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**INDICATORS FOR THE INTEGRATION OF ENVIRONMENTAL CONCERNS
INTO ENERGY POLICIES**

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

Paris 1993

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The 1991 Recommendation of the OECD Council on Environmental Indicators and Information, includes a call for further development of a set of "reliable, readable, measurable and policy-relevant environmental indicators in order to contribute to [...] better integrating environmental concerns in sectoral policies such as agriculture, forestry, industry, aid, energy, transport, trade and urban policies...".

The OECD Group on the State of the Environment, in response to this mandate, has devoted part of its work programme to the development of indicators for the integration of environmental concern into sectoral policies. The present document deals with energy-environment indicators. It discusses the policy context, presents the conceptual approach and draws up indicators around three major themes: i) sectoral trends of environmental significance, ii) environmental impacts of the sector activity, and iii) economic linkages between energy and environment. Indicators for which internationally comparable, comprehensive and readily available data exist, are presented in tabular and graphical form with accompanying notes on policy relevance, the conceptual base and data sources.

La Recommandation du Conseil de l'OCDE de 1991, sur les indicateurs et les informations concernant l'environnement inclut une demande de poursuivre l'élaboration d'un ensemble "d'indicateurs d'environnement qui soient fiables, lisibles, mesurables et pertinents pour les politiques d'environnement afin de contribuer à [...] mieux intégrer les questions d'environnement dans les politiques sectorielles telles que les politiques agricoles, forestières ou industrielles et les politiques d'aide au développement, de l'énergie, des transports, des échanges et les politiques urbaines...".

Suite à cette demande, le groupe de l'OCDE sur l'état de l'environnement a consacré une part de son programme de travail au développement d'indicateurs pour l'intégration des préoccupations environnementales dans les politiques sectorielles. Le présent document concerne les indicateurs énergie-environnement. Il discute le contexte politique, présente le cadre conceptuel et développe des indicateurs autour de trois thèmes principaux : i) les tendances sectorielles importantes pour l'environnement, ii) les conséquences de l'activité sectorielle pour l'environnement, iii) les liens économiques entre le secteur de l'énergie et l'environnement. Les indicateurs pour lesquels la comparabilité internationale et la disponibilité des données sont assurées sont présentées sous forme de tableaux et de graphiques. Ils sont accompagnées de notes sur leur pertinence politique, la base conceptuelle ainsi que les sources des données.

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Introduction

In 1989, the OECD Council meeting at Ministerial level called, *inter alia*, for a next generation work programme on environmental economics that would integrate environment and economic decision-making more systematically and effectively. This was reiterated during several G-7 Economic Summits, as well as by the meeting of the OECD Environment Committee at Ministerial level in 1991.

More specifically, a 1991 Recommendation of the OECD Council on Environmental Indicators and Information made explicit reference to the development of three types of indicators. The work programme of the OECD Group on the State of the Environment reflects this recommendation and aims at the development of these three types of indicators:

- indicators measuring environmental performance;
- sectoral indicators for the integration of environmental concerns in sectoral policies such as energy, agriculture, transport and forestry;
- indicators for the integration of environmental concerns into economic policies have generally, e.g. through environmental accounting.

Concerning sectoral indicators, an OECD workshop held in April 1990 developed an initial list of indicators. This set of indicators was discussed and approved by the Group on the State of the Environment. Other consultations included the International Energy Agency. In the present report indicators are calculated and analysed according to the criteria identified in earlier reports to the Group on the State of the Environment, i.e. policy relevance, analytical soundness and considerations of measurability and implementation.

This document consists of five parts. Part 1 briefly discusses the context of environmental concerns in energy policies. Part 2 describes the conceptual approach of sectoral indicator development, and Part 3 assesses the proposed indicators with respect to the criteria of policy relevance, analytical soundness and measurability. Part 4 presents the actual indicators relating to the integration of environmental concerns into energy policies.

1. Policy Context

Energy is a major component of OECD economies, both as an industrial sector in itself and as an essential factor input to most other economic activities. Through its effects on the environment, energy is one of the key variables of sustainable economic development. Fuel combustion is the main source of air pollution and other energy activities, including energy production, transformation and distribution, have major water pollution, land use and other environmental effects. Overall, the energy/environment relationship is continuously evolving.

One of the conclusions of the OECD 1991 State of the Environment Report was that the environmental impacts of the energy sector will depend greatly on the future capacity of governments to better integrate environmental concerns into the development and implementation of energy policies at the earliest possible stage.

This concern was given particular importance at the June 1991 meeting at Ministerial level of the Governing Board of the International Energy Agency (IEA) of the OECD (see Annex 1). In the following years, Ministers reaffirmed their strong commitment to develop integrated policies which further the objectives of energy security, environmental protection and economic growth and to address energy-related environmental problems nationally and internationally. They underscored the need to find the most-cost effective means for doing so, and to develop policies that harmonise approaches relating to the full range of environmental concerns.

2. Conceptual Approach

As outlined, the OECD environmental indicators programme is focused principally on sets of indicators to facilitate the integration of economic and environmental decision-making at national, international and global levels and to provide a tool for environmental performance evaluation. Indicators to assess projects or specific programmes as well as indicators at the local or sub-national level are less relevant here. The OECD indicators programme recognises that there is no universal set of indicators but rather several sets which respond to specific conceptual frameworks and purposes.

Energy-environment indicators were identified at the workshop of April 1990 and these are recalled in Table 1. These sets of indicators are structured around three themes:

- sectoral trends of environmental significance;
- environmental impacts of the energy sector (with respect to pollution and natural resource use);
- economic linkages between energy and the environment.

This preliminary set of indicators aims at contributing towards integration of environmental concerns in energy decision-making. Sets of sectoral indicators are also being developed by OECD for the integration of environmental concerns into transport, agricultural and forestry policies. As in the case of energy, they are preliminary and follow the same three-part structure indicated below.

Table 1
Indicators for the Integration of Environmental Concerns into Energy Policies

Sectoral Trends of Environmental Significance	
1. Overall Energy Use • Total primary energy supply • Total final consumption by fuel type • Total fuel consumption by sector	4. Energy Intensity • Total primary energy supply per unit of GDP • Sectoral end uses: - residential -- TOE per capita - commercial and public sector -- TOE per square metre - industry -- TOE per unit of value added - transport -- TOE per road vehicle x km • Fossil fuel efficiency for electricity generation
2. Energy Use by Fuel Type • Percent of total primary energy requirement by fuel type • Percent of electricity generation by fuel type	
3. Indigenous Energy Production • Primary energy produced nationally as percent of total • Primary energy supply	
Environmental Impact	
1. Proven oil/coal/gas reserves in tonnes of oil equivalent	4. Waste • Volume of solid waste from energy production • Volume of radioactive waste (spent fuel)
2. Air Pollution • Annual volume of air pollution emissions (SO_x, NO_x, CO₂, CO, VOC, methane) • Ratio of emissions per unit of GDP • Ratio of emissions by end uses	5. Land Use • Hectares of land taken up by energy production, transport, and transformation (reservoirs, pipelines, open-cast mines, harbours, etc.)
3. Water Pollution • Tonnes of oil released - through accidents - on a continuous basis (refineries, platforms, tankers)	6. Safety • Numbers killed and injured
Economic Considerations	
A. <u>Environmental Pollution Damages</u> Environmental pollution damage relating to energy production and consumption, for certain types of pollutants (e.g. SO _x)	2. Taxation and Subsidies • Direct subsidies by fuel type - calculate ratio by TOE - calculate as a percentage of sectoral activity - distinguish subsidies for environmental purposes • Total economic subsidies: direct and indirect subsidies plus externalities • Relative taxation in per cent by different fuel types
B. <u>Energy Policy Responses</u>	
1. Environmental Expenditure • Total expenditure on pollution prevention and clean-up - abatement vs. clean technology - public vs. private • 'Environmentally-related' R&D expenditures: public vs. private	C. • <u>Real energy prices per fuel type</u>

Source: Table extracted from *Summary of the OECD Workshop on Indicators for the Integration of Environmental Concerns in Sectoral Policies*, Paris, 1990.

3. Indicator Development

In the present report, indicators are reviewed according to the following criteria:

- relevance for energy and environmental policies;
- analytical soundness;
- measurability, taking into account availability of data, quality of data, and international comparability.

It is assumed that the first criterion includes concern about the readability of indicators.

Table 2 constitutes a summary view of this work for all indicators identified previously. For each criterion, indicators are evaluated as satisfactory (designated 1) or requiring development work (designated 2). Finally, such evaluations are used to derive an overall assessment of each indicator of the extent of further work required as follows:

- A -- indicators immediately accessible and requiring mainly work on data quality and presentation;
- B -- indicators accessible in the short term (about one year) and requiring modifications of existing definitions and/or statistical procedures;
- C -- indicators to be developed over the medium term and requiring more fundamental development work with respect to concept and definition.

