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ENVIRONMENTAL EFFECTS OF LIBERALISING FOSSIL FUELS TRADE: RESULTS FROM THE OECD GREEN MODEL

This document is submitted to the Joint Working Party on Trade and Environment for DECLASSIFICATION under written procedure. Comments received before 15 September 2001 will be taken into account in the final version of the document.

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NOTE BY THE SECRETARIAT

1. The attached paper is a revised version of document COM/TD/ENV(2000)38, reflecting the discussions at the meeting and comments subsequently received from Delegations. This work has been pursued in response to a request from the JWP parent committees [paragraph 63 of C/MIN(99)14] to follow-up on earlier work in the JWP concerning the nature and extent of pricing distortions in fossil fuels in the industry and power sectors, and the effects of a potential liberalisation of fossil fuel trade on environmental quality. The work has in particular taken advantage of the in-house updating of the GREEN model to analyse changes in CO_2 emissions associated with trade liberalisation induced shifts in the direction and volume of fossil fuel production and consumption. This study draws on research carried out by a consultant, Doug Koplow of Earth Track, Inc., in close collaboration with the Trade Directorate. Assistance by the OECD Economics Department, where the GREEN model is housed, was essential in carrying out the simulations.

2. Delegates are invited to declassify the document under the written procedure. Comments received before 15 September 2001 will be taken into account in the final version of the document. The JWP is advised that the Secretariat intends to commence the process of distributing the paper to the general public in the second half of September 2001.

ENVIRONMENTAL EFFECTS OF LIBERALISING FOSSIL FUELS TRADE: RESULTS FROM THE OECD GREEN MODEL

EXECUTIVE SUMMARY

3. Work on subsidies, trade liberalisation and the environment has over the recent past been of importance in the OECD, and other international organisations. In 1998, a major report responded to a request from the G-7 and the OECD Environment Ministers to undertake a wide-ranging study of the effects of subsidies and tax disincentives to sound environmental practices in various economic sectors and the costs and benefits of their elimination or reform: *Improving the Environment through Reducing Subsidies*. The current work on fossil fuels trade fits closely into the long-standing work programme item of the Joint Working Party on Trade and Environment on environmental effects of trade liberalisation and more recently in its analysis of potential ‘win-win' sectors – those for which trade liberalisation may offer both economic benefits and enhanced environmental protection. In this vein, work in the Joint Working Party on Trade and Environment has focussed on the environmental goods/services sector, as well as commenting on similar work in the Organisation on other sectors, e.g. fisheries and agriculture. The recent IEA publication, *Looking at Energy Subsidies: Getting the Prices Right*, focuses on fossil fuel subsidies in eight developing and transition economies, identifying environmental and economic gains from subsidy removal. Also the WTO Committee on Trade and Environment has examined several sectors offering potential "win-win" benefits, including fossil fuels [WT/CTE/W/67].

4. As recalled in the 1999 Ministerial Report on trade and environment [C/MIN(99)14], governments have traditionally intervened heavily in energy markets, through a variety of policy instruments such as taxation, government ownership, subsidised lending, purchase commitments, direct budgetary transfers and forms of indirect support, trade barriers, etc. It is also appropriate to add that energy sector reforms have been widespread in the last decade in both OECD and non-Member countries, one objective of which has been to move towards market-oriented pricing (e.g. the "Shared Goals" statement adopted by IEA Ministers in 1993). The earlier note submitted to the Joint Working Party on Trade and Environment [COM/TD/ENV(99)129 and Annex] contained a long list of government interventions in the energy sector – both generic and country-specific. Measuring the effects of each intervention – either on trade or on the environment - is not possible with current methodologies. Nor have fossil fuels received the detailed attention on the size of transfers that has for example agriculture in terms of measuring producer and consumer support estimates for all OECD countries on an annual basis (PSEs are calculated by the IEA only for a handful of IEA coal producers).

5. On the other hand, as a proxy, the cumulative effects of many government interventions can be captured by the "price gap" methodology, as was explained in detail in document COM/TD/ENV(1998)129. Other data, e.g. direct subsidies, have, where available, also been used. Originally developed in the 1970s for measuring assistance to agriculture, the price gap approach was applied to fossil fuels by the World Resources Institute and the World Bank to measure consumer subsidies in developing and transition economies in the late 1980s and early 1990s. It has most recently been used in this OECD work and by the IEA in their book *Looking at Energy Subsidies: Getting the Prices Right*.[1]

1 A summary of this IEA publication can be found in COM/TD/ENV(2000)37.

This price gap and other available fossil fuels support data were input into GREEN, an OECD in-house general equilibrium model.

6. Production, use and trade of fossil fuels give rise to a number of environmental concerns, including emissions of not only various greenhouse gases, but also SO_x, NO_x and particulates. As explained in the first phase of this work, emissions of these latter gases are mainly local phenomena, either in terms of their pollution effects or due to the regulations and control technologies in place. A global problem - that of the change in carbon emissions - has been chosen for study here with the help of the GREEN model which tracks CO_2 emissions for a number of countries and regions. The implications of reform for emissions at a national as well as global level are of interest since most OECD countries have Annex B commitments to reduce CO_2 emissions under the Kyoto Protocol to the UN Convention on Climate Change. This is done in full recognition nonetheless of the fact that carbon emissions are not the only environmental effects of fossil fuels use. In various counter-factual scenarios, the removal of these fossil fuel-related price distortions were simulated. Resulting changes in CO_2 emissions, welfare and trade flows are reported.

7. Trade liberalisation and energy policy reforms modelled in GREEN indicate net reductions in global carbon emissions. Relatively small changes (less than plus or minus one per cent) in welfare are likely. While small in terms of net global shifts in energy trade, the reforms would stimulate significant shifts in the import/export patterns for particular fuels and regions. Reform of large negative price gaps (where domestic prices are above world prices) increased demand, sometimes substantially, and the surge was generally met through increased energy imports. Conversely, where positive price gaps were large (domestic prices substantially below world prices), reforms tended to curb domestic consumption in the face of higher prices, freeing up this supply for export.

8. The GREEN model results show that for some countries, although not all, liberalisation of fossil fuels could reduce the greenhouse emissions for liberalising countries and help them to meet their emission commitments under Kyoto Protocol. For other countries, in particular Japan, the simulations show adverse effects on emissions which offset emission reductions elsewhere in the OECD. In the absence of appropriate environmental policy regimes in OECD countries, reforms outside of the OECD would be necessary in order to obtain the CO_2 emission reductions from less distortionary fossil fuel pricing. In fact, the simulated carbon emission reductions come almost entirely from liberalisation of non-OECD policies. The “OECD-only liberalises” scenario tends to increase fossil fuel demand (and hence imports), as above-world market prices in Japan and Europe fall. Global trade in fossil fuels actually declines slightly if only non-OECD nations liberalise pricing. This is because the drop in demand associated with eliminating subsidies to domestic consumers is not offset by the increased demand in Japan and high energy price countries in Europe, such as Germany (and in other nations as well, once the terms of trade shift slightly in favour of the consuming nations).

9. In ‘win-win’ sectoral work results are sometimes mixed – that is, there are inevitably provisos on how and to what extent eliminating trade distorting measures brings positive environmental benefits. The results of the GREEN model runs set out in this study are similarly mixed with respect to impacts on CO_2 emissions. In the “non-OECD liberalising” and the “all countries liberalise” scenarios, GREEN model simulations eliminating price distortions lead to important reductions in global CO_2 emissions. For a number of OECD countries, liberalisation of fossil fuel policies also results in CO_2 emission reductions and would assist these countries to meet their emission commitments under the Kyoto Protocol. However, certain fossil fuel price distortions in OECD countries are so large (e.g. negative price gaps showing ex-tax prices well above world reference levels) that the shock of eliminating them, as is posited in the "counter-factual" modelled below, leads, in some cases, to reduced energy prices, increased demand and, in the absence of appropriate environmental policies, larger CO_2 emissions. These effects vary according to the type of policy instrument which governments have put in place to support and subsidise fossil fuel markets

and which result in trade distortions. Obviously therefore the issues surrounding the pace, nature and structuring of trade and pricing reforms are as important as their overall effects. In the scenarios considered here, implementation of the Kyoto Protocol would need to complement the liberalisation of fossil fuel policies in some cases to ensure favourable outcomes for both the economy and the environment. Moreover, while trade liberalisation is important for enhancing competitiveness and economic growth, it has to be accompanied by appropriate energy security, social, and regional policies in order to safeguard against energy shortages, social hardship, and regional divergence.

10. From the outset therefore it is emphasised that the interpretation and use of the study's results should be undertaken with care.

INTRODUCTION

11. Governments have traditionally intervened heavily in energy markets, using a variety of policy instruments such as taxation, government ownership, subsidised lending, purchase commitments, direct budgetary transfers, and import protection. Yet, efforts to reform energy policies have been widespread in the last decade in both OECD and non-OECD countries. Such policy induced changes in the scale, structure, and technology of the energy sector can have substantial impacts on the environment.

12. This study investigates one of the most important environmental effects of policy reform in detail, namely the impact of liberalising fossil fuel trade on CO_2 emissions. There are other environmental concerns associated with the production, use and trade of fossil fuels, including changes in air quality due to emissions of $SO_{x,}$ NO_x and particulates or environmental risks associated with tanker accidents or oil spills. Yet, the focus of this particular study has been on global environmental effects, notably CO_2 emissions, which are contributing to the greenhouse effect.

13. The coverage of the analysis has been confined to the industry and power generation sectors. Other economic activities, including transport, might also have a substantial impact on the global CO_2 balance, but were not considered in this study to limit the scope of analysis. Similarly, external effects associated with the production, trade, and consumption of fossil fuels were not covered in the study.

