA	NA
Revenue ($1990 billions)	6.04	3.37	3.34	2.25	15.0

Source: US Congress (1990, p. 68).

Impacts on other domestic sectors

A carbon tax levied on carbon in fuel would affect non-energy sectors because the rest of the economy would adjust to higher fossil fuel prices. Firms would have incentives to shift to less carbon-intensive products and thus demand for those products would fall. In contrast, the demand for non-carbon and non-energy intensive products would increase. Over the longer term, a carbon tax would affect virtually all sectors of the economy in some way.

The net result is that although a carbon tax would initially affect carbon-intensive energy sources, the ripple effects would extend throughout the economy. The ultimate distributional impacts would thus depend upon many linkages. In the long-run, most of the burden of a carbon tax would likely to be borne by final consumers in the form of increased prices and by carbon-intensive energy producers in the form of lower rents. Final consumers, however, can rely on technical alternatives to improve their energy efficiency.

In the "short-run", the burden might be spread much more widely. For example, companies that owned specialized equipment to transport carbon-intensive fuel would find that the value of their equipment had decreased. In the long-run, they would reduce investments in this equipment. Workers with specialized skills related to carbon-based fuels might also suffer "short-term" or transitional losses, even if in the long- term the numbers of people with such skills would decline to reflect the decreased demand.

In many ways, these effects may not be specific to carbon/energy taxation, but apply to all policies aiming to reduce energy-related greenhouse gas emissions.

Regional impacts

Regional impacts are difficult to assess since most models are national, and observations on energy use patterns by regions only provide a static picture on top of which one can, at best, simply apply the price changes on energy expenditures, and relate these changes to overall income (first-round effects). The first round effects are totally related to the differences in income across regions. A simple analysis like this omits the effect of taxes in affecting local activities whether these effects would be positive or negative (second-round, or income effects).

Such an analysis was done for Canada.[30] The results account for the economic structure of each region, including the international trade dimension, important when considering a unilateral tax. Most energy-oriented regions would experience the largest economic losses in 2000: Alberta, for instance, would lose 4 per cent of its regional domestic product. More economically-diverse regions (Québec, Ontario) would suffer less (about 2 per cent loss of regional GDP), but would be affected through lower exports. For the year 2010, the effects of the same tax would be somewhat lower, except for Alberta, where coal extraction would remain under baseline levels. It is not clear whether this study accounts for the geographic mobility of industries and labor force. As in the case of other modelling approaches, the potential development of new activities in response to the carbon constraint is not explicitly simulated either.

Trade, competitiveness: effects of unilateral measures

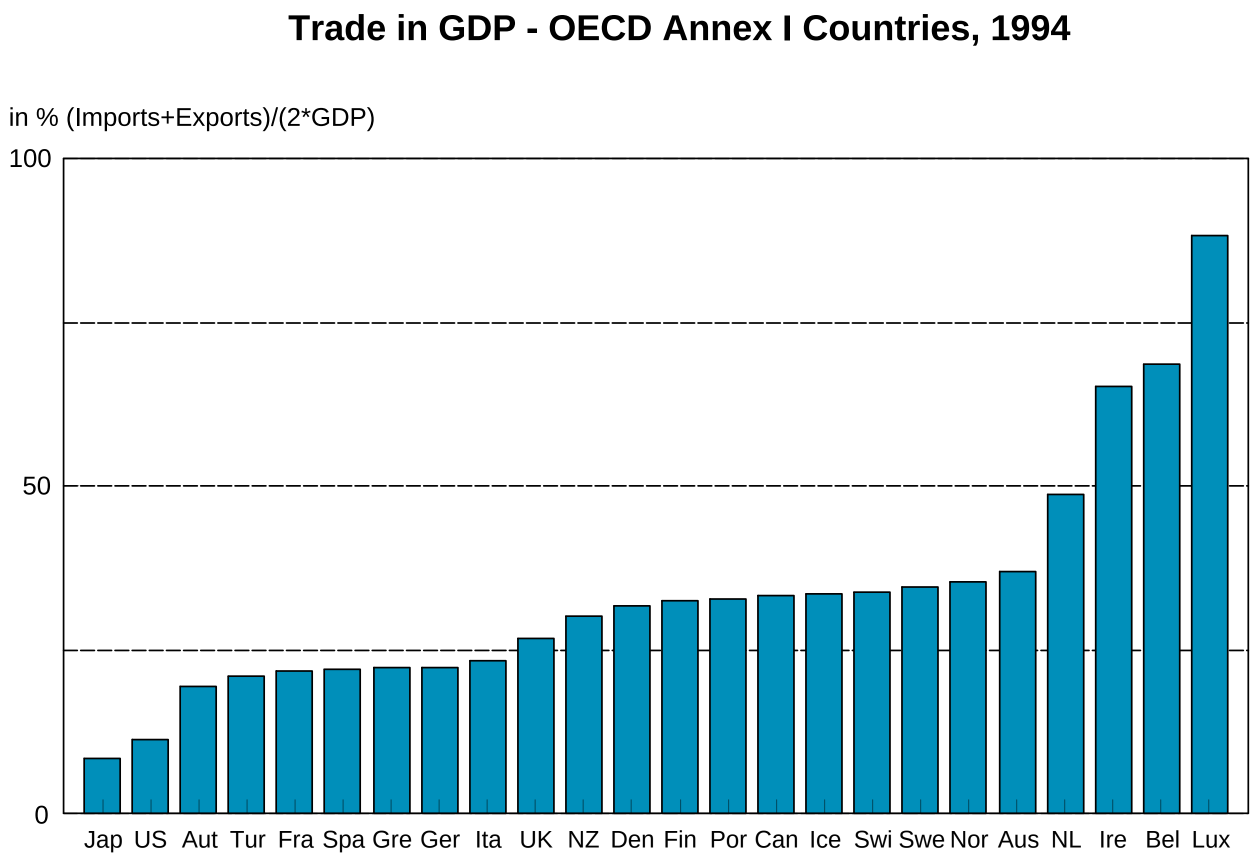
The trade and competitiveness issues have received much attention, since they provided the main argument to reject a unilateral tax, and led to exemptions in most cases where carbon/energy taxes were adopted. Exemptions suggest that this is a sensitive issue in countries where such tax exists.

Before turning to the issue itself, it is worth recalling that although industries in Annex I countries operate and compete on the same international markets, they work under very different conditions at home. Labor costs, including taxes, corporate income taxes, regulations, including environmental regulations *and* intermediate input prices (energy) show a wide disparity, and carbon/energy prices are not an exception. The whole set of circumstances must not be forgotten when considering the effects of a carbon/energy tax on competitiveness; since the issue at stake is the taxation of carbon and energy, there is a risk of overemphasizing the role of energy in driving international competition. This is even more crucial when we consider the leakage issue from the adoption of taxation of carbon/energy at some common level.

The next figure gives an indication of trade's weight in OECD economies. The energy trade *per se* may not be so crucial in the case of unilateral carbon/energy taxation: if the country is a net importer of energy, its fossil-fuel trade balance ought to be improved from the tax. In the case of electricity, whether a net electricity importer would gain or lose from taxing carbon/energy depends on the fuel mix of its domestic production versus that of the imported electricity, as well as on the structure of its tax (on energy, in which case imported energy can be taxed, on carbon, in which case the embodied carbon may not be taxable, see section below on border tax adjustments). Fossil energy exporters would lose only if importing countries are taking measures to reduce their fossil fuel emissions (either through a tax or any other policy).

30. DRI (1993)

Figure 14



Trade in GDP - OECD Annex I Countries, 1994
in % (Imports+Exports)/(2*GDP)
100
50
0
Jap
US
Aut
Tur
Fra
Spa
Gre
Ger
Ita
UK
NZ
Den
Fin
Por
Can
Ice
Swi
Swe
Nor
Aus
NL
Ire
Bel
Lux

A few theoretical considerations and some empirical evidence

A key dimension is the size of a country's production compared with the international market for the product,[31] in other words, a country is either price-maker or price-taker for each of its exported product. For instance, a carbon tax unilaterally imposed by a small country would not change the world market prices for steel; if applied by all Annex I countries, the situation would be different. If a large country decides on a tax which changes its output prices for exported goods, international markets would be affected, and in turn affect the internal allocation of resources within the country. The relative magnitude of these effects remains very difficult to assess, beyond first-round impacts (price increase induces lower demand...) When considering common action by a group of countries which represent a significant share of world trade, this dimension should not be underestimated.