Shaded lines designate indicators which have been evaluated and which are presented in part 4 of the document.

Table 2
Energy: Preliminary evaluation of environmental indicators

Indicator	Policy Relevance	Conceptual Base	Statistical Base		Summary and Notes on Future Work	
			Data Availability	Data Quality/ Comparability		
1. Sectoral Trends of Environmental Significance						
Total primary energy supply (TPES)	1	1	1	1	A	
Energy intensity (TPES per unit of GDP)	1	1	1	1	A	
Total final consumption by fuel type	1	1	1	1	A	
Total final consumption by sector	1	1	1	1	A	
Per cent of total primary energy supply by fuel type	1	1	1	1	A	
Per cent of electricity generation by fuel type	1	1	1	1	A	
Primary energy produced nationally as per cent of total primary energy supply	1	1	1	1	A	
Sectoral end uses: industry (Toe per unit of value added)	1	1	2	2	B	(d)
Sectoral end uses: residential (Toe per capita)	1	1	2	2	B	(b,d)
Sectoral end uses: commercial and public sector (Toe per sq. metre)	1	2	2	2	B	(a,b,e)
Sectoral end uses: transport	1	1	1	1A	A	
Fossil fuel efficiency for electricity generation	1	1	1	1	A	
2. Environmental Impact						
Proven coal/oil/gas reserves in Toe	1	2	2	2	B	(c)
Annual volume of air pollutant emissions	1	1	2	2	B	(a,b)
Ratio of emissions per unit of GDP and per capita	1	1	2	2	B	(a,b)
Ratio of emissions by end uses	1	1	2	2	B	(a,b)
Tonnes of oil released	1	2	2	2	C	(a,b,e)
-- through accidents						
-- on a continuous basis						
Volume of solid waste from energy production	2	1	1	2	B	(a,b,c)
Volume of solid waste per unit of GDP	2	1	1	2	B	(a,b,c)
Volume of radioactive waste (spent fuel)	1	1	1	1	A	
Radioactive wastes per unit of GDP and per capita	1	1	1	1	A	
Land taken up by energy production, transport and transformation	2	1	2	2	C	(a,b,e)
Numbers killed and injured	1	2	2	2	B	(b)
3. Economic Considerations						
Environmental pollution damages relating to energy production and consumption	1	2	2	-	C	(e,f)

Total expenditures on pollution prevention and clean-up	1	2	2	2	C (a,e,f)
"Environmentally related" R&D expenditures in the energy sector	1	2	2	2	C (e,f)
R&D expenditures on energy	2	2	2	2	C (e,f)
Real energy end-use prices by fuel type	1	1	1	1	A (d)
Total subsidies	..	..	..	-	C (e,f)
Relative taxation in per cent by different fuel types	1	1	2	1	B (a,b)

Criteria: 1 - Satisfactory
2 - Needs development work

Summary: A - Immediately accessible
B - Short-term accessibility
C - Medium-term development

Future work: a) Improve country coverage
b) Extend time series
c) Standardise definitions
d) Technical data adjustment, e.g. disaggregation/aggregation exchange rate conversions
e) Develop appropriate definitions
f) Improve conceptual basis

4. Selected Indicators: Energy

4.1. Total Energy Use

Relevance to energy and environmental policies

The environmental impact of energy activities varies with levels of total energy use, and with the composition of energy use by energy source (fossil fuels, nuclear, hydro, etc), although the use of clean technologies may reduce these impacts. Pollutants such as CO₂ and SO₂ vary directly with the amount of energy consumed, while emissions of NO_x, CO and VOC are also technology dependant. As a result, the overall improvement in pollution levels from reduced energy consumption is not necessarily directly proportional to the reduction in energy use. Also, some measures to reduce fuel consumption have increased pollution problems (e.g. insulation of buildings impairing in-door air quality). As with most indicators, however, exceptions can be found and the question is one of establishing broad rules of thumb. Other things being equal (mix of energy sources, technology, etc.), reduced total energy use can generally be expected to alleviate environmental pressures at all stages of the fuel cycle (production, transport and use).

Definition - Conceptual base

Total primary energy supply (TPES) is designed to measure total energy use. TPES is defined as indigenous primary energy production plus imports, minus exports and international marine bunkers, and plus/minus stock changes of primary energy. Primary energy forms include hard coal, lignite and other solid fuels, crude oil and natural gas liquids, natural gas, nuclear and hydro-electricity, geothermal and solar energy.

Presentation: TPES values, 1970, 1975, 1980, 1985, 1991
Percentage change in TPES, 1970-1980, 1980-1991

Statistical basis

Source: IEA Energy Balances of OECD Countries, 1990-1991

Table 4.1. Total Energy Use

		Total primary energy supply (Mtoe)					Change (%)	
		1970	1975	1980	1985	1990	1991	1970-198 1980-199
Canada		132.1	161.1	192.1	193.3	210.7	211.8	45.4 10.3
USA		1 545.9	1 646.7	1 801.0	1 771.9	1 919.9	1 933.2	16.5 7.3
Japan		256.4	307.4	345.6	359.6	428.3	438.4	34.8 26.9
Australia		51.3	61.0	70.4	73.9	88.1	90.5	37.1 28.6
New Zealand		7.0	8.5	8.9	11.2	14.0	14.3	26.6 60.4
Austria		18.3	20.4	23.5	23.2	25.4	27.0	27.9 15.3
Belgium		40.3	42.6	46.1	44.0	48.3	50.6	14.5 9.7
Denmark		20.2	18.0	19.5	19.6	18.3	20.1	-3.4 3.1
Finland		18.1	20.0	25.0	26.2	28.5	28.9	38.4 15.5
France		147.3	162.2	190.7	200.7	221.2	232.3	29.5 21.8
Germany	a)	304.6	316.1	359.2	359.8	355.1	347.4	17.9 -3.3
w.Germany		234.4	239.1	272.9	270.0	278.2	..	16.4 ..
e.Germany	a,b	75.4	82.2	89.9	97.3	88.8	..	19.1 ..
Greece		8.1	12.2	16.0	18.6	22.1	22.4	97.4 40.2
Iceland	c)	0.7	0.8	0.9	1.1	1.4	1.3	42.4 39.4
Ireland		6.3	6.9	8.5	8.9	10.6	10.5	35.5 23.9
Italy		110.7	124.4	139.2	136.6	154.7	158.9	25.7 14.1
Luxembourg		4.2	3.8	3.6	3.2	3.6	3.8	-12.3 4.7
Netherlands		49.9	59.9	65.5	61.6	66.4	70.0	31.4 6.7
Norway		13.9	15.2	18.9	20.4	21.5	21.7	35.9 15.2
Portugal		6.0	8.0	10.3	11.4	16.4	16.6	71.8 61.2
Spain		38.4	58.5	68.7	71.9	88.0	91.9	79.0 33.8
Sweden		38.0	39.5	41.0	47.6	47.8	49.4	8.0 20.4
Switzerland		16.5	18.0	21.0	23.1	25.0	25.2	27.4 20.2
Turkey		12.2	26.8	31.8	39.0	53.1	54.0	159.9 69.9
UK		207.7	201.9	201.2	203.0	211.8	218.1	-3.1 8.4
ČSFR	b)	57.5	63.6	73.3	75.7	69.6	63.5	27.7 -13.4
Hungary	b)	19.4	23.4	28.3	30.4	28.6	26.5	45.8 -6.6
Poland	b)	81.8	99.5	124.5	126.5	98.0	96.5	52.2 -22.5
North America		1 677.9	1 807.8	1 993.1	1 965.1	2 130.5	2 145.1	18.8 7.6
Australia - New		58.4	69.5	79.3	85.1	102.1	104.8	35.8 32.2
OECD - Europe	d)	990.9	1 078.0	1 204.2	1 230.1	1 342.1	1 449.9	21.5 20.4
European Community	d)	873.3	937.3	1 042.2	1 049.5	1 139.5	1 242.4	19.3 19.2
OECD	d)	2 983.6	3 262.7	3 622.1	3 639.9	4 002.9	4 138.2	21.4 14.2