14. The report is structured in four substantive parts. Part I discusses the methodological background for the study, in particular the price gap approach to measure fossil fuel price distortions and the incorporation of such price wedges into the GREEN model. Part II then reports on the quantitative results regarding changes in the volume of CO_2 emissions according to different trade liberalisation scenarios. To complement the quantitative analysis, part III briefly recalls the importance of placing analysis of energy trade distorting measures in the context of taxation, even though it has not been possible to integrate measurement of the ex-tax price gaps and assessment of distortionary effects arising from fossil fuel taxation into the analysis at the present stage of methodological development. Finally, an Annex sets out the results of sensitivity analyses regarding the supply elasticity of coal and the interfuel substitution elasticities used in the GREEN model.

PART I: PRICE GAPS AND THE GREEN MODEL

15. A detailed study conducted in 1998 analysed fossil fuel pricing in the industry and power sectors for 27 countries.[2] The analysis used the price-gap approach, which compares the end-use price for energy to the price at which that same fuel could be brought in from outside the country (referred to as the "reference" price). The analysis found evidence of substantial price differences across countries and widespread pricing distortions, with the value of deviations from the reference prices (both above and below market prices) totalling nearly $60 billion per year. For example, the gross value of consumer subsidies as a result of energy to industry and power being priced below world prices exceeded $22 billion per year.

16. These results suggested substantial *potential* benefits both from liberalised trade and for environmental quality should price signals become a more central factor in energy markets. It has long been recognised that removing consumer subsidies to fossil fuels, by increasing prices, will tend to reduce environmental damages as consumption declines. The 1998 analysis also found that price reforms in many countries with above world market prices could lead to environmental improvements as well. This is because the protected sectors are often national monopolies or in the more heavily polluting sectors such as coal. Freeing market access and pricing would enable more of the demand to be met by more efficient competitors and/or cleaner fuels.

17. On the other hand, as recalled in the 1999 Ministerial Report [C/MIN(99)14, para. 48], “scale effects associated with reducing fossil fuel prices that had previously been, on average, artificially high due to certain kinds of government intervention, might in some cases lead to increased stress on the environment.” The overall effect becomes therefore an empirical question. However, modelling analysis using hypothetical scenarios of distortion removal can provide insights on the magnitude of the different effects.

Overview of the GREEN model

18. It was agreed in the JWP to derive quantitative estimates of the impacts of energy price reforms using the OECD's GeneRal Equilibrium ENvironmental (GREEN) model. Developed in the early 1990s, GREEN is a multi-country, multi-sector, dynamic applied general equilibrium model which has been developed with the explicit aim of quantifying the economy-wide and global costs of policies to curb CO2 emissions. The model allows for energy substitution, gradually improving energy efficiency, and trade between regions. Even though the simulation period in the model goes up to 2050, results in this paper have only been reported for 2005 and 2010, since other issues of oil substitution intervene in the longer-term results, which are beyond the scope of the current analysis.

19. GREEN contains twelve detailed regional sub-models. These include:

- four OECD regions (the United States; Japan; EU-15; and Other OECD (OOE); and
- eight non-OECD regions (the Former Soviet Union (FSU), Eastern Europe (EET), China (CHN), India (IND), Energy-Exporting LDCs (EEX), Dynamic Asian Economies (DAE), Brazil (BRA) and a Rest-of-the-World (ROW) grouping).

2 COM/TD/ENV(98)129 and Annex, “Environmental Effects of Liberalising Trade in Fossil Fuels”, 1998. Prepared for OECD by consultant Doug Koplow.

20. There are eleven production sectors in GREEN, chosen to highlight the relationships between resource depletion, energy production, energy use and CO2 emissions. Since the main source of manmade CO2 emissions is the burning of fossil fuels, a key focus is on the energy sectors. Three sources of conventional fossil-fuel energy - oil, natural gas and coal - and one source of conventional non-fossil (so-called “carbon-free”) energy are distinguished. The carbon-free energy source includes nuclear, solar and hydropower. Both carbon-based and carbon-free “backstop” technologies are available to replace all conventional energy sources at costs and introduction dates specified externally to the model by analysts.

21. The production side of each regional model describes in a detailed way the supply of fossil fuels and the use of fossil and non-fossil energy inputs in the production process. Some allowance is also made for shifts in the composition of production by treating agriculture as a separate sector, and by distinguishing between two broad aggregates, energy-intensive industries and other industries and services.

22. Consumer demand is split between four broad aggregates: food and beverages, fuel and power, transport and communication and other goods and services. Savings is treated implicitly as a “fifth good”, and shifts in energy prices therefore affect both the structure of consumer demand and the consumption/saving mix through changes in real income.

Description of model scenarios

23. The version of GREEN used for the analysis in this paper is based on 1995 data that was assembled within the framework of the Global Trade Analysis Project (GTAP). In addition, producer and consumer fossil fuel price wedges, calculated specifically for this project (see below), were introduced in order to be able to address the central question of this study, i.e. the effects of liberalising fossil fuel trade on CO_2 emissions. While the GREEN model has been used in the past to evaluate the benefits of price reform, this is the first effort that used country-specific data to quantify the magnitude of distortions in energy supply and demand. This data upgrade has undoubtedly helped to improve the quality of the simulation results.

24. To evaluate the impact of trade liberalisation and energy policy reforms on CO_2 emissions, welfare (measured through changes in real incomes), and trade, three scenarios were evaluated. As had been agreed in the initial phase of the project, the analysis has focussed on the industrial and power sectors. The model simulations do not consider the future implementation of the Kyoto Protocol, so that no constraints on emissions rising above countries' commitments are imposed.

25. In the first scenario, trade liberalisation and energy policy reforms were assumed to be implemented within the OECD area alone. In the second set-up, liberalisation and reforms were taken to occur only outside of the OECD zone. And in the third scenario, liberalisation and reforms were assumed to be implemented world-wide. Technically, the trade and energy policy reforms in the three scenarios were simulated by eliminating existing price wedges. All scenarios are compared to a "Business as Usual" situation, which is based on the assumption that energy policies are not reformed, so that existing price wedges persist.

26. The GREEN model is the OECD's tool for quantitative analysis of econo-environmental linkages that has been developed under the guidance of experts from Member countries. Yet, as in all modelling work, the results depend crucially on the parameter values used. In order to determine the influence of alternative elasticity assumptions on the results, sensitivity analyses were conducted for the elasticities of coal supply and of interfuel substitution, results of which are reported in the Annex. Measurement of support

27. For agricultural and other sectoral analyses, the OECD has over the past quarter century been developing indicators of policy support, known as producer and consumer support estimates (PSE and CSE; until 1999 named producer and consumer subsidy equivalents). It is important to stress that these indicators are *aggregate* indicators of support, reflecting the use by governments of a variety of policy instruments. The PSE is an indicator of the value of the transfers from domestic consumers and taxpayers to producers resulting from a given set of policies. In its work on agriculture, OECD originally identified five categories of policy measures as parts of the PSE:[3] *a)* market price support; *b)* direct payments to producers; *c)* reduction in input costs; *d)* provision of general services and *e)* other support (such as sub-national expenditures).[4]

28. Analogous to the definition of the PSE, the CSE is an indicator of the value of the transfers from producers and taxpayers to domestic consumers arising from a given set of policies. Support to consumers was originally classified as either *a)* market transfers due to market price support, or *b)* other transfers which consist mainly of budgetary payments.

29. There is a very close relationship between the PSE and the CSE. All measures that contribute to raise domestic prices above world prices, corresponding to a price support element, will be accounted for as transfers to producers (positive component of the PSE) from consumers (negative component of the CSE). Conversely, policies that reduce domestic prices below world market price levels, which is the case for many developing/transition economy energy producers, will be counted as transfers *in favour of* consumers (positive component of the CSE) paid by producers (negative component of the PSE). Budget-provided transfers to producers or consumers that do not create a wedge between domestic and world market prices are measured directly from budgetary data.

30. Furthermore, in OECD's analysis of agricultural support, nominal assistance coefficients (NACs) are derived for producers and consumers by relating total producer receipts (reference price plus per unit PSE) or consumer outlays (reference price minus per unit CSE) to the reference price. These producer and consumer NACs provide a means of analysing the structure and development of support on a per-unit basis. Their derivation is closely related to the price wedge approach for analysing fossil fuel price distortions used in this study. The particular advantage of a NAC-type indicator or a price wedge over a PSE or CSE indicator is that the former can be more easily implemented in a model like GREEN, which is driven by prices adjusting to clear markets.

Data and methodology used to calculate fossil fuel price distortions

31. For the purpose of this study, detailed price series for various fuels (light fuel oil, heavy fuel oil, natural gas, and coal) were gathered and compared to appropriate reference prices in order to calculate price gaps.[5] The latter were derived as the differences between the reference price at which that fuel could

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3 *Modelling the Effects of Agricultural Policies*, OECD Economic Studies, No. 13, winter 1989-1990, OECD, Paris.

4 In 1999, the classification of agricultural support policies was changed to provide a more detailed account of different forms of budgetary support (see OECD, 1999. *Agricultural Policies in OECD Countries: Monitoring and Evaluation*. Paris: OECD publications).

5 OECD work on agriculture, focussing on Member country support to producers, has always defined the difference the other way around, i.e. domestic price minus world price. Here the World Bank methodology, emphasising (positive) consumer subsidies, has been adopted. The difference is only one of sign. Thus, here *high* energy prices yield *negative* price gaps.

be brought in from outside the country (adjusted for transport costs and fuel quality differentials)[6 7] and the domestic end-use price of a particular fuel, net of taxation (ex-tax prices). In particular, energy excise taxes were subtracted before comparing domestic and reference prices, while value-added taxes on fossil fuels used in the power and industry sectors were taken to be effectively zero.[8] All price gaps were calculated from 1996 data. Unfortunately, data on producer price distortions seems to be incomplete, so that government support to producers (e.g. for fossil fuel exploration, extraction, refining, and distribution) might be understated for some countries and fuels.