Other elements influencing the effects of carbon/energy taxes on the international competitiveness of a country's industry include

- its factor-endowments, including technology;
- the factor mobility, in the energy-intensive sectors, which would hamper or enhance de-location of production abroad;
- the possibility of non-competitive behavior (oligopoly or monopoly), which determines the effect of a carbon/energy tax on the output price, i.e., either rising or falling;[32]
- the recycling of tax revenues through the lowering of other taxes.

The concern from industry comes mostly from the loss of competitiveness that a tax would introduce. This question cannot be approached *in abstracto*, since various tax levels have obviously different effects on production cost and prices.

Although the case of carbon/energy taxes may differ from other types of environmental regulations, it is useful to look at empirical evidence of the effects on competitiveness and trade of such regulations.[33] An OECD report (1996) summarizes the empirical literature on the subject. Quoting Dean (1992), it states: "More stringent regulations in one country are thought to result in loss of competitiveness, and perhaps industrial flight and the development of pollution havens. The many empirical studies which have attempted to test these hypotheses have shown no evidence to support them." The report concludes that studies attempting to find evidence of the links between environmental regulation and competitiveness have provided non-significant statistical results, or results that are not robust to tests of model specification. It adds, however, that "this finding may simply reflect the fact that environmental regulations have historically affected costs very little. More ambitious policies have been proposed, and it is possible that these would have more significant effects on competitiveness." Carbon/energy taxes may indeed have such an effect.

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31. OECD (1996)

32. In France, an increase in taxes on cigarettes recently resulted in a net decrease in total prices.

33. It is worth recalling at this stage that, in *theory*, taxes (and tradable permits) are more efficient than other types of regulations to internalize externalities, and provide a more cost-effective outcome.

Price effects of carbon/energy taxes and international competitiveness: an open question

Several national studies provide estimates of how various carbon/energy tax proposals would effect industrial prices, and also how best available technologies could contribute in energy cost reductions. From these “observations” to trade implications, the linkages are not straightforward, because:

- not all these products are competing on an open international market (export and import-wise);
- industries apply mark-ups to their production cost, which give them some margin for “absorbing” the increase in input prices when selling abroad, although at a cost in terms of profits;
- the share of energy in total cost may not be significant, so that the effect on output prices would be negligible.

A US$100/tC applied in the United States

Montgomery (1993) computed the effect of a US$100/tC tax on industrial prices, including the price increase caused by the use of intermediate inputs which also rely on fossil fuels; this represents what we may call the full *static* price increase caused by a US$100 carbon tax. Obviously, coal mining, crude oil and natural gas extraction, refining, power production, iron and steel, and the chemical sector would be most hurt (price increases ranging from 277 per cent for coal to 13 per cent in petro-chemical production). All other sectors would undergo a less than 10 per cent increase in prices. Note that these price increases do not incorporate the effect of a possible recycling of tax revenues in these sectors, nor any effect that these higher prices would have on the adoption of more energy efficient processes.

Tax and a subsidy on energy efficiency improvements: an example for the Europeen Union

A similar exercise was done for some member of the European Union: Belgium, France, Germany, Italy, Netherlands, and United Kingdom.[34] Basic assumptions are similar to those used for the United States. The tax amounts to ECU25/tCO_2, roughly equivalent to US$100/tC; in this case, however, a *60 per cent subsidy is provided for energy efficiency improvements in industry*.

Average effects on production costs in industrial branches of these six countries are summarized in Table 10 for the initial year, the short-run and in the longer-run; those effects are derived from a baseline scenario in which all firms stick with the old technology. In the initial year, price changes do not completely diffuse in the economy. In the short-run, prices reach a peak when the effect of the tax is completely incorporated in all prices; in the longer-run, prices decrease when the savings brought about by the energy efficiency subsidy are achieved in all sectors and reductions in cost are transmitted throughout the economy.

These results are entirely dependent on the underlying set of technologies, and the cost estimates corresponding to each technology. They nevertheless show that most energy-intensive industries would be able to minimize the impacts of a significant tax on carbon with the help of a subsidy to reduce its carbon-intensity. This effect, however, would take place after allowing some time for capital renewal. In

34. Boetti and Botteon (1995)

the short run, the tax would have a "spiral" effect on production costs, resulting in a peak in production costs.

The study does not assume, however, the possibility of phasing in the tax over time so as to minimize this detrimental short-run effect (as done in Denmark, and recommended in the original EC tax proposal).

Table 10: Estimates of changes in production costs under a ECU25/tCO_2 with a 60 per cent subsidy on energy efficiency improvements in industry

(Average for Belgium, France, Germany, Italy, Netherlands and the UK)

ron and Steel	nitial Change	6.0%
	hort-run chance	7.8
	ong-run change	7.6%
luminum [35]	nitital change	[-6.1%]
	hort-run chance	[-8.2%]
	ong-run change	[-6.8%]
ement	nitital change	6.4%
	hort-run chance	8.5%
	ong-run change	[-6.8%]
asic Chemicals	nitial change	14.9%
	hort-run chance	22.7%
	ong-run change	19.2%
aper	nitital change	1.9%
	hort-run chance	4.1%
	ong-run change	3.4%

Dynamic effects on trade

Changes in prices are only the first round of effects on trade resulting from a unilateral carbon/energy tax. Real and nominal exchange rates, linked to interest rates, would also alter the competitiveness of industry abroad. Last, income effects on the domestic economy affect the overall demand for imports (we do not, here, focus on the imports/exports of energy). For an energy-exporting country, its size would determine whether the reduction in local demand, if sold instead on the international market, would affect international prices and therefore lower exports revenues.

Any model-based analysis needs to formulate a number of assumptions on the trade balance, the reaction of interest rates and exchange rates, as well as to the import and export price-elasticities for each category of traded goods. Without going through careful revision of all these assumptions and testing the robustness of results to alternative values for key parameters, the confidence in these results remains low, and more so when longer time horizons are considered.

For the United States, the impacts of a US$100/tC on trade would be as follows.[36] Exports would suffer from a rise in real exchange rate, and the limited decline in foreign GDP, coming from increased prices

35. The technology underlying the important savings shown here is recycling of aluminium. The authers note that the profitability of that technology has been overestimated (ibid., p. 55).

36. EPRI (1994)

for US products. On the whole, in the year 2010, exports would decrease by 1.9 per cent, non-oil imports by 2.6 per cent, and oil imports by 8.2 per cent, leading to a trade balance improvement of US$10 billion (1987 dollars).

In the case of a small economy, the results differ mostly because the higher price of its exports would not be reflected in higher prices in imports. In the case of **Norway**, which also exports fossil energy, the reduction in domestic demand for natural gas leads to an increase in exports of that product, under a unilateral stabilization scenario through a tax. That result, however, is driven by the specification of gas production in the model: natural gas production is exogenous, and quantities not sold on the domestic markets are necessarily exported. Moreover, this analysis is based on a computable general equilibrium which implies that some assumption is made on the evolution of the trade balance over time, either fixed for the baseline and policy cases, or linked to the current account balance, itself exogenously specified. In all cases, alternative assumptions would produce different results on trade.

The above are only presented here for illustration of what the effects of a tax would be on trade. They are based on detailed descriptions of the underlying economies, but are still determined by assumptions on:

- changes in exchange rates;
- effects of a carbon/energy tax on prices over different time-horizons, which may leave important elements out (lack of flexibility in the short run, increased opportunity to reduce energy requirements in the longer run);
- recycling schemes: a subsidy on energy efficiency would greatly lower the price effect of a tax even in most energy-intensive industries. Lower labor costs would also contribute positively to the competitiveness of some sectors;
- industrial prices are set assuming perfect competition; margins could be adjusted in some sectors, offsetting the price increase. While this would have implications for investment and profits of these industries, this could annihilate the short term effect of the tax on international prices.

Points for consideration of results

Also, the share of energy in total cost may not be high enough that all industries see an advantage in dislocating production based on an increase in their energy costs, whereas other costs (labor, investment...) would be reduced (labor costs seem to be driving most of the competitive advantage of South-East Asian countries, rather than low energy costs).

Very few modelling analyses are based on econometric analysis that would offer statistical basis for the described changes in trade patterns, nor do they replicate strategic pricing behavior by exporting industries. Computable general equilibrium models operate under the assumption of perfect competition. If that assumption is set aside, on can envision that export-oriented industries would rather lower their margins to absorb the extra energy/carbon cost, therefore not facing direct losses of competitiveness (but reduced profit-margins). Such behavior is not usually reflected in computable general equilibrium models. Another major assumption behind modelling estimates on this question is that products within a certain category (steel, cars) compete on prices only, whereas the quality of the product, its technological advance, may bring a comparative advantage offsetting price differences. Some countries have argued that improving energy efficiency and carbon content could enhance their product's competitive edge through technical improvements.