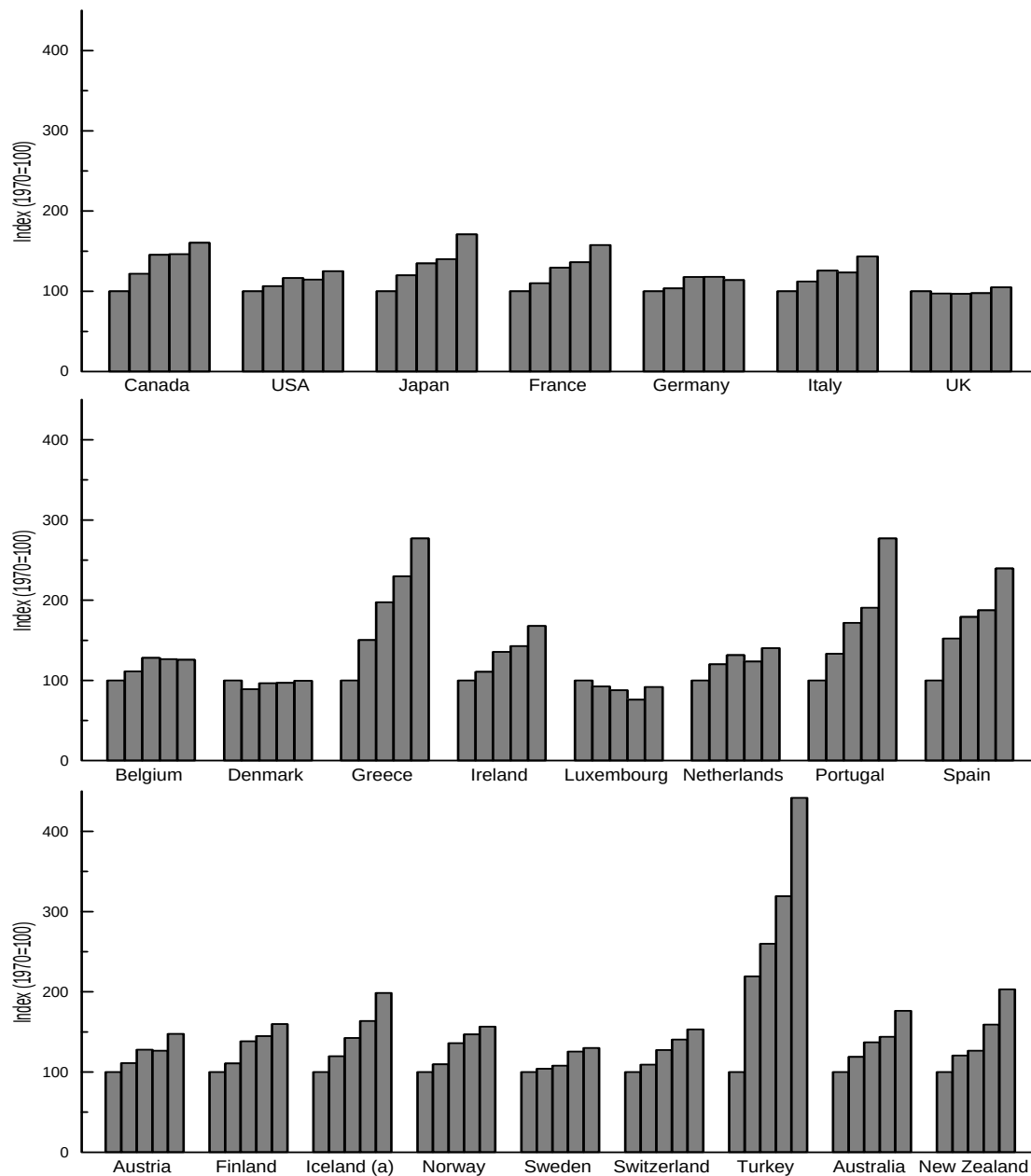
Notes:

- a) The sum of the two parts of Germany does not add up to the total because of differences in methodologies. Data for the eastern and the western part of Germany will be discontinued.
- b) 1970 data refer to 1971.
- c) Data do not include geothermal water directly used for heating and other purposes (i.e. 0.67 Mtoe in 1990).
- d) Includes western Germany only, except for 1991 which includes total Germany.

Source: IEA-OECD

Figure 4.1. **Total Energy Use (1970=100)**

Trend: 1970, 1975, 1980, 1985, 1991



Note:

a) Data do not include geothermal water directly used for heating and other purposes (i.e. 0.67 Mtoe in 1990).

Source: IEA-OECD

4.2. Structural Changes: Energy Intensity

Relevance to energy and environmental policies

Reducing the energy intensity of an economy -- for instance through cost-effective energy conservation -- is a major dimension of environmentally sound energy policies. The IEA estimates that without the twenty-five percent decline in energy intensity since 1973, CO₂ emissions in IEA countries would be nineteen percentage points higher.

In the interpretation of energy intensity ratios, however, there is the need to take into account differences in economic structures, to examine whether trends are sustained over a long time period, and to assess energy intensity ratios along with other indicators (see Total Energy Use, section 4.1). Three principal factors make it necessary to undertake this type of broader analysis. First, shifts in the production mix towards less energy intensive industries could also reduce the ratio of TPES to GDP. Second, growth in GDP could imply increased levels of energy use and pollution even if the ratio of TPES to GDP were to decline. Third, and finally, resources-based economies could be expected to have higher ratios of TPES to GDP than service-oriented economies.

Definition - Conceptual base

The main energy intensity indicator is the ratio of TPES to gross domestic product (GDP), with TPES per capita also providing a useful measure of the intensity of energy use. GDP is a measure of the flow of goods and services produced by the economy over a particular time period, normally a year. It is obtained by valuing goods and services at market prices and aggregating. GDP is expressed here in volume terms at 1985 prices. It should be noted that international comparisons of energy intensities require that the denominator, GDP, be converted into a common currency. The U.S. dollar is generally used for such international comparisons. Wide fluctuations in exchange rates, however, pose the difficulty that international comparisons based on exchange rates may not reflect the actual purchasing power of different currencies. Conversion should then be conducted in terms of purchasing power parities, which assumes that exchange rates move in line with longer term price differentials among countries.

Presentation: Energy intensity values, 1970, 1975, 1980, 1991
Percentage change in energy intensity, 1970-1980, 1980-1991
Energy supply per capita, 1991

Statistical basis

Source: IEA Energy Balances of OECD Countries, 1990-1991
OECD Environmental Data, Compendium 1993