32. Four categories of support instruments were covered through the calculation of price wedges:

- Energy subsidies to consumers where domestic end-use prices are lower than the world reference prices. Removing these subsidies would increase the prices paid by consumers for domestically produced and imported energy in the same proportion.

- Economic rents paid by consumers due to market imperfection in the distribution of energy products where domestic end-use prices are above corresponding world reference prices. Removing the underlying market imperfections would reduce prices paid by consumers for domestically produced and imported energy in the same proportion.

- Market price support arising from trade restrictions raises the domestic price above world prices, which was represented through equivalent taxes on imports and subsidies on exports.[9] Removing these trade restrictions would result in a reduction of domestic production[10]

- Subsidies to current production arising from budgetary transfers. These producer subsidies were calculated in different ways depending on available data. For coal in OECD countries, data used by the International Energy Agency in calculating its producer subsidy equivalents

6 The US price for oil is normally used as the world reference price for price gap calculations. By definition, this yields a consumer wedge of zero for the United States. However, detailed work on government support for oil in the United States indicates that subsidies do exist (Doug Koplow and Aaron Martin, Fueling Global Warming: Federal Subsidies to Oil in the United States, prepared by Industrial Economics, Inc. for Greenpeace, June 1998). Based on this data, the price gaps were adjusted by two percentage points.

7 . It should be noted that the reference prices used are market prices, which might not always reflect the full environmental costs of fossil fuels, due to unaddressed externalities in production and/or consumption.

8 Where value added taxes are charged to the industry and power sectors, there are normally rebated to the firms.

9 There is some judgement involved in classifying these price supports. Positive producer wedges on coal in the US and Japan are treated as producer price supports. However, positive wedges in the natural gas sector are considered as a true consumer tax, reflecting a lack of competition in distribution. A similar division was made in the oil sector, with a positive wedge in Japanese oil treated as a producer price support and a positive wedge on EU refined oil treated as a consumer tax reflecting rent in distribution. It should be noted also that the positive wedge of the price of US exports of coal relative to the world price is attributed to differing qualities of coal, rather than a market distortion. Similarly, the negative wedge of the price of Australian coal exports relative to the world price is usually assimilated to an export tax, corresponding to a rent for high railway charges on coal shipped to export ports. For technical reasons related to GREEN, it was not possible to introduce this export tax.

10 Note that this contraction will occur even if coal consumption remains unchanged, but supplied now by imported rather than domestic coal. In fact, evidence from the UK suggests that there will be substantial fuel switching as well once subsidies are removed, yielding additional carbon reduction benefits. See Jan Pieters, “Gains for Reducing Coal Support with particular reference to the UK Experience” in Environmental Taxes, Recent Developments in China and the OECD Countries, 1999.

(PSE) were used.[11] Values for natural gas and non-OECD coal were derived where possible using the input-output tables that underlie GREEN by subtracting the total factor costs from the producer price for each fuel.

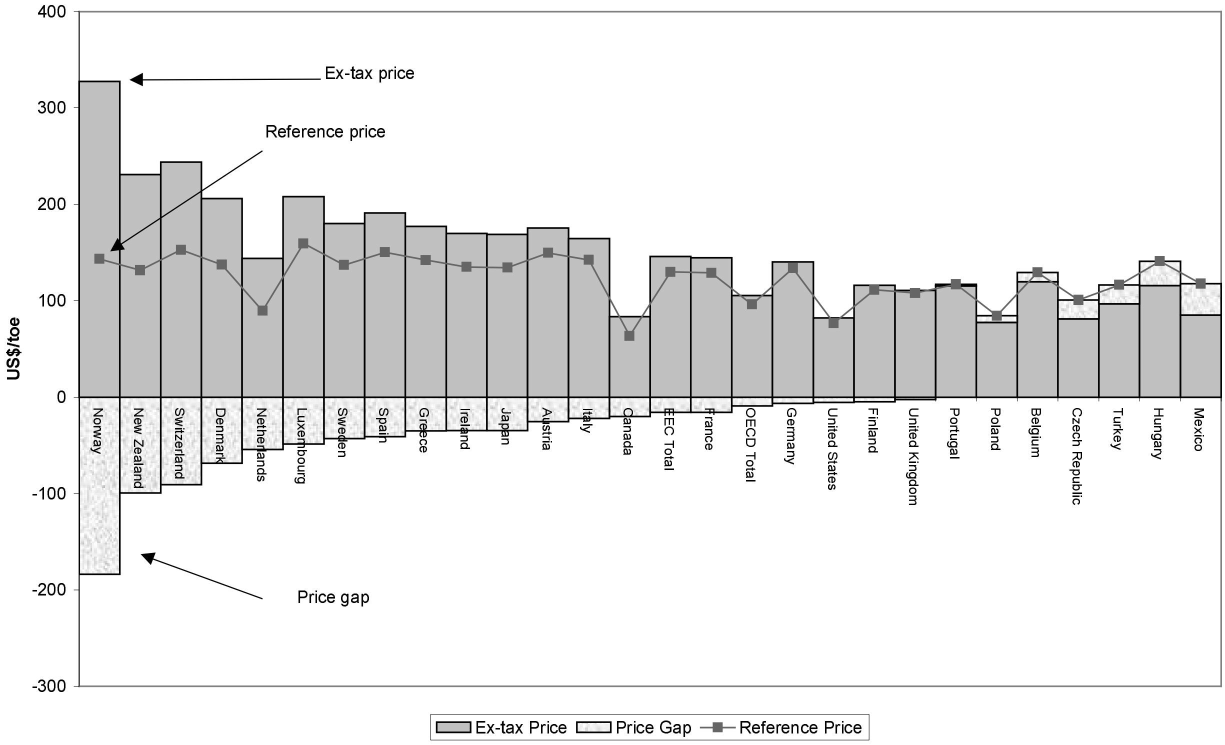
33. For technical reasons, the simulations of energy policy reforms were carried out for groups of countries (see table 1 for a list of the groupings). The resulting averages of policy impacts and price gaps lead to a reduction of country-specific detail, which in turn may not allow to illuminate some important policy issues in individual countries. For example, since Canada is a member of the "other OECD countries" group, trade impacts with the USA, which is Canada's largest trading partner, can not easily be identified. Similar aggregation problems arise at the national level, where price gaps particularly in large countries might differ between regions due to transport costs or policy interventions of regional authorities. This price variability gets lost when using data based on nation-wide averages.

34. Another methodological problem concerns the choice of exchange rates to express domestic prices in US dollars in order to be able to compare them to the reference prices. Market exchange rates tend to fluctuate and can deviate substantially from their long-term equilibrium values, in particular if the markets for foreign exchange are small, such as in many developing countries. In these cases, the use of exchange rates based on purchasing power parities (PPP) has the advantage of eliminating the effects of short term exchange rate fluctuations and reflecting the domestic value of a particular good more closely. On the other hand, PPP exchange rates are more difficult to interpret, as they are hypothetical constructs. Imports and exports are undertaken at market exchange rates, so that the latter have the advantage of authenticity. For this reason, the IEA used official exchange rates to convert domestic prices of tradable goods into a common currency for its 1999-study on *Looking at Energy Subsidies: Getting the Prices Right* (see in particular box 11 in this study for a methodological explanation). Also, the OECD considered during 2000 to use PPP-exchange rates in its calculation of producer and consumer support estimates (see AGR/CA/APM(2000)12 on "Deflation and exchange rate procedures in the monitoring and evaluation of agricultural support"), but Member countries decided to continue using official exchange rates to calculate market price support. The approach in this study follows the general OECD procedure of using official exchange rates for the calculation of price wedges. It should be noted that this choice of exchange rate might overstate or understate the price wedges in particular countries, even though in larger groups of countries any bias will likely cancel out.

35. The data on domestic and reference prices of fossil fuels (charts 1 & 2, and table 1) reveals substantial differences in price gaps across countries and types of fuel. While the price gaps tend to be negative in OECD countries, they are generally positive in non-OECD countries, including in many developing countries. Comparing price gaps across types of fuel, the largest deviations from the reference price in G-7 countries appear for refined oil, with only Canada and the USA showing below average gaps.

11 International Energy Agency, *Coal Information (1999 Edition)*, Part 1, pp. I.4 - I.26.

Chart 1. Ex-tax price, reference price and price gap in OECD countries, 1996
(weighted average of light fuel oil, heavy fuel oil, natural gas, and coal)