Taxation of carbon/energy as a measures for common action

In this section, we consider the advantages/disadvantages of moving from a national tax to a common taxation strategy. This part of the study will be mostly based on modelling results of possible carbon/energy taxation schemes at the international level, and on their simulated effects on emissions. The comments provided in the box at the beginning of this section fully apply here.

One common action may simply be for Annex I Parties to agree that a long-term price signal is necessary, without specifying what the level of the signal should be, since its environmental efficiency depends ultimately on national circumstances, the share of emissions not related to the use of fossil energy, and on other available policies and measures. For the most part, model-based analyses of taxation at some common level do not provide the level of detail required to assess the contribution of a tax as part of a policy package.

Instead, global macro-economic models use the tax as a measure for the marginal cost of reduction, but falling exclusively on energy-related CO_2 emissions. This is the substance of what is reported in this section. Most model-based economic analysis of carbon/energy taxation either focus on:

- a common tax applied to all participating countries or regions (carbon or carbon/energy);
- the tax levels necessary to achieve similar reduction in participating regions.

Another way to look at the advantages/disadvantages of common taxation is to consider what would happen to a region implementing a tax to reduce emissions when other Annex I Parties are not (reference scenario), and then observe the changes under a scenario where all Annex I regions apply taxation to carbon/energy. This comparative analysis leaves out an important issue, however: there is no indication about the policies implemented in the rest of Annex I Parties to control their emissions.

We summarize regional/global studies of carbon taxation, looking at the issues described above, but with some emphasis on the following issues:

- Tax levels that are necessary for various regions to get at the same level of reduction;
- General trade and energy market impacts (prices and quantities);
- Effect of a common implementation of a tax on trade;
- Alternative taxation schemes (a tax raised by producing countries rather than by consuming countries);
- Impacts on non-Annex I countries, who do not implement the tax, but reap some of its benefits (lower energy prices...) and may therefore emit more CO_2, or, else be negatively affected by reduced economic growth in Annex I.

Most of the issues covered here have already been studies by the IPCC Working Group III (Chapter 9). Instead of systematically repeating IPCC's results, we try to concentrate on issues relevant to the common implementation of carbon/energy taxes *within Annex I Parties*. Not all modelling results could be summarized for each question. With a clear understanding of the shortcomings of modelling analyses, the results reported below are taken to be representative of other similar analyses.

Description of the simulated measures

We limit the scenarios to the following:

- a common carbon tax applied to Annex I Parties (either carbon or EC tax),
- common reduction target within Annex I achieved through taxation.

We also comment on the impacts of taking unilateral actions versus those implied by a common strategy.

Results

Common taxes within Annex I: aggregate results

It is noteworthy that model-based scenarios that would fit the needs of this study could not be found, i.e., scenarios where Annex I Parties only apply taxes on a country-by-country basis, then move to a common tax to be applied within the region.[37] To illustrate the gains in economic efficiency from moving to a single common tax, we use a carbon tax scenario which includes other regions of the world. To avoid providing extraneous information, we only report results for Annex I Parties.

Similar reduction objectives imply different marginal costs of reduction across regions

The OECD GREEN model has studied the effects of stabilizing energy-related CO_2 emissions in OECD regions at 1990 levels from the year 2000 to the year 2050. The results are summarized in Table 11:[38]

Table 11: Main results from scenario in which OECD Member countries stabilize their emissionsover the 2000-2050 period at 1990 levels (GREEN model)

	Business as usual growth in emissions (1990-2050)	Cut in CO_2 emissions from baseline	Carbon tax in 2050 (1985$/tC)	Present value of real income changes over 1995-2050 (% from baseline)*
United States	0.9%	-43%	$66	-0.5%
Japan	1.4%	-59%	$236[39]	-1.2%
EC	0.8%	-37%	$88	-0.6%
Other OECD**	1.0%	-44%	$81	-0.4%
Total OECD	1.0%	-44%	$93	-0.7%

* a 1.5% discount rate is used in all regions.

37. We looked at studies based on the OECD GREEN model, as well as those included in the IPCC Working Group III Chapter on Mitigation Cost Studies.

38. Martin *et al*. (1992). note that in *this* scenario, Japan stabilises its emissions in per capita terms, in agreement witht e country's national commitment.

39. The relatively high carbon tax rate for Japan is explained by the high growth in emissions in the baseline scenario for that country, and already important reliance on non-fossil fuels in power generation.

** GREEN describes the rest of the OECD as an aggregate region (Australia, Canada, New Zealand)

These results show important disparities in both tax levels and economic costs associated with stabilization within the region, suggesting that economic gains could be made from co-ordinated action. Other modelling results confirm this general result, with somewhat different ranking of costs over regions. We summarize these results in Table 12, including GDP cost estimates for the former Soviet-Union and Eastern European countries.[40]

Table 12: Cost of a carbon tax to stabilize emissions at 1990 levels, for the year 2020

	Barnes *et al*. (1992) -Energy model-	Oliveira-Martins (1992) -GREEN-	Manne (1992) -Global 2100-	Rutherford (1992) -CRTM-
United States	2.0%	1.1%	2.2%	1.3%
Other OECD	1.9%	1.2%	1.1%	0.4%
FSU + EE	0.9%	1.7%	3.1%	1.5%

Since the above studies are global in nature, the following elements are necessarily sketchy:

- existing price levels and taxes for different types of users; early studies did not assume different energy taxes by regions in the OECD (US versus other OECD);
- energy subsidies are usually accounted for, although they represent price differentials across regions rather than financial subsidies by governments; the presence of subsidies (especially in Easter Europe and the FSU modules of the global models) introduces a distortion that a tax would help reducing, thus improving overall economic efficiency;
- there is usually little detail on economic structures (capital stocks, features of different types of industries, infrastructure for transportation and housing, etc.);
- structural changes and non-price induced technological change are summarized in a single parameter (*autonomous energy efficiency improvement rate)*, sometimes without distinction across agents within the region's economy (i.e. industry and households).

A recent study offers a different geographical disaggregation, with more Annex I detail.[41] The results of a stabilization scenario on a region-by-region basis are summarized in Table 13, and show a different ranking of macro-economic costs across OECD Member countries, from that provided by GREEN.

Table 13: Changes in energy-related CO_2 emissions and in welfarefrom stabilization in OECD regions with region-specific taxes (year 2020)

Region	Changes from baseline emissions (MtC and %)	Change in Gross National Expenditures in 2020
United States	-1203 (-19%)	-0.15%
European Union	-565 (-15%)	-0.08%
Japan	-441 (-26%)	-0.25%
Canada	-146 (-31%)	-0.5%
Australia	-118 (-31%)	-0.5%
New Zealand	-15% (-19%)	-0.8%

40. OECD (1995)

41. ABARE and Department of Foreign Affairs and Trade (1996)

Total	-2488 (-19%)	NA

Any comparison of these results with that of other studies would require considering, in addition to elements already mentioned:

- differences in baseline emissions, which affect the effort necessary to reach stabilization;
- differences in carbon taxes necessary to reach these levels;
- differences in regional aggregation;
- differences in cost of technologies;
- differences in discount rates used to report results;
- differences in the treatment of trade (assumptions on trade balances, possibility inter-regional trade in similar commodities);
- differences in the treatment of oil/gas/coal markets. Some models rely on exogenous assumptions on international prices, others assume no inter-regional trade in natural gas, which might reduce opportunities for fuel-switching and therefore affect abatement costs.

In all, the variety of results suggests some uncertainty as to the ranking of regions in terms of the cost of achieving common reduction objectives through carbon taxation in Annex I. What is certain, however, is that a similar reduction target would require different tax levels, given existing taxes, the carbon intensity of the various economies, and their substitution possibilities.

Illustrations of the aggregate economic gains from common taxation

Observing the differences in marginal costs of stabilization reported above (the different carbon taxes), sound economics immediately suggests that a better allocation of effort could be achieved through the application of a single tax to all participants to achieve an overall “cap” on emissions, rather than relying on individual taxes to achieve a country-by-country reduction level.

The GREEN model illustrates the economic impacts from stabilization in the OECD over the 1990-2050 period, when achieved with region-specific taxes and with an OECD-wide tax, and the efficiency gains from a multi-lateral agreement.[42] Table 14 shows the tax rates and the changes in real income for the four OECD regions identified in the model when regional taxes are imposed to stabilise emissions, as well as the impacts on non-OECD regions for the year 2000, 2010 and 2050. These results are naturally heavily dependent on what baseline emissions are, since this determines the level of effort required to achieve stabilization. For instance, Japan faces the largest cutback from baseline emissions (66 per cent in the year 2050) which explains the higher loss in real income among all OECD regions; any other “forecast” on baseline emissions would lead to a different ranking in income losses incurred in different regions.