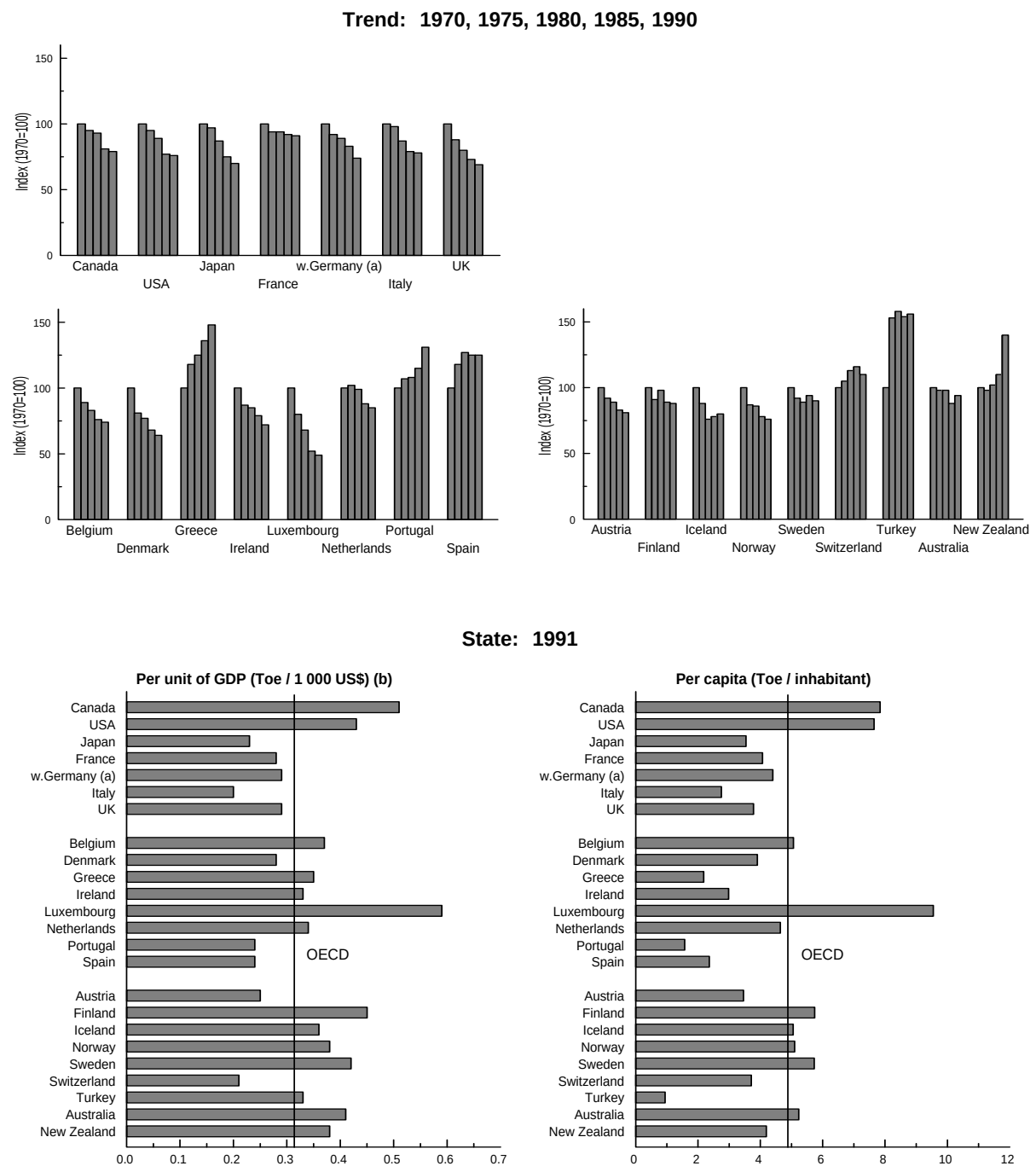
Table 4.2. **Energy Intensity**

	Primary energy supply per unit of GDP (Toe / 1 000 US\$) (a)						Change (%)		Toe/capita
	1970	1975	1980	1985	1990	1991	1970-1980	1980-1991	1991
Canada	0.65	0.61	0.60	0.52	0.50	0.51	-6.9	-15.2	7.84
USA	0.57	0.54	0.51	0.44	0.42	0.43	-11.3	-14.9	7.65
Japan	0.33	0.32	0.29	0.25	0.24	0.23	-13.3	-19.1	3.54
Australia	0.43	0.42	0.42	0.38	0.39	0.41	-1.6	-4.3	5.23
New Zealand	0.27	0.26	0.28	0.30	0.37	0.38	2.4	36.9	4.19
Austria	0.30	0.28	0.27	0.25	0.24	0.25	-10.5	-9.7	3.46
Belgium	0.50	0.44	0.41	0.38	0.36	0.37	-16.8	-11.3	5.06
Denmark	0.44	0.35	0.34	0.30	0.26	0.28	-22.6	-17.2	3.90
Finland	0.51	0.46	0.50	0.45	0.41	0.45	-2.3	-9.5	5.74
France	0.31	0.29	0.29	0.28	0.27	0.28	-5.9	-3.5	4.07
Germany	..	..	..	..	..	..	..	..	4.35
w.Germany	0.39	0.36	0.35	0.33	0.29	..	-10.9	..	..
e.Germany	..	..	..	..	..	..	..	..	..
Greece	0.24	0.28	0.30	0.32	0.35	0.35	24.6	18.6	2.18
Iceland	0.46	0.40	0.35	0.35	0.40	0.36	-24.3	5.3	5.05
Ireland	0.45	0.40	0.39	0.36	0.34	0.33	-14.7	-15.7	2.98
Italy	0.26	0.25	0.23	0.21	0.20	0.20	-13.2	-9.7	2.75
Luxembourg	1.21	0.97	0.82	0.63	0.57	0.59	-32.1	-28.5	9.55
Netherlands	0.40	0.41	0.40	0.36	0.33	0.34	-1.4	-13.5	4.64
Norway	0.50	0.43	0.42	0.39	0.38	0.38	-14.5	-11.4	5.10
Portugal	0.18	0.20	0.20	0.21	0.24	0.24	8.1	20.8	1.57
Spain	0.19	0.22	0.24	0.23	0.23	0.24	27.4	-1.9	2.36
Sweden	0.46	0.43	0.41	0.44	0.40	0.42	-11.0	1.1	5.73
Switzerland	0.19	0.20	0.22	0.22	0.21	0.21	12.5	-2.1	3.71
Turkey	0.21	0.33	0.34	0.33	0.34	0.33	58.0	-1.1	0.94
UK	0.43	0.38	0.34	0.31	0.28	0.29	-20.0	-14.1	3.78
ČSFR	..	..	..	..	..	..	..	..	4.05
Hungary	..	..	..	..	..	..	..	..	2.56
Poland	..	..	..	..	..	..	..	..	2.52
North America	0.57	0.55	0.51	0.45	0.43	0.44	-10.7	-14.9	7.67
Australia - New Zealand	0.40	0.39	0.40	0.37	0.39	0.40	-0.5	0.4	5.06
OECD - Europe b)	0.34	0.32	0.31	0.29	0.27	0.22	-9.7	-28.6	2.62
European b)	0.35	0.32	0.31	0.29	0.27	0.21	-11.2	-32.6	2.71
OECD b)	0.44	0.42	0.40	0.35	0.33	0.32	-11.0	-20.3	4.49

Notes :

- a) Primary energy supply per unit GDP and per capita. GDP is expressed in thousands of US\$, at 1985 prices and purchasing power parities.
- b) Includes western Germany only.

Source: IEA-OECD

Figure 4.2. **Energy Intensity** (1970=100)

Notes:

- a) 1991 data refer to 1990.
 b) Primary energy supply per unit GDP and per capita. GDP is in 1985 prices and purchasing power parities.

Source: IEA-OECD

4.3. Structural Changes: Energy Supply by Fuel Type

Relevance to energy and environmental policies

Structural changes in the energy supply mix have a major effect on environmental performance because environmental effects differ greatly from one source of energy to another, and include the following:

- traditional local or regional atmospheric pollution related to the combustion of fossil fuels (e.g., urban smog, acid rain);
- global climate change related to the emission of greenhouse gases such as CO₂ and CH₄ generated by fossil fuel production, transport and use;
- land use for a range of energy activities, and notably for mining and for hydroelectric reservoirs;
- risks relating to the various stages of the nuclear fuel cycle, including those connected with the disposal of high level radioactive wastes;
- risks relating to the extraction, transport and use of fossil fuels (e.g., fires, explosions, spills, etc.)

The IEA estimates that changes in the fuel pattern since 1973 have caused the share of carbon fuels to fall nearly seven per cent and that without these changes CO₂ emissions would be three percentage points higher.

Definition - Conceptual base

A disaggregation by fuel source according to: (a) solid fuels (b) oil (c) gas (d) nuclear power and (e) hydro, geothermal and solar energy would be added to the TPES, as it is defined in section 4.1.1.