Source: OECD Secretariat

Table 1. Fossil fuel price wedges used to the GREEN model simulations

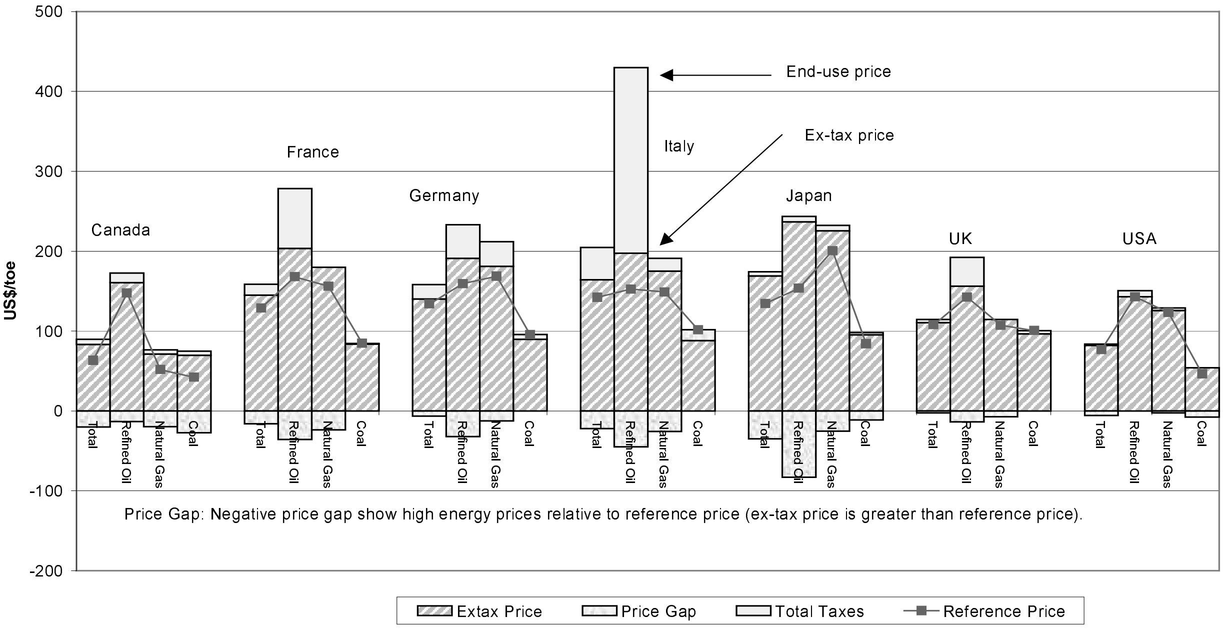
Country group	Consumer price wedges			Producer price wedges		
	Coal	Natural gas	Refined oil	Coal	Natural gas	Refined oil*
BRA	16%	9%	-25%	0%	0%	0%
CHN	16%	29%	8%	3%	0%	0%
DAE	29%	-264%	11%	0%	7%	0%
EEC	5%	-11%	-19%	34%	0%	0%
EET	33%	47%	10%	0%	0%	0%
EEX	7%	46%	54%	0%	4%	0%
FSU	35%	20%	12%	0%	1%	0%
IND	15%	22%	3%	0%	0%	0%
JPN	-14%	-15%	-54%	17%	0%	0%
OOE	21%	15%	11%	0%	0%	0%
ROW	50%	-101%	38%	0%	5%	0%
USA	-16%	-4%	2%	0%	12%	0%

Abbreviations: BRA (Brazil), CHN (China), DAE (Dynamic Asian Countries), EEC (European Union 15); EET (Eastern Europe), EEX (Oil Exporting Countries), FSU (Former Soviet Union), IND (India), JPN (Japan), OOE (Other OECD), ROW (Rest of World), USA (United States).

*) The world market price for oil is endogenous in GREEN, so that the producer price wedge is taken to be zero (see van der Mensbrugghe (1994). GREEN: The Reference Manual. Economics Department Working Paper No. 143, OECD, Paris)..

Source: OECD Secretariat

Chart 2. Components of fossil fuel prices in G7 countries by fuel type, 1996



Source: OECD Secretariat

Simulations of trade liberalisation and energy price reforms

36. There are many reasons why differences in energy prices may exist across countries. In addition to direct producer or consumer subsidies, regulatory structures may inhibit trade or allow monopolistic control of markets. Also, government ownership of key energy assets may impede or divert new investment or development. Moreover, in some cases national endowments may influence pricing to some degree, though adjusting price comparisons for transport, distribution, and fuel quality generally reduces the impact of this factor. Imported fuels tend to be quite close substitutes for domestic ones, and improved logistics are making most markets contestable by imports.

37. Reforming all of these possible distortions would involve reforming a host of policy instruments and would likely proceed in stages. Nonetheless, the simulations undertaken in this study can help to illustrate the effects of such broad-based reforms. Indeed, one particular strength of the analytical approach is that all countries, all fossil fuels, and the entire scope of policy measures are considered for reform simultaneously.

38. Energy policy liberalisation is simulated by eliminating existing distortions - regardless of their source. In the GREEN runs all of the various wedges on consumer, producer and traded fuel prices for coal, natural gas, crude oil, and refined oil products are set to zero. For example, where market price support was simulated as an equivalent tax on imports, this situation was “liberalised” by eliminating this tax. Or in the case where producers received direct subsidies, the liberalising scenarios assumed that these direct subsidies were abolished and the wedge in the model on producer prices was set to zero. Conversely, where consumer energy prices were higher than world reference prices reflecting the rent arising from various market imperfections (e.g. monopoly distribution rights), the equivalent consumer tax was set to zero in the liberalisation scenarios run, resulting in a decline in energy prices for the fuel in question.

PART II: RESULTS OF GREEN MODEL SIMULATIONS

39. The simulations with the GREEN model approximate how a free market in fossil fuels would operate, and allow an examination of the shifts in CO_2 emissions, economic welfare and trade. Reform of large positive price gaps (domestic prices substantially below world prices), reforms would tend to curb domestic consumption in the face of higher prices, freeing up this supply for use in other countries. Conversely, where negative price gaps are substantial (in case domestic prices are above world prices), demand would increase and this additional demand would generally be met through increased energy imports. In this case, fossil fuel use and carbon emissions would increase. However, as noted above, the scenarios did not make any allowance for the future implementation of the Kyoto Protocol, which would constrain emissions from rising in some countries as a result of liberalisation and policy reform.

40. Trade liberalisation and energy policy reforms modelled in GREEN indicate net reductions in global carbon emissions, and reductions in CO_2 output for some countries with emission commitments under the Kyoto Protocol. Aggregate welfare as measured by real incomes would remain largely unchanged. While small in terms of net global shifts in energy trade, the reforms would stimulate significant shifts in the import/export patterns for particular fuels and regions. Table 1 provides a summary of model results and notes regions in which the impacts of liberalisation are substantially different from the global average. Results from sensitivity analysis on some central model parameters is reported in the Annex.

Carbon dioxide emissions

41. The results of the "all countries liberalise" scenario indicate that energy policy reforms would lead to reductions of carbon emissions of 6.2 per cent by 2010 compared to the "business as usual" scenario, even without taking the effects of the implementation of the Kyoto Protocol into account. Liberalisation of energy markets outside of the OECD would be necessary in order to obtain large benefits in terms of CO_2 reductions from less distortionary fossil fuel pricing. Indeed, reductions come almost entirely from non-OECD countries and result from reduced energy consumption following the removal of subsidies. Regions in which both energy supports and energy consumption are large experience the strongest CO_2 declines.

42. The “OECD-only liberalises” scenario tends to increase fossil fuel demand (and hence imports), as above-world market prices in Japan and Europe fall. Indeed, the increase in global CO2 emissions in this scenario is largely due to the strong increase in consumption of fossil fuels in Japan. In most other OECD countries emissions would be lower as a result of reductions in demand or substitution towards less carbon-intensive fuels, and hence would help them to meet their emission commitments under the Kyoto Protocol.

Table 2. Results from GREEN model simulations

(changes relative to "business as usual" scenario)

	OECD only liberalise	Non-OECD only liberalise	All countries liberalise
CO_2 Emissions			
2005	-0.0%	-3.9%	-3.9%
2010	+0.1%	-6.3%	-6.2%
Larger Impacts	OOE-5% JPN+10%	CHN-15%, EET-15%, FSU-13%, DAE-10%, EEX-10%, IND-8%, BRA+11%	CHN-15%, EET-15%, FSU-13%, DAE-10%, EEX- 9%, IND-8%, BRA+10%, JPN+10%
Welfare Effects			
2005	+0.0%	+0.0%	+0.1%
2010	+0.1%	+0.0%	+0.1%
Larger Impacts	 EEX+0.8%	FSU-0.7%, EEX-0.5%, EET+0.7%, ROW+0.8%	 ROW+0.8%, EET+0.9%
Imports			
2005	+4.8%	-1.9%	+2.8%
2010	+7.2%	-2.6%	+4.4%
Larger Impacts	 EEC+18%, JPN+19%	ROW-20%, EET-14%, EEX-13%, FSU-11%, BRA+29%,	ROW-21%, EET-14, EEX-10%, FSU-9%, BRA+28%, JPN+18%, EEC+17%
Exports			
2005	+4.8%	-1.9%	+2.8%
2010	+7.2%	-2.6%	+4.4%
Larger Impacts*	 EET+15%, USA+16%, OOE+17%, CHN+17%, DAE+24%	CHN-11%, DAE-11%, EET-12%,	 USA+11%, OOE+12%, DAE+14%

Note: The percentage number after regional abbreviations denotes significantly higher or lower values within the particular region as compared to the global totals in 2010.

*) The simulation results indicate large changes for IND and ROW also, but these results are due to the technical specification of price wedges in the model and low export quantities in the base period, so that the numerical values are not reported in the table.

Abbreviations: BRA (Brazil), CHN (China), DAE (Dynamic Asian Countries), EEC (European Union 15); EET (Eastern Europe), EEX (Oil Exporting Countries), FSU (Former Soviet Union), IND (India), JPN (Japan), OOE (Other OECD), ROW (Rest of World), USA (United States).

Source: OECD Secretariat.

43. Two regions in Table 1 show significant increases in CO_2 emissions: Brazil and Japan. Japanese coal and oil demand is expected to rise as reforms lead to lower domestic prices - now in some cases several times the world price. The increase in emissions simulated for Japan would offset emission reductions for the rest of the OECD. Brazilian emissions rise as a heavily subsidised ethanol programme would lose out to imported oil.

44. Domestic supports for energy consumers (as shown by a large positive price gap) are significant in China, the Dynamic Asian Economies, the Former Soviet Union, Eastern Europe, and in many Energy Exporting countries. In all of these regions, liberalisation of domestic prices will reduce domestic demand for fossil fuels, and with it CO_2 emissions.

Welfare

45. Trade liberalisation and energy reforms affect welfare in a number of ways. There are direct gains in economic welfare from the removal of economic distortions as limited resources are deployed more productively across the economy. There are also terms of trade effects. As energy prices rise to world levels, demand for the fuels decline. On a global level, the reduced demand softens fossil fuel prices, worsening the terms of trade (TOT) for exporters (and improving them for energy importing developing countries). The TOT impact is most pronounced in oil markets.