Positive or zero cost (e.g. for the United States in the year 2000) is explained by the terms of trade effects of the carbon tax in this scenario; it does not result from the simulation of a “no-regret” potential, and is entirely macro-economic in nature.

The GREEN study shows that, through international trade, non-participating regions would be affected by the stabilization of CO_2 emissions adopted by the OECD regions. The results reported here reflect both

42. In these scenarious, countries with economies in transition are not committed to any constraint on the CO_2

the effects of stabilization on international energy prices, entailing a loss of income in energy-exporting countries and a more beneficial effect on oil importing countries, as well as the combined impact of changes in terms of trade and trade flows to and from the OECD, due to altered economic growth. According to this exercise, the non-OECD region would be, as a whole, more affected than the OECD region itself in earlier years (see losses of real income for the year 2000 and 2010). As time goes by, the stabilization objective becomes more constraining on OECD regions, and increases the overall economic cost for the participating regions.

Table 14: OECD Stabilization Scenario over the 1990-2050 period

Changes in real income and carbon tax rates under region-specific constraint

(per cent changes from baseline scenario) - carbon taxes are indicated in italics for OECD regions.

Region \ Year	2000	2010	2050
OECD			
USA	0.0 ($51)	-0.2 ($58)	-1.4 ($118)
Japan	-0.8 ($272)	-1.9 ($86)	-3.1 ($305)
European Union	-0.1 ($77)	-0.3 ($66)	-2.2 ($158)
Other OECD*	-0.1 ($56)	-0.2 ($70)	-1.1 ($164)
Non-OECD			
Former Soviet Union	-1.0	-1.0	-0.7
Eastern and Central Europe	0.3	0.4	0.5
China	-0.3	-0.1	0.2
India	0.0	0.2	0.0
Brazil	0.7	0.8	0.7
Dynamic Asian Economies	0.0	0.0	-0.1
Energy-Exporters	-3.1	-4.1	-0.5
Other	-0.7	-0.5	0.1
Totals			
OECD	-0.2	-0.5	-1.9
Non-OECD	-1.1	-1.3	-0.1
Total	-0.5	-0.8	-1.0

* Other OECD includes member countries of the European Free-Trade Agreement, as of 1994, Australia, Canada and New Zealand.

When stabilization constraint achieved through an OECD-wide carbon tax, both the aggregate cost and the distribution of cost across regions are altered. Table 15 shows that those OECD Member countries/regions that would face the higher tax rates in the region-by-region approach are better off under a common stabilization objective, while others are more affected. For the OECD as a whole, the macro-economic impact is slightly less under a common carbon tax approach to achieve stabilization. This confirms the economic intuition that a more economically-efficient outcome can be achieved through a common tax, i.e. an equal marginal cost of reduction for all participating countries.

Note that this scenario does not address the issue of possible compensation for those countries which would face a higher tax rate (and higher income losses) by those countries which would benefit from adopting the common tax. We turn briefly to this question in a section below.

Table 15: OECD Stabilization Scenario over the 1990-2050 period

Changes in real income under a common carbon tax

(per cent changes from baseline scenario)

Region \ Year	2000	2010	2050
OECD			
USA	-0.1	-0.3	-1.5
Japan	0.1	-0.3	-1.5
European Union	-0.2	-0.3	-2.2
Other OECD	-0.1	-0.3	-1.1
Totals			
OECD	-0.1	-0.4	-1.9
Non-OECD	-1.0	-1.2	0.0
Total	-0.4	-0.7	-1.0

The ABARE study also provides a region-by-region comparison of the economic effects of multi-lateral stabilization with individual taxes versus common taxation for the OECD, but on a different geographical basis (Australia, Canada and New Zealand are separate regions in the model, whereas they are part of the "*Other OECD*" region in GREEN and 12RT). For a stabilization scenario over the 1990-2010 period, the study finds that all OECD regions except the European Union would be less affected by a common carbon tax to achieve an OECD-wide stabilization objective than if each were to adopt a regional tax to stabilise its emissions.[43] Non-participating countries would benefit from such an approach, with an overall economic gain from baseline levels in the common taxation scenario.

The EC tax: a common carbon and energy tax

Given its format, the EC tax proposal was tested as a "common option" for the European Union in several models, including GREEN.[44] The GREEN shows that the EU would be able to stabilize its emissions with such a tax,[45] but that it would result in leakages which would partly offset reductions within the region. We touch upon the leakage issue in a section below.

On the other hand, specific countries would be hurt more, or less, through a common taxation approach. We briefly turn to these results in terms of distribution of cost among countries, as opposed to aggregate macro-economic costs.

The GREEN study does not provide an assessment of what would be gained from moving from unilateral reduction objectives to an aggregate, regional, reduction objective achieved with the common EC tax.

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43. ABARE (1995), p. 95.

44. Nicoletti and Oliveira-Martins (1993)

45. A result with which econometric neo-keynesian models donot agree, Bossier and Bréchet (1995).

Compensation and common taxation: insights from tradeable quotas scenarios

It is obvious from the results above that specific regions would gain and other would lose from shifting to a common taxation approach, when compared with a country-by-country approach to emission reductions through taxes adopted unilaterally. Provided it is possible to determine the additional cost/benefit for regions participating in a common taxation scheme, what would be the effect of transfers to compensate those countries which agree to adopt a higher tax under the common action?

Other modelling exercises provide insights on this question, by testing a tradeable quotas approach to CO_2 reductions. Instead of adopting a common tax, each region is allocated a quota proportional to its base-year emissions, and allowed to trade quotas with other participating countries. In theory, such a system allows reductions to be achieved at the same marginal cost across all regions (like a common tax) while providing an automatic system for regions which emit more than their allocated quota to compensate other regions for over-achieving their commitment. For the sake of illustration only, we assume that similar transfers could be organised under a common tax system.

Modelling runs on tradeable quotas using both the GREEN and 12RT models show that almost all participating regions would gain from adopting a common tax to abate CO_2 emissions, compared with a region-by-region tax approach, when such transfers are assumed.[46] This result is obtained in spite of different modelling structures, different assumptions on trade, and different baseline emissions for Annex I and the world as a whole.[47] The key assumption here, though, is the possibility of reaching an agreement on what taxes would have to be in each region for a given reduction objective, and what baselines emissions would be absent any tax. Only then would it be possible to determine the financial compensations to be provided by some regions to others...

Common carbon/energy taxes versus unilateral action: cost for specific sectors and countries

Energy exporting countries

Global models do not offer enough regional detail to study the effects of common taxation on those countries within Annex I which export fossil energy (e.g., Russia, Canada, Australia, the Netherlands, and Norway). Like any other policy aimed at reducing CO_2 emissions from fossil fuel use, common taxation of carbon/energy would entail reductions in fossil fuel output. However, energy-exporting countries within Annex I do not export the same mix of fuels, and would therefore be affected differently (see Figure 3 on fossil fuels trade per capita in Annex I countries).

The principal mechanisms through which these countries would be affected are

- a decrease in their exports to Annex I Parties (a volume effect), potentially an increase for those exporting less carbon-intensive fuels;

- a potential reduction in international prices for fossil fuels (with coal being most hurt, then oil, then gas), that would further reduce their revenues (price effect, although that effect

46. Manne and Oliveira-Martins (1994), p. 39.

47. The two models only disagree on the level of effort implied by stabilizatin of emissions for the Former Soviet Union. 12RT assumes higher emissions for the FSU in the baseline, and an increase in cost from adopting a common tax with financial transfers instead of a region-specific tax to stabilise its emissions.

could induce higher demand from non-Annex I Parties).[48] Here again, less carbon-intensive fuels might incur a benefit, with higher demand pushing international prices up.

Note, however, that the reduction in international prices from lower demand is based on the assumption that international energy markets operate competitively: it is not possible for energy-exporting countries outside the Annex I region to increase their prices to capture the rent created by a carbon tax. Preliminary results based on game theory show that with or without OPEC's ability to act as a cartel (restrict its output or not), oil prices would be driven down by a *global* carbon tax. However, the non-OPEC Member countries would be better off if OPEC could maintain its cartel power.[49] Any results in this field should be considered exploratory, and one may not definitely rule out the possibility of international prices being driven up by the prospect of a tax.

Energy sector

In way of distributional effects, the energy sector would be most affected by a common strategy to reduce energy related CO_2 emissions such as a carbon/energy taxation scheme. Under stabilization of greenhouse gas emissions among OECD Member countries, the decrease relative to the baseline level of activity would be as shown in Table 16, according to Abare (1995).