Presentation: Fuel demand as a percentage of primary energy supply, 1991

Statistical basis

Source: IEA Energy Balances of OECD Countries, 1990-1991

Table 4.3. Energy Supply by Fuel Type

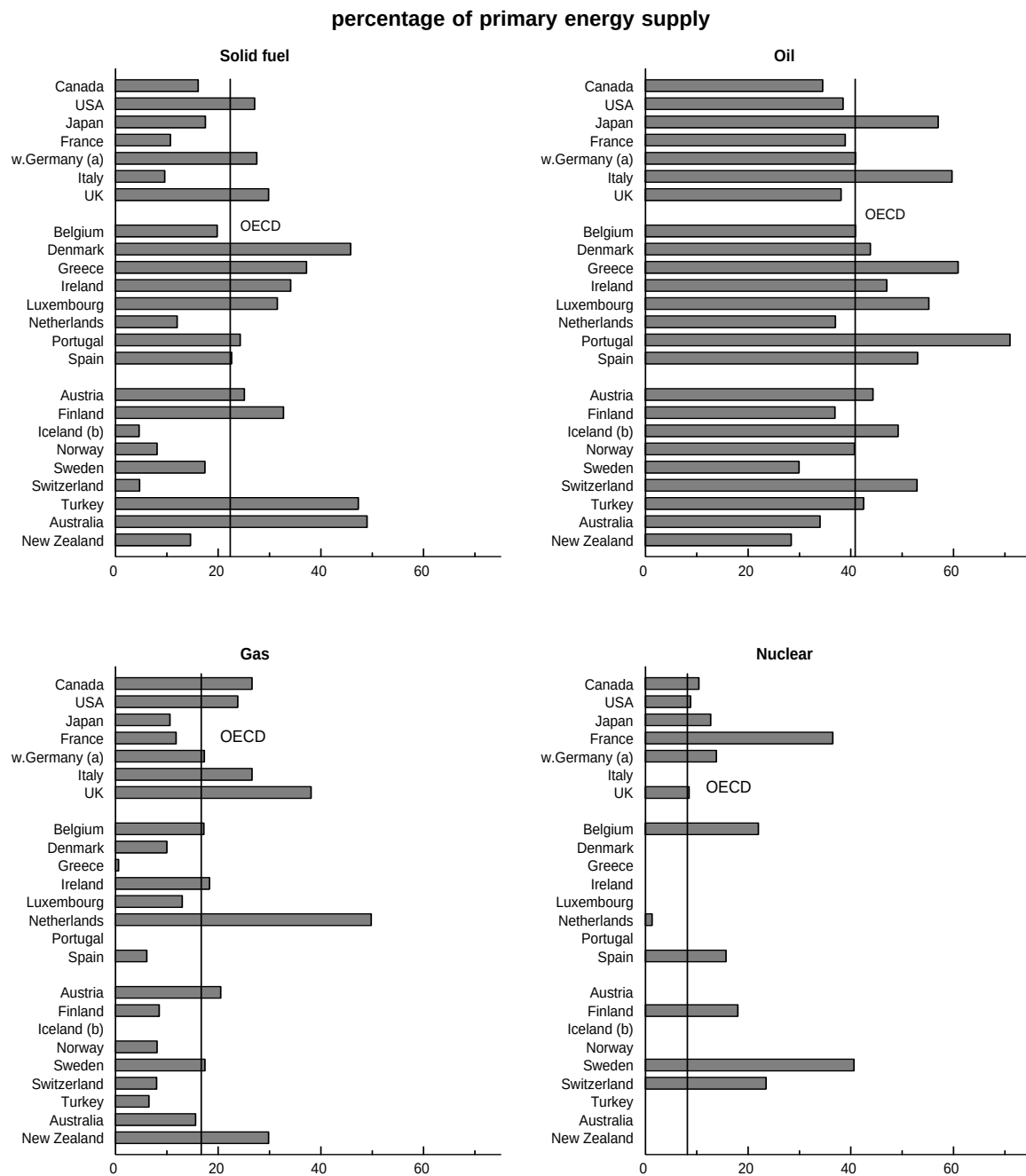
		percentage of total primary energy supply														
		Solid fuel			Oil			Gas			Nuclear			Other (a)		
		1970	1980	1990	1970	1980	1990	1970	1980	1990	1970	1980	1990	1970	1980	1990
		0	0	1	0	0	1				0	0	1	0	0	1991
Canada		12.	15.	16.	54.	45.	34.	22.1	22.2	26.6	0.2	5.1	10.	10.	11.	12.4
USA		21.	24.	27.	44.	44.	38.	32.3	26.5	23.8	0.4	3.9	8.8	1.4	1.6	1.9
Japan		24.	17.	17.	71.	67.	57.	1.2	6.2	10.6	0.5	6.2	12.	2.5	2.4	2.3
Australia		48.	44.	49.	47.	43.	34.	2.3	10.6	15.6	–	–	–	1.5	1.6	1.5
New Zealand		17.	14.	14.	52.	45.	28.	1.3	10.2	29.8	–	–	–	29.	29.	27.2
Austria		28.	20.	25.	49.	51.	44.	13.2	17.6	20.5	–	–	–	9.5	10.	10.1
Belgium		30.	22.	19.	60.	51.	40.	8.5	19.2	17.2	–	7.1	22.	–	–	–
Denmark		11.	31.	45.	88.	68.	43.	–	–	10.0	–	–	–	–	–	0.3
Finland		36.	33.	32.	59.	52.	36.	–	3.2	8.5	–	7.4	18.	4.4	3.5	4.0
France		26.	18.	10.	63.	58.	38.	5.6	11.4	11.8	1.0	8.4	36.	3.3	3.1	2.1
Germany	b)	49.	40.	33.	45.	41.	38.	4.0	14.3	16.6	0.6	4.0	11.	0.5	0.5	0.4
w.Germany	c)	38.	31.	27.	54.	48.	40.	5.0	16.1	17.3	0.7	4.2	13.	0.6	0.6	0.5
e.Germany	b,c,d)	83.	71.	74.	14.	17.	16.	1.2	7.8	7.6	0.1	3.4	1.6	0.1	0.2	0.1
Greece		22.	23.	37.	75.	74.	60.	–	–	0.6	–	–	–	2.8	1.8	1.2
Iceland	e)	–	2.1	4.6	80.	65.	49.	–	–	–	–	–	–	20.	32.	46.2
Ireland		33.	22.	34.	65.	68.	47.	–	8.7	18.3	–	–	–	1.1	0.8	0.6
Italy		9.8	9.1	9.6	74.	69.	59.	9.6	16.4	26.6	0.8	0.4	–	5.3	4.5	4.1
Luxembourg		65.	54.	31.	33.	32.	55.	0.5	12.4	13.0	–	–	–	0.2	0.3	0.3
Netherlands		10.	6.8	12.	58.	45.	37.	30.9	46.4	49.8	0.2	1.7	1.3	–	–	–
Norway		7.7	8.6	8.1	56.	48.	40.	–	4.6	8.1	–	–	–	35.	38.	43.1
Portugal		24.	11.	24.	67.	81.	71.	–	–	–	–	–	–	8.3	6.8	4.7
Spain		23.	18.	22.	69.	73.	53.	0.3	2.1	6.1	0.6	2.0	15.	6.2	3.7	2.6
Sweden		12.	14.	17.	77.	56.	29.	–	–	1.1	–	16.	40.	9.5	12.	11.0
Switzerland		4.8	3.7	4.7	76.	61.	52.	0.2	4.5	8.0	2.7	17.	23.	15.	13.	10.9
Turkey		34.	47.	47.	63.	49.	42.	–	–	6.5	–	–	–	2.1	3.1	3.7
UK		42.	34.	29.	48.	40.	38.	4.9	20.0	23.5	3.3	4.8	8.5	0.2	0.2	0.2
ČSFR	d)	75.	62.	54.	20.	25.	18.	3.4	9.9	17.4	–	1.6	9.8	0.4	0.6	0.4
Hungary	d)	48.	33.	25.	36.	40.	30.	15.4	25.9	30.8	–	–	13.	0.1	0.1	0.1
Poland	d)	83.	78.	77.	10.	14.	13.	6.0	7.1	8.2	–	–	–	0.2	0.2	0.3
North America		20.	23.	26.	45.	44.	38.	31.5	26.1	24.1	0.4	4.0	8.9	2.1	2.5	2.9
Australia - New		44.	40.	44.	48.	44.	33.	2.2	10.6	17.5	–	–	–	4.9	4.7	5.0
OECD - Europe	f)	29.	23.	21.	60.	54.	43.	6.3	14.7	17.2	1.2	4.6	14.	3.0	3.1	3.0
European Community	f)	30.	23.	21.	59.	54.	44.	6.8	16.4	18.9	1.3	4.2	14.	1.8	1.7	1.4
OECD	f)	24.	23.	24.	52.	49.	41.	19.9	20.1	20.1	0.6	4.3	11.	2.5	2.8	2.9

Notes:

- a) Includes hydro, geothermal and solar energy.
- b) The sum of the two parts of Germany does not add up to the total because of differences in methodologies. Data for eastern Germany will be discontinued.
- c) 1991 data refer to 1990.
- d) 1970 data refer to 1971.
- e) Data on geothermal energy exclude direct use of geothermal water for heating and other purposes (i.e. 0.67 Mtoe in 1990).
- f) Includes western Germany only.

Source: IEA-OECD

Figure 4.3. Energy Supply by Fuel Type



Note:

a) Data refer to 1990.

Source: IEA-OECD

4.4. Air Pollution

Relevance to energy and environmental policies

As indicated in the 1991 OECD State of the Environment Report, fossil fuel production, transport and combustion is also an important source of such emissions as SO_x, NO_x, CO, VOC and methane, all of which pose significant environmental concerns. Particular attention attaches to anthropogenic carbon dioxide, which is predominantly emitted from fossil fuel combustion and is an important contributor to the greenhouse effect. Indicators measuring the emission of atmospheric pollutants from energy use are therefore a key input for both energy and environmental policies. Air pollution indicators should be supplemented with and compared to similar measures of waste to take account of cross-media impacts of energy activities (see Table 4.5 below, on radioactive waste) and of their environmental control (e.g., solid waste generated air pollution control devices such as scrubbers and other filtering devices).

A. Emissions of CO₂

Definition - Conceptual base

Emissions of carbon dioxide included are from energy activities and do not include CO₂ emissions from other human activities (e.g., cement production). They are OECD estimates based on OECD-wide primary energy emission coefficients. Two measures of carbon intensity are also provided (CO₂ emissions per unit of GDP and per capita). GDP is defined as in (4.2).