46. Real income effects are less than plus or minus 1 per cent under all scenarios, with a total global effect of a 0.1 per cent *increase* in real income from the reforms. This suggests that reforms can be carried out without any region experiencing severe economic hardships, and with many regions actually better off. Somewhat higher negative impacts will be felt in oil exporting nations. Exporting nations benefit if only the OECD reforms are put in place, as demand in Japan and high-energy price European countries, such as Germany, rises bolstering their export markets. However, once domestic prices as well are reformed (as they are in the other two scenarios), real incomes in energy exporting regions (EEX and FSU) decline slightly as the global drop in oil demand reduces world equilibrium prices. Increased real income in both Eastern Europe (EET) and the Rest of the World (ROW) are driven by the improving terms of trade as the oil prices fall.

47. Moreover, sensitivity analysis (see Annex) shows that making coal producers less responsive to changes in the price of coal (i.e. using a lower elasticity of supply) had no significant effect on anticipated real income effects either regionally or globally.

48. Despite these apparently small impacts, an important caveat is in order. Because the GREEN results report only national or regional values, it is possible that there will be geographic pockets that experience significant declines in welfare as countries/regions are forced to pay more for fuel or no longer able to continue production. IEA reports that because many low-income populations rely on unsubsidised biomass rather than subsidised conventional fuels, many energy subsidies are actually regressive.[12] This finding suggests that on the retail side at least subsidy reforms would not cause undue hardship to the poorest citizens. However, careful assessment of reform plans is needed to more accurately determine where hardship is likely to occur and how it can be mitigated.

Energy trade

49. Reducing large price distortions of fossil fuels will increase imports to Japan, Europe and Brazil, countries that today have domestic pricing well above the reference price for at least some fuels. Imports rise substantially within the OECD because of this factor, but fall within non-OECD countries as demand drops from subsidy removal. Exports rise in most of the big exporting countries under global liberalisation. Overall fossil fuel trade flows are expected to rise by 4.4 per cent by 2010.

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12 International Energy Agency, *World Energy Outlook, Looking at Energy Subsidies: Getting the Prices Right*, 1999, pp. 49, 50.

50. Despite relatively small overall shifts in global trade flows, regional trade flows for all of the fossil fuels are expected to change substantially. Table 3 provides an overview of changes in imports by region and by fuel. Table 4 provides similar information for exports. It should be noted that only regions in which the change in export flows was more than 15 per cent above or below the baseline scenario have been listed individually.

Trade flows with global liberalisation

51. Tables 3 and 4 show that many regions are expected to experience relatively large shifts in fossil fuel trade flows should trade liberalisation and energy reforms be implemented globally. Notable shifts include:

– A large increase in imported coal and gas within the EEC (e.g. to serve German and Spanish needs once coal supports end).

– Substantial declines in fuel imports to Eastern Europe, the FSU, India, and China as domestic pricing reforms (where domestic energy is generally well below world prices) reduces demand and with it the need for imports.

– Sharp increases in refined oil imports into Japan (although crude imports actually fall) and crude oil imports into Brazil, as less expensive external suppliers replace domestic sources (e.g. refined oil in Japan and ethanol in Brazil).

– On the export side, the largest increase comes with oil from the Rest of the World, expected to rise by more than 300 per cent. As energy reforms bring oil prices to world levels, domestic demand is expected to fall. Energy exporting regions (e.g. EEX, FSU) can sell some of the energy previously consumed domestically on world markets. This may also be what is driving the large increase in ROW oil exports. Crude oil exports from Other OECD (OOE) and refined oil exports from India will also rise substantially.

52. Though many regions seem to benefit from the increased European demand for imported coal, the largest increases in exports come from the USA and the Former Soviet Union.

Trade flows with liberalisation within OECD only

53. Reforms within the OECD alone would open up large but currently relatively distorted energy markets, primarily in Japan and parts of Europe. Coal imports increase to the EEC and refined oil imports into Japan. Demand is met by several exporters shown in Table 4, with large increases in coal exports from China, Eastern Europe, the Former Soviet Union, the United States, and the Rest of the World. Increased exports from the OOE (which includes Australia, a large coal exporter) are not that significant, perhaps due to transport costs.

54. Declines in coal exports from the EEC are quite steep, underscoring the shrinkage of the industry and the high cost position on world markets. EEC natural gas exports also decline, illustrating at least some substitution of local natural gas for the coal that is no longer being produced. Japan's large rise in refined oil imports would be met by OOE, India, DAE, and the energy exporting countries, all of which see their exports of oil or refined oil products increase significantly.

Trade flows with liberalisation within non-OECD countries only

55. Reforms outside of the OECD zone would correct the many subsidies for energy consumption that allow domestic prices to be below (sometimes far below) world prices. Where domestic sources of supply are high cost producers (e.g., natural gas from DAE and from some of countries contained in ROW), the results suggest industry contraction, with a large drop in exports and a substantial rise in imports from lower cost suppliers. Within Brazil, this same process is occurring, with domestic ethanol from sugar cane being replaced by imported crude oil.

56. As internal use of fossil fuels drops from energy policy reforms, less imported energy is needed by a host of consumers including those now relying on refined oil in ROW, natural gas in China, and gas and coal within EET, EEX, and FSU. The reduced domestic demand frees up additional resources to sell into export markets. The simulations suggest that other exporting regions such as FSU and EEX decrease their fuel imports as domestic demand declines, without showing large increases in exports. Without the additional demand pull provided by liberalisation within OECD as well, some export markets would decline.

Caveats

57. While the simulation results are instructive in demonstrating that significant opportunities exist to achieve environmental and economic benefits jointly, it is important to underscore some of the limitations that affect the results. The magnitude of pricing distortions, for example, are calculated using either 1996 country-specific data or 1995 input-output table calculations. Following energy policy reforms since that time, e.g. in several transition economies and OECD coal producers, current pricing distortions could be lower.

58. Data limitations suggesting underestimation of CO_2 reductions include:

- **Analysis excludes significant fossil fuel consumption**. The simulations focussed on distortions in fossil fuel prices used for the industry and power generation. The analysis does not evaluate fuel subsidies to commercial, agricultural, or retail users at all, though these sectors often receive substantial subsidies and comprise on average 40 per cent of total fossil fuel consumption.

- **Poor data on producer wedges.** Data on producer wedges existed for only a limited number of countries, though qualitative data on government interventions in most countries suggests subsidies to fossil fuels are large.[13]

- **Energy efficiency improvements may be understated.** Embedded improvements in the energy efficiency of capital equipment is reflected in the GREEN model using the Autonomous Energy Efficiency Improvement Factor, or AEEI. A higher AEEI means that the normal process of capital replacement will yield greater improvements in energy efficiency. This, in turn, would mean any impetus to shift from carbon-based fuels to an alternative would yield a higher net reduction in CO_2 emissions. There is reason to believe that the embedded AEEI assumptions may be too low, and that the 2010 cut-off data of

13 COM/TD/ENV(98)129, "Environmental Effects of Liberalising Trade in Fossil Fuels" compares the magnitude of price gap subsidy calculations versus transfer-based estimates for a number of countries where detailed data on transfers exists. In every case, the transfers show more in subsidies than is captured in the consumer price wedge alone.

analysis may miss some of the larger, though longer-term innovations that will reduce CO_2 emissions.[14]

- **Exclusion of producer wedges to oil.** The GREEN model does not allow any producer wedges for crude oil to be incorporated into model runs. To the extent that removal of non-OPEC subsidies to crude oil producers would shift supply to less carbon-intensive producers, there would be net emission reductions from reforms.

- **Non-incorporation of the effects of Kyoto Protocol implementation**. Implementation of the Kyoto Protocol would require most OECD countries to constrain emissions across the entire economy. Increases in emissions resulting form the liberalisation of fossil fuel policies simulated for Japan, for example, would have to be offset by emission reductions elsewhere in the Japanese economy. Consequently, in the context of the implementation of the Kyoto Protocol, the magnitude of emission reductions across the OECD taken as a whole would be greater than under the model scenarios presented.

14 The AEEI factor was previously set at 1.0% per year; recently, it has been set to the greater of 0.2% per year or 40% of the productivity growth rate. Because the energy sector is under intense pressure to innovate both from deregulation and from environmental controls on emissions, it is likely that the economy-wide productivity measure will understate the actual pace of change in the energy sector.

Table 3. Changes in imports, by fuel

(percentage change from "business as usual" scenario)

Scenario 1: OECD only liberalise			Scenario 2: Non-OECD only liberalise			Scenario 3: All countries liberalise		
Regions	**2005**	**2010**	**Regions**	**2005**	**2010**	**Regions**	**2005**	**2010**
All	4.8	7.2	All	-1.9	-2.6	All	2.8	4.4
Large Effects			**Large Effects**			**Large Effects**		
EEC Coal	87.3	78.1	BRA Coal	-13.1	-21.5	BRA Oil	28.7	49.7
EEC Gas	4.3	19.1	BRA Oil	29.0	51.2	BRA Gas	-10.6	-15.3
EEX Gas	-26.5	-31.3	CHN Gas	-25.9	-36.6	CHN Coal	-10.8	-16.3
FSU Gas	-4.7	-24.0	DAE Gas	44.3	41.8	CHN Gas	-26.7	-38.7
JPN Oil	-12.2	-22.6	EET Coal	-12.6	-21.7	DAE Coal	-17.9	-26.8
JPN Ref. Oil	130.4	261.6	EET Gas	-23.9	-35.5	DAE Gas	41.8	37.8
USA Coal	37.0	67.6	EEX Coal	12.1	24.3	EEC Coal	87.7	78.5
			EEX Gas	-15.6	-24.7	EEC Gas	6.7	19.9
			FSU Coal	-19.5	-29.5	EET Coal	-13.6	-22.8
			FSU Gas	-13.0	-15.7	EET Gas	-24.0	-36.1
			ROW Coal	11.5	19.5	EEX Coal	15.3	29.2
			ROW Gas	38.9	60.9	EEX Gas	-37.8	-47.9
			ROW Ref. Oil	-17.4	-25.3	FSU Coal	-20.4	-29.7
						FSU Gas	-17.1	-35.3
						IND Coal	-12.7	-18
						IND Gas	-9.5	-15.4
						JPN Oil	-10.3	-18.8
						JPN Ref. Oil	118.1	231.8
						ROW Coal	9.1	16.9
						ROW Gas	33.5	50.0
						ROW Ref. Oil	-17.8	-20.5
						USA Coal	35.5	64.2
						USA Ref. Oil	-8.1	-13.7

Note: Cut-off: plus or minus 15 per cent relative to baseline in 2010.