What is reflected here is that a common stabilization target achieved through a tax would be a powerful tool to reduce the output of coal, oil and natural gas sectors; domestic production could no longer be exported to other OECD Member countries were such taxes are not applied and would then see production further reduced than in a scenario where the tax is applied nationally *and* other countries do not reduce their demand for fossil fuels through other policy tools.

Table 16: Change in output of oil, gas and coal in selected OECD Member countries (2010)

Relative to business as usual under a stabilization scenario

Region	**Coal**	**Oil**	**Gas**
United States	-27.7%	-6.3%	-13.8%
European Union	-32.8%	-21.0%	-10.3%
Japan	0	-8.6%	-8.2%
Canada	-41.3%	-11.3%	-13.9%
Australia	-26.7%*	-6.9%	-12.3%
New Zealand	-24.9%	-13.6%	-50%[50]

* represents a 10% decrease from 1990 level

48. Note that some models disagree on this issue. Manne and Rutherford (1994) find that, under the assumption of a coal-based technology replacing oil and gas in the long-run, which puts a ceiling on the prices of these fuels in the baseline scenario, a carbon tax would allow oil prices to increase further than in the baseline scenario.

49. Berg *et al* (1995)

50. The size of this decrease is misleading, as it represents, to a large extent, the closure of a major gas field (around 2005) and the reduced level of domestic gas reserves inthe post-closure period. Cumulative changes over the period would be a more reliable indication of total output variations.

It is worth recalling, again, that these distribution effects, which should not be ignored, are not specific to carbon/energy taxes, and that they would be brought about by any common policy aiming to reduce energy- related CO_2 emissions.

A carbon/energy tax can be designed, however, so as to reduce the distribution effects of an international taxation scheme. Whalley and Wigle (1991) have explored a *global* carbon tax raised by producers, as opposed to current carbon/energy. Their analysis, which remains very aggregate,[51] does illustrate that energy-exporting developing countries would incur a net economic gain under such a scenario, as opposed to significant losses when the tax is raised on consumption. They do not, unfortunately, look into the effects of taking such an approach within Annex I only. Some implementation issues of a carbon/energy tax applied by producers are touched upon in the next section.

Leakage issue and common action

The previous section provides a good transition to the issue of leakage in energy-related CO_2 emissions possibly resulting from a carbon tax being implemented in common.

CO_2 leakage can be defined as the ratio of increased emissions in the non-participating region to the decrease in emissions in the region implementing a tax (or another policy to abate its emissions). Three elements could contribute in such a phenomenon:[52]

– changes in the trade structure: imposing an energy tax changes the comparative advantage in the production of energy-intensive goods, entailing changes in the location of its production;

– changes in world energy prices, namely a decrease in international energy prices, which would induce increased demand from the non-participating region;

– gains and losses in regional terms of trade, inducing changes in emissions through a change in real income; depending on the region and its trade structure, this could result in positive or negative leakage.

In models, this issue is treated with a number of assumptions on trade, the evolution of exchange rates, terms of trade, and the mobility of factors across regions. The overall effects on trade and therefore on leakages result from the combination of various demand and supply elasticities, usually calibrated, as opposed to econometrically estimated.

There is relatively little agreement from models on the size,[53] and sometimes even on the actual *sign* of possible leakages. That being said, these models also suppose that industry re-location would be driven by a change in energy prices across regions; that assumption in itself could be questioned:

– for those sectors where energy costs are a major component of total cost, most of the relocation might already have taken place during the past two decades (iron and steel,

51. Their model, for instance, does not distinguish the three main fossil fuels, neither does it include any *authonous energy efficiency* improvement rate. This leads to clearly too high baseline emissions. The odel only includes three regions: developed countries, energy exporters, and developing countries.

52. OECD (1996)

53. See IPCC Working Group III observation on this issue (Chapter 9, section 9.1.5.5)

aluminum), and were probably driven by the need to get a better access to raw material; it is unclear whether a carbon/energy tax would affect that trend significantly;

– labor costs, a much larger component of total cost, is obviously more influential in affecting location choices for new production in other activities (such as services, software manufacturing, etc.);

– swings in exchange rates, political stability, the availability of infrastructure (physical, financial, operating markets) and education of the workforce are probably the main obstacles to activity relocation. One can doubt that the energy cost differential would alone overcome these barriers.

We nevertheless outline some key results, both on the low and the high side of leakage estimates.

GREEN has estimated the effects of the EC tax proposal on global emissions, if EU countries were to reduce their energy-related CO_2 emissions alone.[54] The model shows that both positive and negative leakages may arise following the implementation of the EC tax. Negative leakages occur when the tax implemented in the EU lowers economic output in other regions (oil exporting countries, particularly); for some regions like China, due to their specific energy context, lower international oil prices could deter the substitution away from oil to coal, and therefore result in lower emissions. Positive leakages, especially in other OECD regions, result from a shift in the comparative advantage of producing energy-intensive goods away from the European Union.

On the whole, leakages from the EC tax would decrease from 11 per cent in 1995 to -0.55 per cent in 2050, where negative leakages in non-participating OECD regions would overcome positive leakages in non-OECD Member countries. The latter, as a whole, would always emit more CO_2 under a common tax than they would otherwise, suggesting a slightly higher level of economic growth (energy exporting countries would, of course, be an exception).

The study by ABARE and Department of Foreign Affairs and Trade (1995) finds that stabilization of energy-related emissions through regional taxes in OECD Member countries would lead to a 9 to 10 per cent leakage in emissions (231 MtC in 2020, offsetting 90 per cent of emission reductions of Australia and Canada for the same year). The study also highlights the uncertainty coming from values of elasticities which determine the substitutability of imported goods to domestic goods. Another model (12RT) assumes perfect substitutability between domestic and foreign goods and finds that leakages could be as high as 35 per cent.[55] The Abare study concludes, like the IPCC, that such estimates should be considered indicative given the uncertainties on parameters.

Other studies, based on sectoral approaches, find that in activities experiencing increasing returns to scale (such as fertilizers), leakage rates could be above 100 per cent, as all firms in the participating countries move to non-participating countries where it is optimal to use more carbon-intensive fuels than it would be in the participating countries. This should be viewed as a theoretical result, since, again, decisions to re- locate may be hindered by other considerations. In *that* sense, common action by all Annex I Parties would make it more difficult for activities to re-locate in a country with similar economic infrastructure and stability. In reverse, leakage could be high in the case of partial agreement to introduce a price signal on carbon/energy.

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54. Nicoletti and Oliveira-Martins (1993)

55. Nicoletti and Oliveira-Martins (1994)

At the end, what can be said is that leakage, like shifts in competitiveness, is a potentially serious problem for policies which do not include all major countries that compete on international markets; it should not however be considered in general, but linked with the underlying energy price increases, their effects on total cost of production, and the potential reactions of international energy markets.

Other policy goals

We will not, in this section on common taxation, address the potential benefits from recycling carbon/energy tax revenues to lower labor costs, provide investment incentives or reduce government deficits. It may be interesting to do so to find out how different policies in different countries would interact, and how they fit current policy objectives, such as government deficit reduction.

To the extent that carbon/energy taxes would lower the use of fossil fuels in general, they may help contribute to reduce other externalities linked with energy use. Based on an energy model for nine western European countries, coupled with the IIASA RAINS model on emission-transport-deposition of SO_2 and NOx, Alfsen *et al*. (1995) study the effects of the EC tax on these emissions.[56] Their results indicate that CO_2 emission reductions is not only a matter of taxation, but also a question of the investment behavior of government-controlled power production. By assuming a shift towards a more cost-efficient regime for investment decisions, the study finds that the EC tax would reduce sulphur emissions more than about 14 per cent. On the whole, the EC tax would have a limited effect on CO_2 emissions in the year 2000 (6 to 10 per cent from baseline), but a sizeable effect on other emissions which have well-known external effects. However, if coupled with a more cost-efficient investment behavior in the power sector, the EC tax would help meet the Helsinki protocol on SO_2 and the Sofia protocol on NO_x. This result also emphasizes the key role of market forces in driving all energy-related emissions down, and the fact that the EC tax would not provide much reductions if existing barriers are not removed.

These results probably will not apply to all Annex I countries, since other countries are taking separate actions to internalize the cost of externalities related to the emissions of these pollutants, and may meet their targets with their own set of instruments.

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56. Countries covered are: Denmark, Finalnd, France, West-Germany, Italy, the Netherlands, Norway, Sweden and the United Kingdom.

5 KEY ISSUES IN IMPLEMENTATION

This section covers both the current experience with carbon/energy taxation as a measure to abate energy-related CO_2 emissions, and some issues raised by modelling results.