Presentation:

CO ₂ emission values, 1971, 1975, 1980, 1985, 1990, 1991
Percentage change in CO ₂ emissions, 1971-1980, 1980-1991
CO ₂ emissions per unit of GDP, 1991
CO ₂ emissions per capita, 1991

Statistical basis

Source: OECD Environmental Data, Compendium 1993

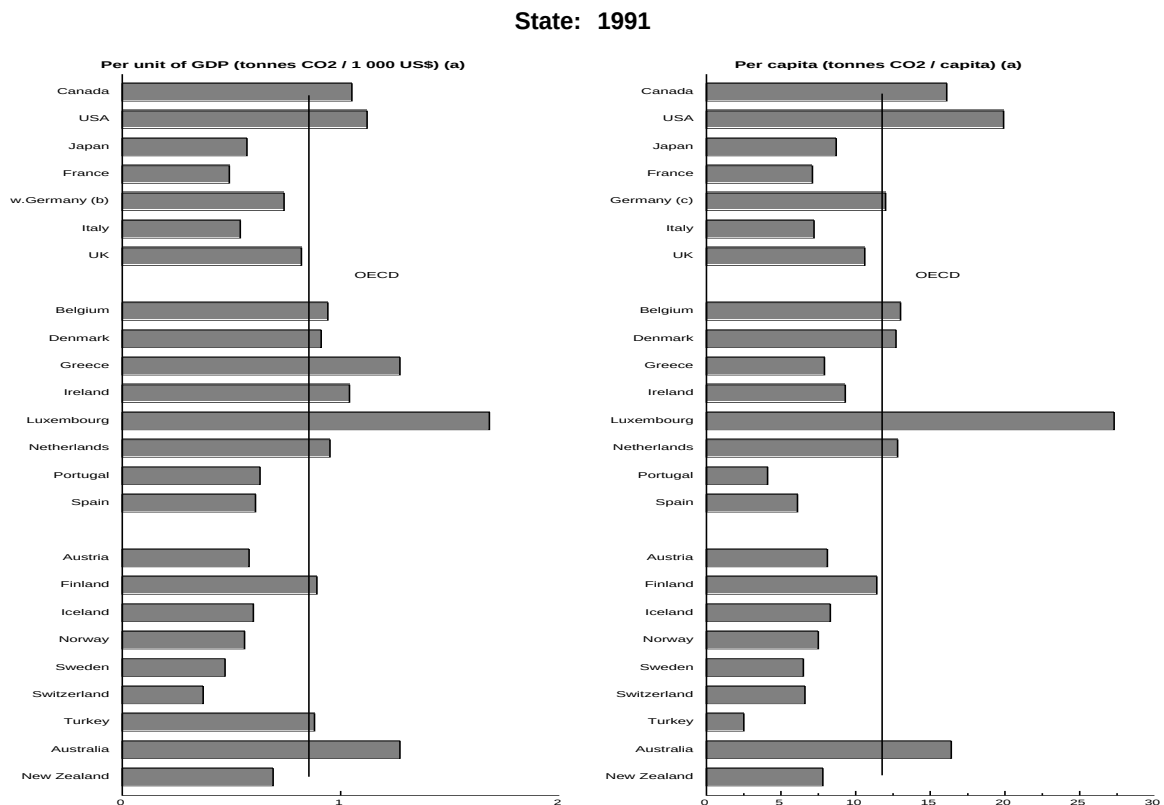
Table 4.4a. Emissions of CO₂ from Energy Use (a)

		Emissions (million tonnes of CO ₂)						Change (%)		Per unit of GDP (b)	tonnes/capita
		1970	1975	1980	1985	1990	1991	1970-198	1980-199	1991	1991
Canada		342	402	439	406	437	435	28.1	-0.7	1.05	16.1
USA		4 267	4 444	4 913	4 732	5 038	5 035	15.2	2.5	1.12	19.9
Japan		781	912	937	912	1 060	1 079	20.0	15.2	0.57	8.7
Australia		163	191	221	229	272	283	35.3	28.3	1.27	16.4
New Zealand		16	19	19	23	26	26	19.3	37.5	0.70	7.8
Austria		49	53	59	55	59	63	18.9	8.4	0.58	8.1
Belgium		134	130	136	111	125	130	1.2	-4.4	0.94	13.0
Denmark		64	56	64	64	56	65	-	2.5	0.91	12.7
Finland		41	47	60	53	55	57	48.4	-5.1	0.89	11.4
France		443	462	499	395	385	406	12.7	-18.6	0.49	7.1
Germany	c)	1 018	994	1 092	1 039	989	957	7.3	-12.4	..	12.0
w.Germany	c)	749	716	791	721	713	..	5.6	-9.8	0.74	11.2
e.Germany	c)	..	307	322	357	326	..	..	1.2	..	20.0
Greece		25	39	51	62	81	81	105.6	57.8	1.27	7.9
Iceland		1.6	1.7	1.9	1.8	2.4	2.2	21.2	14.3	0.60	8.3
Ireland		21	22	27	28	34	33	28.2	22.4	1.02	9.3
Italy		307	342	382	369	411	419	24.5	9.5	0.54	7.2
Luxembourg		15	12	11	10	10	11	-22.1	-3.5	1.68	27.3
Netherlands		161	175	184	167	183	193	14.6	4.6	0.95	12.8
Norway		28	28	32	30	32	32	11.7	1.3	0.55	7.5
Portugal		16	22	27	28	43	44	68.1	63.9	0.63	4.2
Spain		119	170	203	198	227	236	71.1	16.5	0.61	6.1
Sweden		98	85	75	65	56	56	-22.9	-25.3	0.48	6.5
Switzerland		39	39	42	41	44	45	7.2	6.7	0.38	6.6
Turkey		39	63	75	101	139	142	90.9	88.8	0.88	2.5
UK		662	614	601	574	598	608	-9.2	1.2	0.82	10.6
ČSFR	d)	214	231	254	254	215	199	19.0	-21.7	..	12.7
Hungary	d)	64	75	87	85	73	69	35.7	-21.3	..	6.6
Poland	d)	308	371	461	470	358	354	49.8	-23.2	..	9.3
North America		4 609	4 845	5 352	5 138	5 475	5 470	16.1	2.2	1.11	19.6
OECD - Europe	e)	3 279	3 354	3 622	3 392	3 529	3 580	10.5	-1.2	0.71	8.2
European	e)	2 983	3 038	3 277	3 045	3 141	3 182	9.9	-2.9	0.72	11.0
OECD	e)	8 848	9 321	10 150	9 694	10 361	10 439	14.7	2.8	0.86	12.1

Notes:

- a) Anthropogenic CO₂ emissions from energy use only. Oil held in international marine bunkers is included. Quantities are assigned to the countries in which bunker deliveries were made. Oil and gas for non-energy purposes, and the use of biomass fuels are excluded. Peat is included.
- b) Tonnes of CO₂ per 1 000 US\$, at 1985 prices and purchasing power parities.
- c) The sum of the two parts of Germany may not correspond to the total due to differences in methodology. 1991 data for west Germany and east Germany refer to 1990.
- d) 1970 data refer to 1971.
- e) Secretariat estimates.

Source: IEA-OECD

Figure 4.4a. Air Pollution: Emissions of CO₂ (a)

Notes:

- a) Anthropogenic emissions from energy use only. Oil held in international marine bunkers is included. Quantities are assigned to the countries in which bunker deliveries were made. Oil and gas for non-energy purposes and the use of biomass fuels are excluded. Peat is included. GDP is expressed at 1985 prices and purchasing power parities.
- b) Data refer to 1990.
- c) Data include both eastern and western Germany.

Source: IEA-OECD

B. Emissions of SO_xDefinition - Conceptual base

Data on anthropogenic emissions of SO_x are given as quantities of SO₂ by source. Definitions and estimation methods for SO_x emissions vary from country to country. Two measures of SO_x emission intensity are also provided (SO_x emissions per unit of GDP and per capita). GDP is defined as in (4.2).

Presentation: SO_x emission values, 1970, 1975, 1980, 1985, 1990
Percentage change in SO_x emissions, 1980-1990
SO_x emissions per unit of GDP, 1970, 1980 and 1990
SO_x emissions per capita, late 1990

Statistical basis

Source: OECD Environmental Data, Compendium 1993

C. Emissions of NO_xDefinition - Conceptual base

Data on anthropogenic emissions of NO_x are given as quantities of NO₂ by source. Definitions and estimation methods for NO_x emissions vary from country to country. Two measures of SO_x emission intensity are also provided (SO_x emissions per unit of GDP and per capita). GDP is defined as in (4.2).