Abbreviations: BRA (Brazil), CHN (China), DAE (Dynamic Asian Countries), EEC (European Union 15); EET (Eastern Europe), EEX (Oil Exporting Countries), FSU (Former Soviet Union), IND (India), JPN (Japan), OOE (Other OECD), ROW (Rest of World), USA (United States).

Source: OECD Secretariat.

Table 4. Changes in exports, by fuel

(percentage change from "business as usual" scenario)

Scenario 1: OECD only liberalise			Scenario 2: Non-OECD only liberalise			Scenario 3: All countries liberalise		
Regions	**2005**	**2010**	**Regions**	**2005**	**2010**	**Regions**	**2005**	**2010**
All	4.8	7.2	All	-1.9	-2.6	All	2.8	4.4
Large Effects			**Large Effects**			**Large Effects**		
CHN Coal	20.8	20.7	BRA Coal	18.4	34.1	BRA Coal	23.2	40.6
DAE Coal	17.4	16.9	DAE Coal	13.2	23.5	DAE Coal	32.1	43.0
DAE Ref. Oil	12.3	24.3	DAE Gas	-59.9	-58.8	DAE Gas	-56.9	-50.9
EEC Coal	-83.9	-84.9	EEC Gas	-15.8	-17.0	EEC Coal	-84.1	-85.2
EEC Gas	2.8	-22.6	EET Coal	-11.0	-17.3	EEC Gas	-13.3	-34.8
EET Coal	25.1	21.4	IND Coal	16.3	27.9	EET Gas	16.4	42.4
EET Gas	5.7	26.6	OOE Oil	3.4	-23.8	EEX Coal	28.1	17.7
EEX Coal	34.2	29.5	ROW Oil	109.3	358.9	EEX Gas	7.8	17.5
EEX Ref. Oil	17.7	35.5	ROW Gas	-28.7	-37.5	FSU Coal	43.7	46.5
FSU Coal	33.2	29.4				IND Coal	20.8	32.6
IND Ref. Oil	29.1	57.7				IND Ref. Oil	22.5	49.3
OOE Coal	15.8	15.7				JPN Coal	-34.3	-43.1
OOE Oil	21.1	103.4				JPN Gas	-10.6	-9.1
ROW Coal	38.3	37.5				OOE Oil	18.0	81.9
USA Coal	39.8	36.6				ROW Oil	107.5	351.8
USA Gas	-30.4	-34.8				ROW Gas	-20.8	-24.8
						USA Coal	36.4	31.3
						USA Gas	-34.1	-41.4

Note: Cut-off: plus or minus 15 per cent relative to baseline in 2010.
Abbreviations: BRA (Brazil), CHN (China), DAE (Dynamic Asian Countries), EEC (European Union 15); EET (Eastern Europe), EEX (Oil Exporting Countries), FSU (Former Soviet Union), IND (India), JPN (Japan), OOE (Other OECD), ROW (Rest of World), USA (United States).
Source: OECD Secretariat.

59. On the other side, the case of market transfers to consumers (through domestic prices that are lower than world market prices) calls for careful interpretation of the results from the "non-OECD liberalising" scenario. The large degree of energy under-pricing in certain developing and transition economies suggests that availability has been a constraint in meeting what otherwise would have been normal demand. Hence while consumers in such countries were paying a low price on average, they often could not obtain the quantity they would have liked to purchase at that price. Classic examples are the fuel shortages and electricity brown-outs witnessed during the late-1980s and early 1990s in Eastern European countries. Estimating the drop in consumption that would occur with the freeing up of and consequent rise in fossil fuel prices may tend to over-state the expected reduction in demand, given that the demand was already constrained. In fact, the observed reductions in demand following the consumer price reforms in Russia and Poland were not as great as had been initially forecasted by the World Bank.

60. However, the existing data limitations suggest that the CO_2 reductions predicted by GREEN serve overall as a lower bound for what will actually be realised through reforms.

Comparison to other studies

61. There have been a number of past analyses to gauge the potential environmental and economic benefits of fossil fuel price reform. Table 5 below provides a cursory summary of a few of them. Because the approach, parameter assumptions and the fuels and sectors included generally differ, these results are difficult to compare. Nonetheless, some general conclusions can be drawn based on the broad type of analysis.

62. World Coal Trade Model. Studies relying on this model (DRI, Light) tend to conclude that there are little or no carbon reduction benefits from subsidy reforms to coal pricing. This is because imported coal is assumed to immediately and almost completely replace uneconomic domestic coal. These assessments seem likely to understate the benefits of reform for two reasons. First, once supports for coal are removed, alternative fuels seem to be able to compete more effectively. Second, inefficient domestic operations can often be less environmentally friendly as well as less economically efficient than imported coal. In such circumstances, the shifting of supply sources might yield environmental benefits.

*63. Limited Evaluation of Fuels, Regions, Sectors***.** Depending on the design of a particular study, the projected carbon reductions may be smaller or larger than what would occur were reforms to apply to all fossil fuels, world-wide, in all fossil fuel consuming and producing sectors of the economy. This might partly explain the variety of results on CO_2 reductions in the different studies.

Final remark

64. The mandate of this study was to analyse the effects on carbon emissions and trade flows of removing fossil fuel price distortions. It is beyond the scope of this stage of the analysis to discuss which distortions, to what extent and where they are appropriately negotiated away. As mentioned several times, these distortions are due to a large number of policy instruments and imperfect market structures. Trade liberalisation, regulatory reform and subsidy reform - at national and international levels - are some of the means to move towards market-oriented pricing. And as noted above, Member and many non-Member countries have been engaged in movements towards market pricing in energy products. Nonetheless in a trade and environment exercise it is important to underscore the importance also of assessing the environmental impact of these trade and pricing reforms. The

GREEN model results show that for some countries, although not all, liberalisation of fossil fuels could reduce the greenhouse emissions for liberalising countries and help them to meet their emission commitments under the Kyoto Protocol. For other countries, in particular Japan, the simulations show adverse effects on emissions, a result which underscores for these countries the importance of considering the pace, nature and structuring of reforms and to accompany these where appropriate with a strengthening of environmental policy instruments. In the scenarios considered here, implementation of the Kyoto Protocol would need to accompany the liberalisation of fossil fuel policies in some cases to ensure 'win-win' outcomes with respect to both the economy and the environment.

Table 5. Comparison of benefits from price reforms

Study	Regional and Sectoral Coverage	Fuel Coverage	Anticipated Carbon Reductions	Comments
Current Analysis	-Global -Industry and power sectors	-Coal, natural gas, crude oil, refined products -Data from 1996	1.9 – 6.2% of global emissions (through 2010)	-General equilibrium analysis (GREEN). -Country-specific price gap and producer subsidy data used wherever possible.
IEA 1999	-8 LDC/EITs -All energy sectors	Coal, natural gas, refined products, electricity	4.6 % of global emissions (5 years out)	-CO_2 Reductions within range of current global estimate even though included only 8 countries. -Static modelling using elasticity values; thus does not offset reductions in demand from subsidy removal with increased demand from changing terms of trade. - CO_2 may also be higher because it covers more sectors.
Anderson and McKibbin (1997)	OECD/LDCs	Coal only, using 1990 data.	5% of global emissions by 2005	-General equilibrium analysis (G-Cubed) -Subsidy phase-out assumed to trigger a rise in world price of coal and improved TOT for coal exporters -Portion of projected gains may already have occurred due to price reforms since 1990 data base year.
Light, 1999	Global	Coal only.	0.2% of global emissions; less if gas or oil are used as substitutes for coal.	-More detailed evaluation of role of coal trade using the World Coal Trade model. -Subsidy reforms will have little impact since domestic supply will be immediately and nearly totally replaced with imported coal. This can be done because coal markets have become much more homogenous.
Lee, Oliviera-Martins, van der Mensbrugghe, 1994	Global	All fossil fuels	18% of global emissions by 2010	-GREEN using model calibrated to 1985 data. Pre-dates price reforms in Eastern Europe, FSU and China.
DRI 1997	France, Germany, Spain, UK, Japan, Turkey	Coal	1% of emissions from coal sector in included countries by 2010	-Based on World Coal Trade model. -Low values because analysis assumes domestic coal use will be replaced by imported coal rather than by substitute fuels.
Shelby *et al.*	USA All sectors	All fossil fuels	0.7 – 4% of carbon emissions within the US by 2010	-General equilibrium modelling using the Jorgenson/Wilcoxin model and the Decision Focus model. -Subsidy values based primarily on 1989 and 1990 data; did not include all fossil subsidies.

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Source: OECD Secretariat

PART III. TAXATION: A POSTSCRIPT

65. As the first phase of 1998 JWP study clearly demonstrated, taxation on fossil fuels varies widely across fuels and across countries. Table 6 sets out tax rates for fossil fuels studied here, based on IEA data and supplemented by a new OECD environmental tax data base. Care is needed in interpreting these rates, as often the applicable tax rates may differ due to sectoral exemptions, refunds, tax ceilings, etc. Chart 3 shows the dispersion among OECD countries of end-use prices for the four fossil fuels with the amount of total tax included. Chart 4 shows the weighted average of OECD tax rates. Between lightly taxed coal and heavily taxed refined products there is a spread of some ten percentage points.