Lessons from national experiences and insights for common action

Countries who have already implemented carbon/energy taxes have found creative ways to raise the political acceptability of such tools among economic agents. This section summarizes insights from unilateral actions and failed proposals. Most of all, it aims to cover aspects of unilateral carbon/energy taxation that are key important elements for discussion if the use of such tools becomes more widespread among Annex I Parties.

Obviously, these elements constitute the set of constraints and opportunities to be used in a potential agreement for a common approach to carbon/energy pricing. They also highlight key design issues, that could be resolved, or else become more complex, when envisioning taxation at some common level.

Taxes, other policies and measures, other policy goals

First, carbon/energy taxes implemented in Europe are part of a policy package to reduce all greenhouse gas emissions. In this package, taxes are targeted to energy-related CO_2 emissions, those emissions being easier to monitor than those of other greenhouse gases, since they result from the combustion of commercial fuels.

Other measures, not systematically covered in this study add flexibility to improve the responsiveness of specific sectors, also making it easier to absorb any price shock that may be caused by the tax. Such measures include government contributions to investment in energy savings, energy audits, subsidies to technology with low fossil-fuel intensity... Modelling results show that this could be an important tool to mitigate the price "shock" of a tax in specific industries.

One potentially positive aspect of carbon/energy taxes is that they may be used to lower other distortionary taxes. In fact, Sweden, Norway, Denmark and the Netherlands have either introduced carbon/energy taxes as part of a much wider fiscal reform aimed at reducing fiscal pressures on households and corporations, or have used compensation measures to help low income groups. The original objective of the BTU tax proposal was to contribute to reducing the government deficit. As for the EC tax proposal, it includes the principle of fiscal neutrality, and countries have given some attention to the possibility of lowering taxes on labor to help solve rising unemployment.

The role of exemptions and other compensation measures

The introduction of new taxes is necessarily constrained by existing price levels, with the higher tax rates being applied to those fuels where taxes are already high (such as gasoline). Where prices are originally low, too large an increase in price is difficult to introduce. Industry faced lower energy prices in the five European countries where carbon/energy taxes have been implemented, which partly explains why a uniform tax rate could not be applied across all sectors of the economy.[57] Introducing a tax at the same rate for all energy-users would either impose an unbearable price increase on some parts of industry, in the case of a tax set to reduce emissions from the household/transportation sector, or too low a signal on the latter, without any impact on their emissions.

Tax rebates, taxes limited to small-scale energy use or the combination with voluntary agreements are used to lower the negative impact on specific economic agents and sectors. Another way to reduce a potential price shock has been to partly substitute carbon/energy taxes for existing energy taxes. This enables putting a specific environmental tax in place without increasing prices too drastically in the short term, and corresponds in some way to a restructuring of energy taxes, leading to more cost-effective reductions. Taxes can also be phased-in with a clear time schedule, providing a more stable environment for energy- related investment decisions.

Part of the tax revenues can be used to offset the negative effects of the tax: audit schemes, investment grants for energy efficiency improvements, lower social security contributions, or lower personal income and corporate income taxes. Such schemes may help ascertain the credibility of carbon/energy taxes as an *environmental* policy tool, and not just a new means for the government to raise revenues.[58] In that regard, renewable energy is usually exempted from new *energy* taxes.

Competitiveness issues, for countries with relatively small economies, were central in the discussion, and have played a major role in the design of implemented carbon/energy taxes. As these are unilateral actions, the international competitiveness argument against any tax could not be avoided. In fact, it led to the removal of the *energy* tax in Sweden, in 1993, after it was clear that other OECD Member countries were not forthcoming on this issue. As a result, industry found itself paying lower prices for energy than before the carbon tax was introduced. Recently, however, the Swedish government raised its carbon tax on industry to half the level of other users.

Design issues

Changing the tax level over time

The tax level required to produce a significant incentive to reduce emissions in the long run makes it necessary to introduce taxes gradually. In addition to reducing a potential energy price shock, this provides some certainty for investment decision-making with significant implications for future energy use. It is often argued that one key element of carbon/energy taxes is the stability they introduce in the

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57. The main reason for not applying a high tax on industry is realted to the potential loss of competitiveness it may entail if adopted unilaterally.

58. While arguing for lower tax rates, industry has also made the oint that because low taxes would not have any incentive effect, taxes shouldn't be used at all. Creative recycling to improve energy efficiency in industry can be an answer to such critiques.

evolution of energy prices;[59] certainly, the decrease of energy prices in OECD Member countries, in real terms, does not provide an incentive high energy-efficiency investments. It is also seems necessary to adjust taxes for inflation, if they are to provide a consistent signal over time.

This sends us back to the question of fiscal versus environmental policies. In the case of fiscal neutrality, the tax ought to be recycled to the economy through a lowering of other taxes. Since the effects of taxes on emissions (and therefore on tax revenues) are uncertain, it is difficult to implement this principle consistently without having to constantly adjust tax rates. We cover below the specific issues raised by this question when carbon/energy taxes are considered at a common level.

Where to apply the tax?

Where should the tax be applied? In terms of economic efficiency, this does not matter, since a given reduction target would entail the same aggregate economic cost (distortion), wherever the tax is applied. This is, however, an important dimension when designing the tax to "maximize" political feasibility.

It is generally recommended that the tax be applied as far upstream as possible, in order to send the price signal as early on in the production chain as possible, thereby creating a broad set of market responses. Otherwise, energy users receive an indirect signal when the tax is applied on final consumption only.

In practice, taxes are applied at various level of the energy "chain". This has an impact on which users would bear the cost of introducing the tax. The point of introduction of the tax is also constrained by the structure of energy markets since fixed-price contracts or regulations may be in place that would not be consistent with the need to pass the tax on all users of the energy production and distribution chain.

Differentiated taxes and tax evasion

In addition to the economic-efficiency argument against differentiated taxes,[60] different tax rates may lead to tax evasion and therefore to lower reductions than anticipated. Experience shows that introducing different tax rates according to the type of energy uses has led to tax evasion. In Denmark and Sweden, firms have isolated and separated those of their activities which concentrate most energy-intensive processes in order to fit in the tax-exempt or lowest tax category; and reduced their overall tax burden. Differentiated taxes, which serve the purpose of accounting for various degrees of rigidity among economic activities, ought to be applied in a way that avoids creating opportunities to evade taxation.

CO_2 versus greenhouse gas emissions, options for absorption

Design issues loom large when thinking of taxation of all man-made greenhouse gas emissions. Since some of these emissions can only be taxed indirectly without full certainty of achieving the expected environmental result, generalizing a carbon/energy tax to other greenhouse gas-emitting activities may not necessarily improve overall greenhouse gas emissions.

The main issue with forestry measures, if they are to offset tax payments, has to do with measuring absorption with some precision, and creating a market, similar with a tradeable permit system, where

59. Godard (1993)

60. Ibid.

buyers would be greenhouse gas emitting activities, and sellers would be the forestry sector. Setting up such an institution would certainly require additional resources from a "simple" carbon/energy tax regime. There are different forestry options available among Annex I Parties. The implementation of this carbon offset scheme would remain dependent on local circumstances.

Trade issues in the case of unilateral action

In most of the modelling results quoted above, carbon taxes are applied according to the so-called destination principle: the tax is paid where the product (oil, gas, coal) is used. In most national-level models, it is assumed that exports of fossil energy (if any) would not be taxed (would be granted a rebate), if the importing region does not implement a tax. If it does implement a tax, its own tax will apply, not that of the exporting country.

The question here is: can border tax adjustments be put in place that would reduce the potential negative competitiveness effects of a tax applied unilaterally? The same question applies to a whole region agreeing on a tax, with respect to the rest of the world.

Border tax adjustments for fuels: an already common practice

The version of the BTU tax passed by the U.S. House of Representatives taxed imported fuels at the point of importation and exempted domestic fuels bound for export. Given where the taxes were to be imposed, the provisions for exported fuels were somewhat academic. Petroleum products were directly exempted and coal and natural gas were taxed at the point that they were consumed by ultimate users (at the utility gate or upon withdrawal from a pipeline). In general, the BTU tax was treated as any other excise tax, as it related to fuels in a manner that has a long standing in international trade. Exported fossil fuel generated electricity would be provided a refund or credit at the point of export. Imported electricity would have been taxed on the basis of its fossil fuel source unless the importer could demonstrate that the electricity was produced with an exempted energy source (e.g., renewable).

All countries with domestic taxes on fossil fuels do apply a border tax adjustments equal to the domestic tax when importing such fuels, as allowed by GATT.