Presentation: NO_x emission values, 1970, 1975, 1980, 1985, 1990
Percentage change in NO_x emissions, 1970-1980, 1980-1990
NO_x emissions per unit of GDP, 1990
NO_x emissions per capita, 1990

Statistical basis

Source: OECD Environmental Data, Compendium 1993

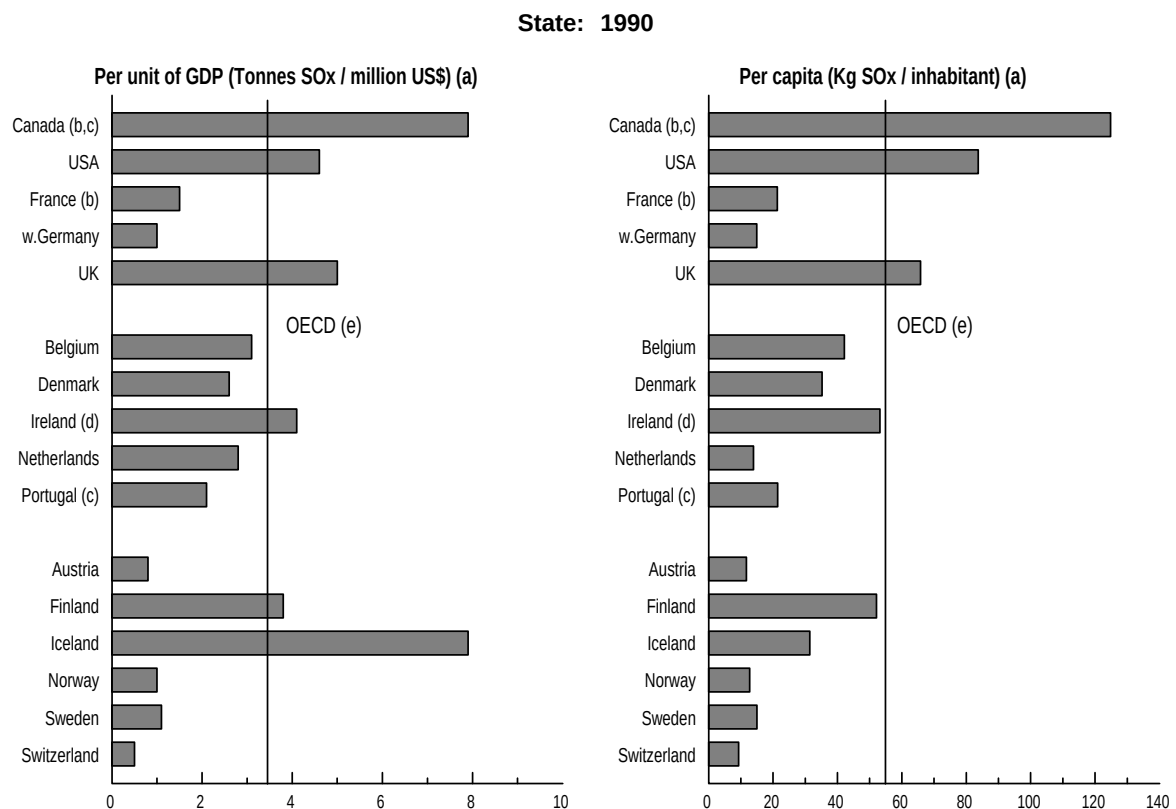
Table 4.4b. Emissions of SO_x

		Total (thousand tonnes)						Change (%)		Per unit kg/capita GDP (b)	
		1970	1975	1980	1985	1990	1991	1970-198	1980-19	1990	1990
Canada	c,d,e	6 677	5 319	4 643	3 692	3 323	3 306	-30.5	-28.4	7.9	124.8
USA	f)	28 42	25 51	23 78	21 67	21 06	20 73	-16.3	-11.4	4.6	83.7
Japan	g,h)	4 973	2 586	1 263	835	876	..	-74.6	-30.6	0.5	7.1
Austria		..	..	397	195	90	84	..	-77.3	0.8	11.7
Belgium		..	..	828	452	420	..	..	-49.3	3.1	42.1
Denmark		574	420	449	341	181	..	-21.8	-59.6	2.6	35.2
Finland		515	535	584	382	260	194	13.4	-55.5	3.8	52.1
France	c,i)	2 966	3 328	3 348	1 451	1 200	1 314	12.9	-64.2	1.5	21.3
Germany		..	7 448	7 517	7 785	5 697	..	..	-24.2	..	71.7
w.Germany		3 743	3 334	3 194	2 396	939	..	-14.7	-70.6	1.0	14.9
e.Germany		..	4 114	4 323	5 389	4 758	..	..	10.1	..	292.9
Greece		..	..	400	..	..	..	..	..	..	..
Iceland		..	6	9	7	8	7	..	-11.1	2.3	31.4
Ireland	j)	..	186	220	135	187	..	..	-15.2	5.9	53.2
Italy	d,h,k	2 830	3 331	3 211	2 241	1 988	..	13.5	-38.1	2.6	34.5
Luxembourg		..	..	24	17	10	..	..	-57.6	1.6	26.2
Netherlands	f)	807	427	502	259	208	204	-37.8	-58.6	1.0	13.9
Norway		171	137	141	91	54	46	-17.5	-61.7	1.0	12.7
Portugal	e)	116	178	266	199	211	..	129.0	-20.6	3.1	21.4
Spain		..	3 003	3 377	2 191	..	..	..	..	..	..
Sweden		930	690	489	261	128	106	-47.4	-73.8	1.1	15.0
Switzerland	l)	125	109	126	95	63	61	0.8	-50.0	0.5	9.3
UK		6 424	5 368	4 898	3 724	3 780	3 565	-23.8	-22.8	5.0	65.8
ČSFR		2 600	2 900	3 100	3 150	2 774	..	19.2	-10.5	..	177.1
Hungary	h)	..	..	1 633	1 404	1 085	..	..	-33.6	..	104.7
Poland	h)	..	..	4 100	4 300	3 216	2 995	..	-21.6	..	84.4
North America	m)	35 10	30 80	28 40	25 40	24 40	24 00	-19.1	-14.1	4.9	87.7
Australia/New		..	..	..	..	..	..	..	..	..	..
OECD - Europe	m)	23 20	22 90	22 70	15 10	13 80	..	-2.2	-39.2	2.8	33.1
European	m)	20 90	20 80	20 70	13 80	11 60	..	-1.0	-44.0	2.7	35.4
OECD	m)	64 90	58 10	53 90	42 70	40 20	..	-16.9	-25.4	3.4	47.9

Notes:

- a) Total anthropogenic emissions.
- b) Tonnes of SO_x per million US\$, at 1985 prices and purchasing power parities.
- c) 1990 and 1991 data are provisional.
- d) 1975 data refer to 1976.
- e) SO₂ only.
- f) 1991 data are provisional.
- g) 1985 data refer to 1986.
- h) 1990 data refer to 1989.
- i) Break in time series in 1980 due to a change in estimation methodology.
- j) Industrial processes are excluded.
- k) Some methodology changed in 1985. Data for 1970-1980 exclude industrial processes.
- l) 1985 data refer to 1984.
- m) Rounded figures which include Secretariat estimates. Data for OECD-Europe, the EC and OECD include western Germany only.

Source: OECD

Figure 4.4b. Air Pollution: Emissions of SO_x

Note:

- a) Total anthropogenic emissions of SO_x. GDP is expressed in 1985 prices and purchasing power parities.
- b) Data are provisional.
- c) Data refer to SO₂ only.
- d) Industrial processes are excluded.
- e) Data are rounded figures, including Secretariat estimates. They refer to the late 1980s and include western Germany only.

Source: OECD

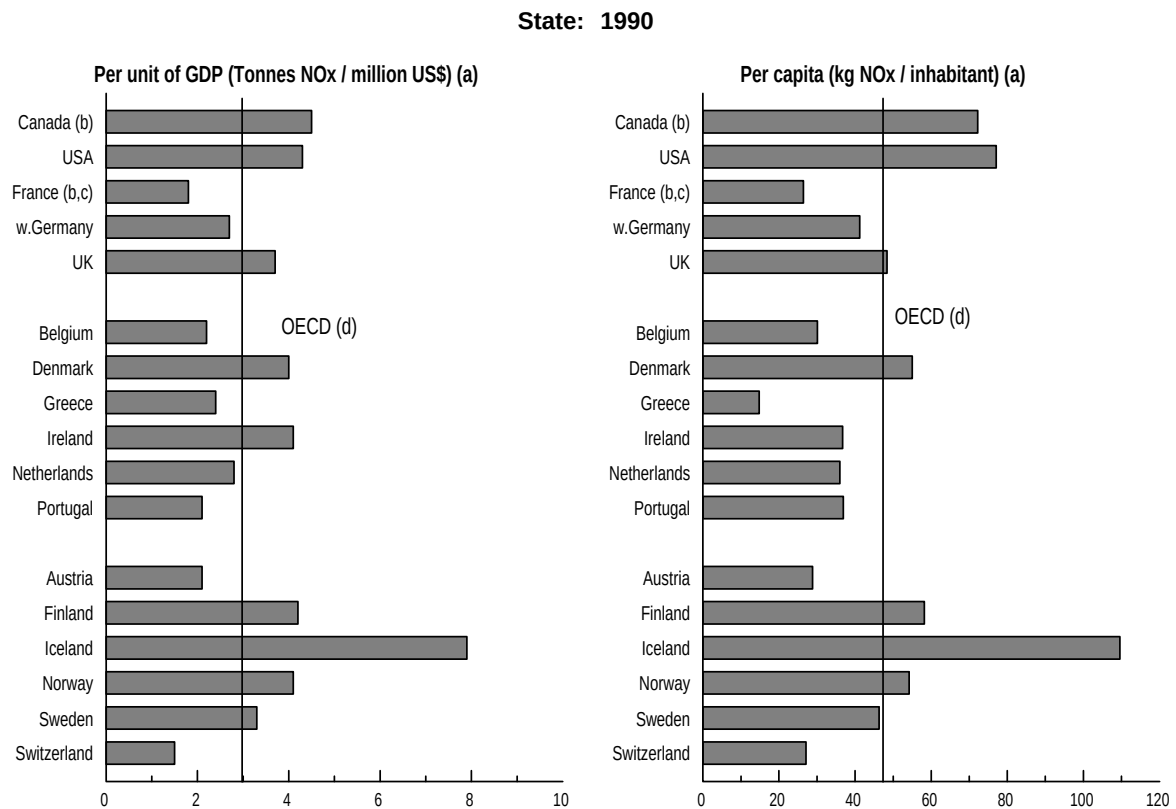
Table 4.4c. Emissions of NO_x (a)