66. It is sometimes argued that energy taxes help offset the damaging effects of subsidies to these very same fuels. While taxes can offset to some extent the impact of subsidies on prices and consumption, it is recognised that they are a much less effective way to do so than reforming the subsidy policies directly. This is because taxes and subsidies do not act on the same part of the production chain and thus do not affect the same decisions. For example, taxes on electricity "would not offset the efficiency losses induced by an inefficient factor mix, such as a bias towards capital-intensive forms of energy production bolstered by a capital-cost subsidy."[15] In sum, careful consideration of variations in energy tax levels is needed to ensure that the tax policies are aligned with existing environmental and trade objectives.

67. A number of points can be drawn from the above sampling of data:

- **International variation.** Energy taxes vary widely *across countries*, contributing to fuel choices driven by fiscal policies more than energy economics. For example, refined oil is tax-free in some countries, while taxes account for more than half of its end-use price in others.

- **Interfuel and inter-sectoral variation.** Taxes vary widely *across fuels*, and even sometimes *across sectors using the same fuel* within the same country. On the basis of the tax data reported to the IEA, in only one OECD country is coal taxed more heavily than the other less polluting fossil fuels. Within the OECD, natural gas - the least carbon-intensive fossil fuel - is generally taxed at a lower rate than oil, though often at a higher rate than coal. Thus, the bias in fuel choice introduced by differential taxation actually works against less carbon-intensive fuels and hence CO_2 mitigation.

- **Poor proxy for environmental externalities.** As shown in Chart 4, the fuel highest in carbon (coal) is taxed at the lowest rate. While CO_2 emissions are not the only environmental impact one would want to internalise through externality-based charges, it is unlikely that taxes on coal would be the lowest of all fossil fuels under any reasonable assessment of total impacts.

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15 IEA, *Looking at Energy Subsidies: Getting the Prices Right*, p. 74.

– **Serious data gaps.** The number of countries for which there is no energy tax data is surprising. The implication of these data gaps are that the role of tax policy in influencing energy choice cannot be evaluated very well. Several countries with tax data include only information at the federal level.[16] However, state/provincial and local excise taxes are common (and large) for many fossil fuels.

68. Taxation *per se* is not generally considered a matter for trade negotiations; it remains the domain of national authorities, i.e. parliaments and governments. Nonetheless the impacts on trade are important as taxes affect input costs. Tax distortions can contribute to trade distortions, which in turn have environmental impacts. As noted in the recent 1998 OECD report on reducing subsidies and tax disincentives, “the behaviour of the recipient sector will not depend on subsidies or taxes *separately*, but on their *net effect.*”[17] This net effect can be environmentally damaging: the report notes that “tax exemptions on fuels and other supports to industrial consumers, in particular, will have a strong effect on the long-term fuel demand.”

69. The results from GREEN model simulations presented above were based on eliminating price distortions due to support to producers and consumers of fossil fuels; tax-related pricing distortions are not reflected in this analysis. Significant efforts regarding data collection and model development would be needed to integrate quantification of tax distortions with subsidy measurement in order to move on to assess their combined, net effects on the environment. Although undertaking this work might provide additional insights into the linkages between energy market liberalisation, international trade, and CO2 emissions, it was beyond the scope of this study.

16 Others, such as Australia, no longer submit price data for most fossil fuels to the IEA.

17 OECD (1998), *Improving the Environment Through Reducing Subsidies: Part 1: Summary and Policy Considerations*, p. 17.

Table 6. Total taxes as a share of end-use prices, 1996

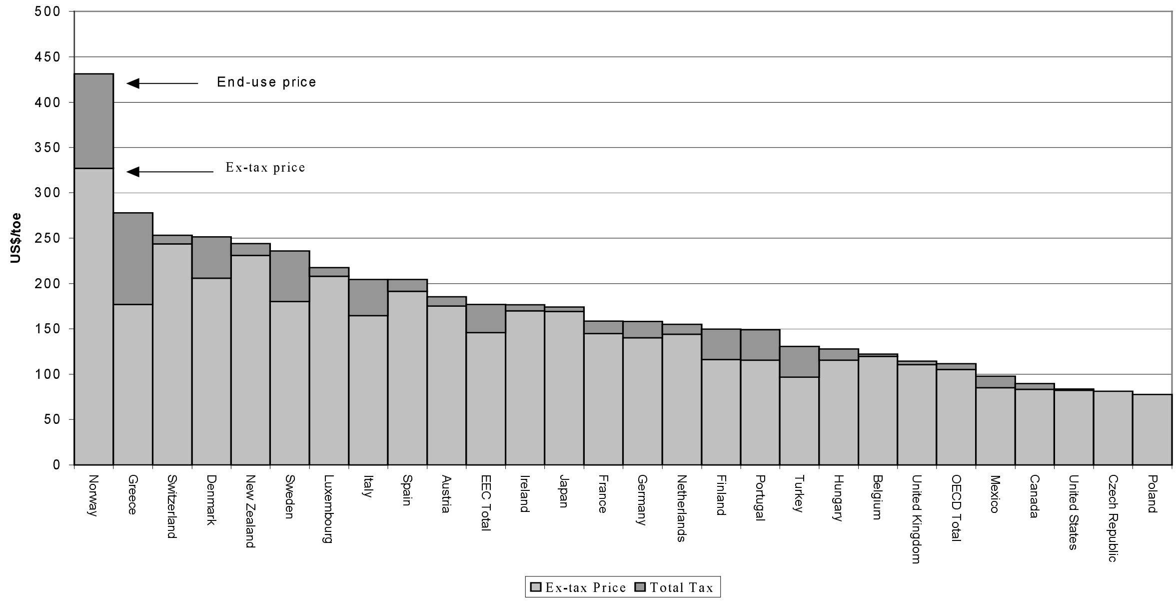
	Heavy Fuel Oil		Light Fuel Oil	Natual Gas		Steam Coal		Coking Coal
	Industry	Power	Industry	Industry	Power	Industry	Power	Industry
Australia	nd	nd	nd	nd	nd	0*	0*	0*
Austria	42.9	nd	19.1	0	0	0	nd	nd
Belgium	14.9	14.9	7.6	0	0	nd	0	0
Canada[1]	7	nd	7	7	7	nd	7	nd
Czech Republic	0	0	0	0	0	0	0	nd
Denmark	27	0*	12	nd	nd	25.4	0*	nd
Finland	21.4	21.4	15.7	8.6	8.6	32.6	0*	33
France	13.3	nd	32.2	0	nd	0	0	0
Germany	13.2	23.6	19	13.8	16.1	nd	0	0
Greece	25.4	25.4	56.7	nd	nd	nd	nd	nd
Hungary	0	0	54.8	0	0	0	0	nd
Ireland	7.7	13.2	20.2	0	0	nd	0	nd
Italy	30.4	nd	64.6	8.5	8.5	0	nd	0
Japan	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
Korea	nd	nd	nd	nd	nd	nd	nd	nd
Luxembourg	5.3	nd	2.7	nd	nd	nd	nd	nd
Mexico	13	13	13	13	13	nd	13	nd
Netherlands	20.6	nd	nd	7	7.3	nd	nd	nd
New Zealand	0	nd	0	6.2	nd	nd	nd	nd
Norway	32.2	nd	17.4	nd	nd	nd	nd	nd
Poland	0	0	0	0	nd	0	0	0
Portugal	19.7	0	58.6	nd	nd	nd	0	0
Spain	8.7	8.7	32.1	0	0	nd	nd	nd
Sweden	27.7	nd	15.8	nd	nd	nd	nd	nd
Switzerland	8.3	nd	7.8	1.2	nd	2.7	nd	nd
Turkey	41	41	nd	7.4	7.4	13	13	13
United Kingdom	18.7	22.1	17.3	0	0	0	0	nd
United States[2]	5	5	5	3	2	0	0	0

1. Canadian federal taxes only.
2. US rates based on US Department of Energy internal estimates.
* Tax data marked with an asterisk (Australia, Denmark and Finland) from OECD Environmental Tax Database, available at http//:www.oecd.org/env/policies/taxes/index.htm
"nd" refers to "no data"

Source: IEA, Energy Prices and Taxes, Q1 1999

Chart 3. Taxes on fossil fuel prices: end-use and ex-tax prices

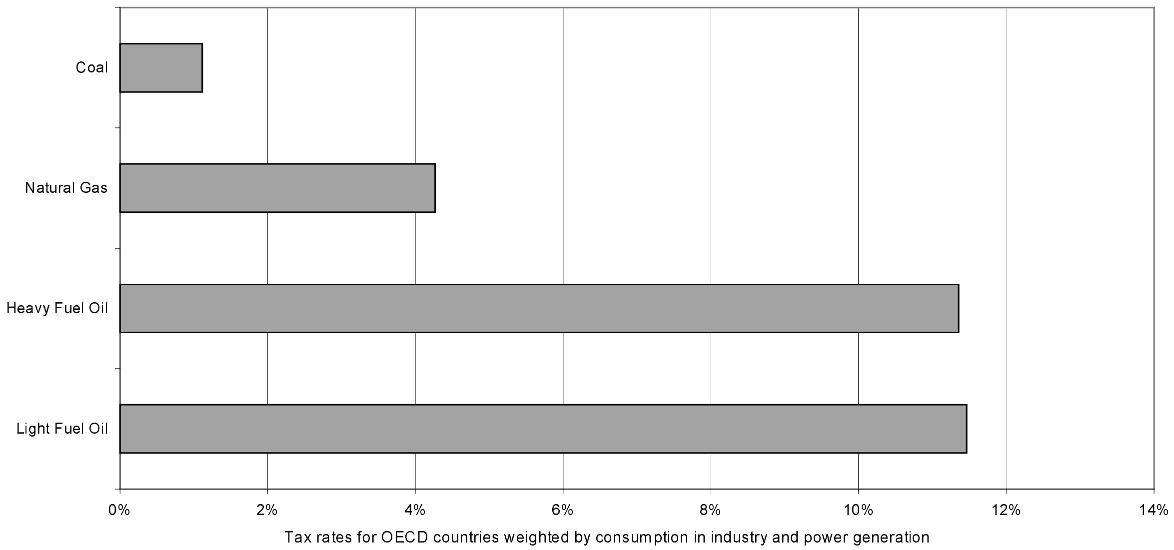
(weighted average of light fuel oil, heavy fuel oil, natural gas and coal)



Source: OECD Secretariat
Source: OECD Secretariat.