Trade in non fossil fuels: an unsettled question ...and a matter of practicality

For non-energy imports and exports, the issue of border tax adjustments becomes more difficult, as it relates to embodied carbon and energy. Interpretation of current trade rules differ, and the World Trade Organization has not agreed on this question yet. At the moment, there is no certainty as to whether border tax adjustments based on so-called PPMs (Processes and Production Methods) would be allowed under WTO rules. Nevertheless, the OECD Report on Trade and Environment to the OECD Council at Ministerial Meeting concluded: "<u>WTO rules have been interpreted</u> as generally allowing, subject to agreed disciplines, for border tax adjustments on products on the basis product characteristics or physically incorporated inputs, but <u>not for taxes on imports on the basis of domestic process taxes</u>" (emphasis added); embodied carbon would fit under the latter category.

Embodied carbon and energy do seem to fit under the category of PPMs: except for fossil fuels, where the excise can be applied directly, taxing a product based on its energy comment (or that of a "like" product) means taxing it based on its process and production method. In other words, the product is not taxed for itself of for physically incorporated input but based on the inputs that went into its production and are not contained in the product itself.

In the United States' BTU tax proposal, however, imports are taxed based on the energy requirement for their production. Goods exported from the United States are not exempted from the tax at the point of export, there is therefore no need to calculate the taxes paid during the course of manufacturing a domestic product. For imports, the BTU tax was to be paid when the cost of fuels consumed exceeded 2 per cent of the cost of the final product. Unless an importer demonstrated otherwise, the tax due on import was to be set equal to the tax on energy consumed to produce a "like" U.S. product. The idea is to assure that imports compete on an equal basis with local production in the country.

Since all traded goods have embodied carbon and energy, from their last production stage as well as from the energy that went into the production of intermediate inputs, estimating the embodied carbon/energy in imports seems very difficult, if feasible at all.

This is especially true for electricity, a "commodity" that is widely traded. Indeed, it isn't possible to precisely determine the inputs that went into the production of a given kilowatt-hour purchased from an country where no carbon/energy tax is in place. In most national taxation schemes, fossil fuel inputs to electricity have been exempted from carbon/energy taxes to avoid increased competition from foreign electricity.

What would border tax adjustments achieve in terms of CO_2 emission reductions?

We assume here that border tax adjustments can be used for both products and processes and production methods (i.e. embodied carbon and energy). If taxes are imposed on imports but rebates are given on exports, domestic production will decrease (income effect from the tax) but producers in a small economy can still sell the products that they couldn't sell domestically on the international market, at the world price, thanks to the rebate. It is quite possible, under such assumptions, that increase in exports may compensate for the reduced domestic demand and, given the tax rebate, that emissions would not fall as much as expected.

If border tax adjustments are introduced on imports but not on exports (no tax rebates, the case in the BTU tax proposal), then domestic producers remain competitive within their own economy, but not so in international markets.[61]

If no border tax adjustments are allowed on exports or on imports, then domestic production would fall unless domestic producers can easily put in place less CO_2-emitting (and less energy intensive) processes to reduce tax payments and energy expenditures. Here again, the extent to which there exists a no-regret potential, that would be untapped in current price conditions, is key in evaluating the trade effects of unilateral actions.

In many ways, the issue of border tax adjustment in the case of unilateral action remains the same for common action in the context of this study, since "common" means coordinated action within Annex I Parties (or a sub-set thereof) only. Additional analysis would be required to see if the competitiveness issue is the same between Annex I and non-Annex I, and within Annex I. The geographic closeness, and the similarities in market conditions make industrial re-location more likely within Annex I, than from an Annex I to a non-Annex I country.

61. At least in the near term, before they can adapt their production methods to reduce energy input.

Carbon/energy taxation at a common level: design issues

Tax level: key dimensions and issues

The above quantitative analyses do not touch on many of the implementation details that would be key when moving towards implementation of taxation as a common policy tool. If common action on carbon/energy taxation consists of a broad agreement on the use of pricing to abate CO_2 emissions, resulting in different levels of taxes being applied across countries, implementation issues would be the same as the ones mentioned earlier in the context of unilateral action. Given the differences in national circumstances among Annex I Parties, a phased-in approach is probably a necessary, but not a sufficient condition, to a common use of taxation to abate emissions.

If a single tax were to be used to abate emission within a group of countries, several points would need clarifying. It is likely that the implementation issues would be substantial and these may appear more important to some countries than the gains from an efficient allocation of effort.

Countries would need to agree on a level for this tax, which should be defined along two dimensions:

- geographically, based on a given exchange rate. Should it be the market exchange rate or should the tax level be computed on the basis of purchasing power parity (PPP)? In absence of a common currency, the latter would provide more stability over time; however, in the face of international competitiveness issues, real exchange rates do matter more than PPP rates.

- over time, what should be basis for changing the rate? If it accounts for inflation, different inflation rates will introduce growing discrepancies in the tax rates over time, and the tax would lose some of the benefits of being common.

An agreement over a tax rate would raise major issues, since individual governments would not be able to fully control the revenues of such a tax. In case these are recycled through a lowering of other taxes, the combination of short-term variations in energy use and uncertainty on the future tax rate would hurt the predictability of government revenues. A general lesson from the EU discussion on the EC tax is that carbon/energy taxation cannot be seen in isolation from the overall fiscal policy, which is not a matter for decision-making at EU level, but a matter for individual governments. The interface between revenues from a tax designed at some common level and other fiscal questions, which are handled nationally, is a potent obstacle to common implementation of a tax. One way around this issue is to agree on a minimum tax rate, which would not constraint individual government's ability to control its fiscal policy.

The commonly agreed tax may turn out to be enough for one country to achieve its reduction target, but not for other participants. In case these participants would need to increase the tax to attain their objectives, they would meet resistance from countries where such increase would not be necessary. Tax rates would then have to differ, and the scheme would lose some of the advantages of commonality (fewer border tax adjustments, etc.) However, a common tax could avoid setting reduction targets for each individual countries. This point hinges on the format the protocol or other legal instrument under the UNFCCC, which is uncertain at the moment.

Previous attempts to harmonize excise taxes on mineral oils at the EU level have led to an agreement on *minimum rates*, roughly equal to the lowest rates in place in member countries at the moment where the agreement was reached. This agreement was reached after several attempts failed to introduce flexibility on the way to harmonized rates.

In comparison with the debate on mineral oil excise, common carbon/energy taxation clearly represents a more complex issue, even if the question of changes in the rate over time and over countries could be solved. The additional complexity comes from existing energy price structures in different countries, across fuels and across users. If one considers the price effects of the uniform EC tax in European countries, one finds that in some cases, existing prices and taxes would lead to substitution away from oil towards coal instead of gas, for instance. In brief, what works in some countries may not work in others, as shown in the overview of carbon/energy taxes in northern European countries.

The substitution of taxes based on the carbon and energy content of fuels to existing energy taxes may provide some flexibility in the implementation of a common tax across several countries. Through this kind of tax restructuring, participating countries would be able to adjust total tax rates *on specific energy sources and users* so as to provide the right signal for the reduction of energy-related CO_2 emissions.

Taxing production: design issues

A tax raised by producers, if applied only in Annex I Parties, would change the distribution of costs, potentially fostering higher participation. A number of issues require careful attention.

A tax raised by producers only creates an opportunity for free-riding: energy-importing Annex I countries could shop for tax-free fossil energy. In fact, most of their current energy imports come from non-Annex I Parties which would not be participant in an Annex I-only scheme. This could result into significant leakage; it cannot be ruled out that the volume of energy exports from Annex I countries might be even lower under a “production tax” than under a “consumption tax”.

To circumvent this problem, the tax could be raised partly by producers and by consumers. Let's assume a system in which:

- energy importing countries (in Annex I) apply a tax on non-Annex I energy, and
- those countries do not tax the energy imported from another Annex I country, since the tax is raised in the exporting country.

A tracking system would have to be set to assure that the fossil energy price, when coming from an Annex I Party, does include the tax. There would be an opportunity for other energy exporting countries to evade the tax by pretending that the sold energy comes from an Annex I Party where the tax was applied. It is unsure whether such tax evasion would take place, or could be avoided, and what the administrative cost to monitor taxes at the border would be.

A price-signal applied by producers in a coordinated fashion should nevertheless be kept in mind since it represents a way to reduce some international distribution issues, and could be used for future climate change strategies, as it provides an option for a wide participation by non-Annex I Parties.

Trade issues in the case of common action

Current energy taxes in Annex I Parties, which are applied to imported fossil fuels, have already been questioned by energy exporting countries as barriers to free trade, without much success. Constant increases in the taxation of fossil fuels in Annex I suggest that carbon/energy taxation of imported fuels (not of embodied carbon) would not pose great problems, since domestic taxes remain the prerogative of individual countries.