Chart 4. Average OECD tax rates for four fossil fuels studied

(percent of end-use price)



Source: OECD Secretariat

ANNEX

SENSITIVITY ANALYSES

70. Two sensitivity runs were conducted. The first reduced the supply elasticity of coal, making producers less responsive to the price changes associated with liberalisation and energy policy reforms. The second changed the interfuel elasticity of substitution , so that different fuels are assumed to be more easily substitutable. Table 7 summarises the overall impacts of these modifications. Each is described in more detail below.

Table 7. Sensitivity analyses on coal supply and interfuel substitution elasticities ("All countries liberalise" scenario)

	Base Case	Lower Supply Elasticity of Coal (1.0 instead of ∞, with downwards price)	Interfuel Substitution Elasticity (5.0 instead of 2.0)
CO_2 Emissions			
2005	-3.9%	-3.7%	-4.3%
2010	-6.2%	-5.5%	-6.1%
Welfare Effects			
2005	+0.1%	+0.1%	+0.1%
2010	+0.1%	+0.1%	+0.1%
Imports			
2005	+2.8%	+2.1%	+2.8%
2010	+4.4%	+3.6%	+4.4%
Exports			
2005	+2.8%	+2.1%	+2.8%
2010	+4.4%	+3.6%	+4.4%

Source: OECD Secretariat

Supply elasticity of coal

71. The fossil fuel undoubtedly receiving the greatest attention when undertaking projections on CO_2 emissions is coal, due to its having the highest carbon intensity. Due to the structure of the international coal market, changes in availability and use of coal is a function of the values of several parameters. Some of these are more important than others. On one of these - the value of the supply elasticity of coal - it was decided to carry out a sensitivity analysis.

72. In the central scenario, the supply elasticity of coal is posited as being very high when price movements are downwards. This is to say that coal is considered to be a quasi-homogenous good – that the international market is well integrated and one source can easily replace another. This is the current view in the literature and the view which has been developing in the IEA. However should the elasticity value be lower than that posited in GREEN, then following the elimination of the price distortions, production will drop less than otherwise expected, with a concomitant lesser reduction in CO_2 emissions. Despite the increasingly widely held view that coal is an homogenous good, it was decided to test the hypothesis that the high elasticity used in the model overstates the phase-out of coal.

73. To test the impact of this assumption on the model results, a sensitivity run was done using a lower downwards elasticity value (first 3.0 and then 1.0 instead of infinity). A reduction to an elasticity of 3.0 yielded practically no difference. The results in Table 7 indicate that a lower supply elasticity, at 1.0, yields somewhat smaller effects on carbon emissions and on trade. This is because more domestic sources continue to produce coal.

74. At the regional level, the changes are much more substantial, as can be seen in Table 8. Regional imports to the EEC are lower since suppliers are less likely to close down. Lower demand within EEC means lower exports for regions such as EEX, OOE, USA, and ROW. On a percentage basis, declines are smallest in the OOE (containing Australia). This may reflect Australia's position as a lower cost producer. Other regions, with higher prices and/or lower quality coal, are more likely to be cut out than is Australia. Not all coal exports decline, however. Because producers are less likely to shut down than under the baseline simulation, regions with relatively inefficient production (BRA, DAE, EEC, IND, and JPN) retain domestic production and some of the exports that disappeared under the baseline scenario.

Interfuel substitution sensitivity

75. As prices rise for one fuel during liberalisation, demand can be met not only with imports, but with alternative fuels as well. The GREEN-model has embedded assumptions - based on the prevailing consensus in the literature - that govern what fuel switching may occur, at what prices. This sensitivity run modified those assumptions by raising the interfuel substitution elasticity from 2.0 to 5.0, thus making it easier to shift from one fuel to another.

76. Table 7 shows that there are very small differences at the global level from modifying interfuel substitution. As with coal supply elasticities, however, examining the regional/national level data tells a different story. Table 9 provides additional details on shifts in regional trade flows under the new interfuel substitution assumptions.

77. The largest shifts in trade relative to the baseline come in the gas and coal markets. Coal import levels fall, sometimes substantially, in most regions of the world. This suggests reduced demand for coal as a greater number of consumers are able to switch to other fuels (primarily natural gas) under the new assumptions. However, these results are not universal. Coal imports rise substantially in EEX and ROW, perhaps because weakening demand for coal makes it more affordable than natural gas or oil for certain applications. Natural gas imports also decline under the new model specifications, though ROW gas also increases sharply.

78. On the export side, shipments of ROW oil, already high, nearly double again while gas exports from the region decline. This may reflect the increased use of harder-to-transport natural gas domestically, freeing up large quantities of oil for export. Coal exports from BRA, DAE, and IND all rise sharply.

Table 8. Impact of changing the coal elasticity of supply on coal trade ("All countries liberalise" scenario)

Percentage change from "business as usual" scenario

Region	Imports						Exports					
	Baseline		Lower Elasticity		Difference		Baseline		Lower Elasticity		Difference	
	2005	2010	2005	2010	2005	2010	2005	2010	2005	2010	2005	2010
ROW	9.1	16.9	11.5	21.7	2.5	4.8	30.7	24.3	12.2	1.0	-18.4	-23.3
BRA	-14.0	-22.5	-14.2	-22.4	-0.2	0.1	23.2	40.6	36.3	64.0	13.1	23.4
CHN	-10.8	-16.3	-16.1	-22.7	-5.4	-6.5	9.9	6.1	14.0	14.1	4.1	8.0
DAE	-17.9	-26.8	-18.4	-27.0	-0.5	-0.2	32.1	43.0	38.0	56.3	5.9	13.3
EEC	87.7	78.5	57.9	47.7	-29.8	-30.8	-84.1	-85.2	-71.7	-69.9	12.3	15.3
EET	-13.6	-22.8	-14.9	-25.0	-1.3	-2.2	16.1	6.7	12.1	5.3	-4.0	-1.5
EEX	15.3	29.2	16.6	29.3	1.3	0.2	28.1	17.7	8.2	-2.8	-19.9	-20.5
FSU	-20.4	-29.7	-21.6	-29.9	-1.2	-0.1	43.7	46.5	45.4	53.7	1.7	7.2
IND	-12.7	-18.0	-15.6	-21.2	-2.9	-3.2	20.8	32.6	30.1	47.7	9.3	15.1
JPN	5.8	9.6	5.2	9.1	-0.7	-0.5	-34.3	-43.1	-13.0	-17.9	21.3	25.2
OOE	1.4	3.7	1.8	4.5	0.4	0.8	11.6	9.2	5.3	2.0	-6.3	-7.2
USA	35.5	64.2	38.7	69.9	3.2	5.7	36.4	31.3	21.9	15.1	-14.5	-16.2

Abbreviations: EEC (European Union 15); JPN (Japan), OOE (Other OECD),USA (United States); BRA (Brazil), CHN (China),
Source: OECD GREEN model
DAE (Dynamic Asian Countries), EET (Eastern Europe), EEX (Oil Exporting Countries), FSU (Former Soviet Union), IND (India), ROW (Rest of World).
Source: OECD GREEN model

Table 9. Impact of a higher interfuel substitution on fossil fuel trade

percentage change from "business as usual" scenario

Imports				Exports			
Region	**Baseline Scenario**	**Higher Interfuel Substitution**	**Difference**	**Region**	**Baseline Scenario**	**Higher Interfuel Substitution**	**Difference**
	2010	2010			2010	2010	
All Regions	4.4	4.4	0	**All Regions**	4.4	4.4	0
Regions With Large Impacts				**Regions With Large Impacts**			
ROW Coal	16.9	97.1	80.2	ROW Coal	24.3	-8.50	-32.8
ROW Gas	27.0	173.5	146.5	ROW Gas	-24.8	-59.00	-34.2
				ROW Oil	351.8	615.70	263.9
BRA Coal	-22.5	-47.6	-25.1	BRA Coal	40.6	162.00	121.4
BRA Oil	49.7	66.9	17.2				
BRA Gas	-15.3	-31.8	-16.5				
CHN Coal	-16.3	-31.2	-14.9				
CHN Gas	-38.7	-62.3	-23.6				
DAE Coal	-26.8	-46.8	-20	DAE Coal	43	132.20	89.2
DAE Gas	37.8	24.4	-13.4	DAE Gas	-50.9	-2.60	48.3
EEC Coal	78.5	40.1	-38.4				
EET Coal	-1.4	-33.9	-32.5				
EET Gas	-0.9	-45.8	-44.9				
EEX Coal	29.2	173.6	144.4	EEX Coal	17.7	-13.50	-31.2
EEX Gas	-47.9	-20.1	27.8				
EEX RefOil	-10.8	-22.6	-11.8				
FSU Coal	-29.7	-42.7	-13.0				
				IND Coal	32.6	136.5	103.9
IND Gas	-15.4	-47.4	-32.O				
				JPN Gas	-9.1	-18.6	-9.5
OOE Coal	3.7	15.0	11.3	OOE Coal	9.2	4.1	-5.1
OOE Gas	-3.3	-10.5	-7.2				
				OOE Oil	81.9	187.7	105.8
				USA Coal	31.3	23	-8.3
				USA Gas	-41.4	2.3	43.7
				USA RefOil	-0.9	-5.5	-4.6

Abbreviations: EEC (European Union 15); JPN (Japan), OOE (Other OECD), USA (United States); BRA (Brazil), CHN (China), DAE (Dynamic Asian Countries), EET (Eastern Europe), EEX (Oil Exporting Countries), FSU (Former Soviet Union), IND (India), ROW (Rest of World).
Source: OECD GREEN model.