We covered above the issue of border tax adjustments in the context of unilateral measures. In some ways, agreeing to a common taxation scheme would avoid complex accounting of embodied carbon/energy *within the region*, if border tax adjustments were put in place to prevent more acute competition from non- participating countries.

Would such border tax adjustments completely avoid leakages? If applied on imports based on embodied carbon in "like" products, and if a tax is rebated on exports based on incorporated carbon/energy inputs, then, in theory, emissions wouldn't change from baseline levels. Domestic and international competition would remain roughly the same, although it may be difficult for exporters to reflect *all* carbon/energy embodied in their products. There would still remain some incentive to re-locate production. Common taxation would just mean that relocation may be more difficult, because fewer countries would not tax energy. At any rate, the technical challenges and the cumbersome administration of such a system may deter its implementation at some common level.

A problem may come from the effects of such policies on non-participating countries, especially outside Annex I. Indeed, a full coverage of trade through border tax adjustments would be perceived as trying to influence foreign emissions and to push for policies to reduce such emissions, in countries which do not yet have made such commitments.

6 ADVANTAGES AND DISADVANTAGES FROM COMMON CARBON/ENERGY TAXATION

Summary of results relevant to common carbon/energy taxation

In the case of carbon/energy taxes, for which there are many options, addressing the question of advantages and disadvantages of common action requires either a thorough analysis of all aspects of precisely defined options, or a wide coverage of issues at some general level as done in this study.

In this section, we summarize information provided in the report vis-à-vis taxation of carbon and energy as a measure for common action, before turning to the advantages and disadvantages of such options. This needs to go much further than the confirmation of theoretical results on the need to equalize marginal reduction cost across regions through the use of a carbon/energy tax (or a system of tradeable emission permits). Barriers to taxation at the national level and practical ways to overcome those barriers are part and parcel of the discussion of common taxation strategies. They also indicate what degree of commonality in taxation could be achieved in the near-to-medium run.

In general, providing a signal on the external effects of CO_2 emissions from fossil fuel use contributes to achieving energy-related emission reductions. The current experience *at national level* shows that applying a common signal to all users is hardly feasible because of the distributional implications. In most cases, differentiated tax rates are applied to account for the specifics of energy users, or exemptions are granted. Indeed, there is a variable ability across sectors to adapt to an increase in energy costs in the short and medium term. Reduction of final energy consumption is constrained by rates of capital stock turnover (in the household sector, services and industry, not to forget infrastructures), the ability to pass the additional cost to consumers through a price increase (reduced if the sector operates in international markets, less so if all other trade partners adopt a similar measure) and the availability of more efficient or cleaner technologies domestically.

Obviously, different energy users face very diverse constraints and their welfare or income would not be affected in a homogeneous fashion by a carbon/energy tax. This remains true when considering a single tax level at international level, where different national circumstances introduce another level of complication. Some questions related to carbon/energy taxation will therefore remain in the domain of individual nations (recycling schemes, the compensation of negative distribution effects, fiscal policy, and the effects of carbon/energy taxation on local environmental issues).

The modelling results from global macro-economic studies, given their level of aggregation, and the use of a tax as a proxy for the marginal cost of reduction, do not provide significantly new material in favor or against a common approach to CO_2 emissions. They simply confirm that equalizing the marginal cost of reduction would provide a more cost-effective outcome than reaching the same reduction objective with country-by-country objectives. If one considers shifting from a set of unilateral taxes to a common tax for the sake of economic efficiency, one needs to consider the ways for those countries who would gain to compensate countries that would lose from shifting to the common tax rate. There is not, at present, a non- controversial method to estimate gains and losses across Annex I countries at such aggregate level (see the disparity of results from global models). The issue of compensation, linked to equity, is not specific to taxation, but is well illustrated with this tool because of the generated financial flows.

In brief, the following aspects will have to be considered, to determine advantages and disadvantages of trying to apply tax policies in a coordinated fashion among Annex I Parties:

- **Cost, including distribution issues**. Distribution is, in fact, the political basis for rejecting a uniform tax applied to a group of countries (the issue of "starting points"); whatever design aspects favor one participant is likely to affect another participant. There seems to be a need for more careful consideration of national circumstances in designing the tax. Although Annex I countries, looked at in an aggregate fashion, differ in their use of energy, they face the same constraints for same types of energy use (transportation, electricity, industrial stationary sources and the residential sector). In fact, sector-specific considerations have led to current pricing regimes, which display a wide range of tax/subsidies levels across users in most countries. This explains why we observe such diverse approaches among countries who have adopted carbon/energy taxes and other policies to reduce CO_2 emissions.

- On the potentially positive side, an agreement for common taxation of carbon/energy would provide a larger and more **secure market for less carbon and energy-intensive technologies**. This would avoid "picking winners and losers" in response to the climate change issue. There may be a spillover effect from technology development outside the region implementing such taxes, which would help reduce emissions in non-Annex I Parties as well.

- On the **trade** front, the legal and technical possibility of applying border tax adjustments on embodied carbon may affect the efficiency of a common taxation approach. The WTO is still discussing this issue at the moment. Apparently, at least at the EU level, taxing embodied carbon, say in electricity trade, would not be technically feasible. Common implementation may avoid having to rely on complex exemption systems for traded commodities within a region. The structure of trade with countries outside Annex I is an important dimension of this question, since countries trading mostly outside the participating region would not gain much by adopting a common policy. Along the same lines, investment grants for energy efficiency, through a recycling of tax revenues, may raise legal issues if adopted unilaterally, in the context of the European Union.

- The political **lead-time** to reach a consensus ought to be considered in light of what gains could be achieved through common taxation. Important in that respect is the uncertainty on the persuasive effect of the establishment of carbon/energy taxation by other trade partners on domestic opposition to a tax.

This study should also stress the shortcomings of evidence on the effects of taxes (either positive or negative):

– Modelling studies have a limited ability to simulate the long term effects of a price-signal on technology. Neither do they adequately represent energy-related decision-making at the sector level, or real world constraints on the flexibility of different users, which determine responsiveness to a tax in the short term. "No-regret" reductions appear not to be represented in most global models looking at taxes. This automatically rules out the possibility of showing a competitive advantage from increasing domestic energy prices;

- Empirical evidence of the effects of differentiated energy prices on competitiveness is scant and based on opaque assumptions in macro-economic models;

- The effects of currently implemented taxes are still difficult to measure, inasmuch as other policies and measures are applied to energy use, on top of taxes.

Options for common action on carbon/energy pricing

In the face of current difficulties to reach an agreement on a common tax level across several Annex I countries, it is necessary to think of more flexible options, that best account for different national circumstances, while providing a signal for greenhouse gas emission reductions from energy use.

It is quite obvious that the current environment of decreasing energy prices (in real terms), at least in OECD Member countries, is not conducive to reductions in CO_2 emissions. If pricing policies are to be used to foster greenhouse gas emissions reductions, they should first address this question.

An option would be to keep domestic energy prices from declining in real terms. This would require, for instance, a provision in national tax systems that inflation should be "compensated". A "non-declining price regime" would provide some incentive to energy-users to look for energy-using equipment that is rather less energy-intensive than more energy-intensive. This could be done in a number of ways, e.g. through an upward adjustment of existing excise taxes, or a tax expressed as a per centage of the energy price. In the latter case, any upward change in the energy price would be passed on to consumers "automatically", whereas a reduction in the price would have to be offset by an increase in the tax rate.

The advantage of this option is that it fully takes into account the different starting points across countries, since it does not require immediate increase of energy prices by some common tax level. With respect to trade issues, industrial actors in Annex I countries are already competing under different energy (and other) price regimes, so this would not trigger as much concern as the introduction of a common carbon/energy tax on top of very disparate prices across regions.

One could envision sharing the potential rent from such a policy across all agents:

- domestically: from energy producers to the governments who raise the tax (either local or federal governments, for some Annex I countries). The recycling options described in this study could still be used in this context, although probably with lower total tax revenues.

- internationally, from energy-exporting countries to governments in energy-importing countries within Annex I, if this can help address significant differences in distribution effects across countries. Indeed, the "non-declining price regime" still represents a tax based on the destination principle, i.e., the tax is raised where energy is consumed, not where it is produced.

This option would not prevent other countries who wish to do so from applying additional carbon/energy taxes. In fact, once experience is acquired with this non-declining energy price regime, it might be easier to progressively introduce additional carbon/energy taxes.

All these aspects would have to be studied in some detail to provide an assessment of the practicality and efficiency of such an option.

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