		Total (thousand tonnes)						Change (%)		Per unit GDP (b)	Kg/capita
		1970	1975	1980	1985	1990	1991	1970-1980	1980-1990	1990	1990
Canada	c)	1 364	1 756	1 959	1 958	1 923	..	43.6	-1.8	4.5	72.2
USA	d)	18 96	20 33	23 56	19 39	19 38	18 76	24.3	-17.7	4.3	77.1
Japan	e,f)	1 651	1 782	1 400	1 176	1 301	..	-15.2	-7.1	0.7	10.5
Austria		..	..	246	245	222	216	..	-9.8	2.1	28.8
Belgium		..	..	317	281	300	..	..	-5.4	2.2	30.1
Denmark		..	197	270	296	283	..	..	4.8	4.0	55.0
Finland	g)	..	160	264	252	290	286	..	9.8	4.2	58.2
France	h)	1 322	1 608	1 646	1 400	1 487	1 507	24.5	-9.7	1.8	26.4
Germany		..	3 113	3 537	3 565	3 234	..	..	-8.6	..	40.7
w.Germany		2 345	2 530	2 944	2 928	2 605	..	25.5	-11.5	2.7	41.2
e.Germany		..	583	593	637	629	..	..	6.1	..	38.7
Greece		..	..	217	..	150	..	..	-30.9	2.4	14.8
Iceland		..	15	14	21	28	27	..	104.4	7.9	109.6
Ireland		..	..	73	91	128	..	..	74.9	4.1	36.7
Italy	f,i)	1 410	1 507	1 585	1 630	1 996	..	12.4	25.9	2.6	34.6
Luxembourg		..	..	23	22	..	..	..	..	..	..
Netherlands	d)	456	481	571	564	552	550	25.2	-3.3	2.8	36.9
Norway	d,j)	159	179	186	216	230	218	17.0	23.7	4.1	54.2
Portugal		72	104	165	96	142	..	130.6	-14.0	2.1	14.4
Spain		..	625	946	849	..	..	..	..	..	..
Sweden	k)	302	308	424	434	396	389	40.4	-6.6	3.3	46.3
Switzerland		149	162	196	214	184	175	31.5	-6.1	1.5	27.1
UK		2 293	2 245	2 365	2 392	2 779	2 747	3.1	17.5	3.7	48.4
ČSFR	f)	..	..	1 204	1 127	960	..	..	-20.3	..	61.3
Hungary	f)	..	..	273	263	249	..	..	-8.8	..	24.0
Poland		..	..	..	1 500	1 280	1 205	..	..	..	33.6
North America	l)	20 30	22 10	25 50	21 30	21 30	..	25.6	-16.5	4.3	76.6
Australia - New		..	..	..	..	..	..	..	..	..	..
OECD - Europe	l)	10 10	11 00	12 80	12 40	13 10	..	26.7	2.3	2.7	31.4
European	l)	8 900	9 800	11 10	10 70	11 60	..	24.7	4.5	2.7	35.4
OECD	l)	32 90	35 80	40 70	35 90	36 70	..	23.7	-9.8	3.1	43.8

Notes:

- a) Total anthropogenic emissions of NO_x.
- b) Tonnes of NO_x per million US\$, at 1985 prices and purchasing power parities.
- c) 1975 data refer to 1976. 1990 data are provisional.
- d) 1991 data are provisional.
- e) 1985 data refer to 1986.
- f) 1990 data refer to 1989.
- g) 1975 data refer to 1977.
- h) 1990 and 1991 data are provisional. Includes industrial fuel combustion. Excludes some agriculture-related emissions, e.g. from fertilizer and slurry, which are estimated at 700 kt/year.
- i) 1975 data refer to 1973. Data for 1970-1980 exclude industrial processes. Some methodological changes were made in 1985.
- j) Excludes ocean transport and national aircraft abroad.
- k) 1985 data refer to 1987.
- l) Rounded figures, including Secretariat estimates. 1990 data refer to the late 1980s. Data for OECD-Europe, the EC, and OECD include western Germany only.

Source: OECD

Figure 4.4c. **Air Pollution: Emissions of NO_x****Note:**

- a) Total anthropogenic emissions of NO_x. GDP is expressed in 1985 prices and purchasing power parities.
- b) Data are provisional.
- c) Data include industrial processes and exclude some agriculture-related emissions, e.g. from fertilizer and slurry, which are estimated at 700 kt/year.
- d) Data are rounded figures, including Secretariat estimates. They refer to the late 1980s and include western Germany only.

Source: OECD

4.5. Radioactive Waste

Relevance to energy and environmental policies

The environmental effects of radioactive energy differ substantially from those of fossil fuel generation. In substituting radioactive power for fossil fuel electricity generation, beneficial effects of reduced air pollution have to be weighed against the risks of accidental releases of radioactivity and the long term need to manage and control the storage of radioactive waste.

Radioactive waste is produced at various stages of the radioactive fuel cycle, including uranium mining, uranium mills, fuel enrichment, reactor operation and decommissioning, and spent-fuel reprocessing. These activities generate low-, intermediate- and high-level wastes (depending on the amount of short- or long-lived radionuclides contained in the waste) that require different disposal and control measures. The dispersal of low-level liquid and gaseous wastes into rivers, coastal waters and the atmosphere can only be considered suitable for limited amounts of radioactive waste. As the amount of waste to be disposed of increases, the balance between dispersal and containment (for instance in shallow ground or rock cavity repositories) will shift towards containment, increasing the volume of waste that needs controlling during storage, while decay takes place. High-level and long-lived wastes disposal involves concentrating the wastes and confining them in a manner and for a period of time sufficient to ensure that any residual activity making its way back into the environment would not lead to unacceptable exposure levels, the most favoured solution being long term storage in deep, stable geological formations.

Definition - Conceptual base

The amount of spent fuel, expressed in metric tonnes of heavy metal, though it does not distinguish between various types of radioactive waste and includes only part of the total volume of radioactive waste produced by the radioactive fuel cycle. Nevertheless, this indicator can be considered as providing a reliable representation of the radioactive waste disposal situation and its evolution over time, which can also be related to economic activity (per unit of GDP) and population (per capita). GDP is defined as in (4.2) above.

Presentation: Volume of radioactive waste generated, 1982-1991
 Radioactive waste generated per unit of GDP, 1982-1991
 Radioactive waste generated per capita, 1982-1991

Statistical basis

Source: OECD Environmental Data, Compendium 1993

Table 4.5. **Radioactive Waste**

	Spent fuel arisings (tonnes of heavy metal)										Per unit of GDP 1991	Per capita 1991
	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	(kg HM/ billion US\$)	(kg HM / 1 000 inhabitant)
Canada	856	830	1 070	1 420	1 400	1 500	1 500	1 300	1 213	1 383	3 330	51.2
USA	1 100	1 116	1 200	1 300	1 600	1 621	1 700	2 000	2 200	2 100	467	8.3
Japan	a) 510	530	630	625	660	1 060	830	790	688	995	524	8.0
Australia	-	-	-	-	-	-	-	-	-	-	-	-
New Zealand	-	-	-	-	-	-	-	-	-	-	-	-
Austria	-	-	-	-	-	-	-	-	-	-	-	-
Belgium	44	37	85	97	140	140	135	122	120	120	867	12.0
Denmark	-	-	-	-	-	-	-	-	-	-	-	-
Finland	62	62	64	65	72	76	73	73	74	63	981	12.5
France	375	200	200	300	640	750	900	1 000	1 120	1 200	1 450	21.0
w.Germany	270	300	300	350	430	380	320	360	490	510	509	6.4
Greece	-	-	-	-	-	-	-	-	-	-	-	-
Iceland	-	-	-	-	-	-	-	-	-	-	-	-
Ireland	-	-	-	-	-	-	-	-	-	-	-	-
Italy	38	26	26	38	58	13	-	-	-	-	-	-
Luxembourg	-	-	-	-	-	-	-	-	-	-	-	-
Netherlands	16	16	12	12	14	14	14	15	17	15	74	0.3
Norway	-	-	-	-	-	-	-	-	-	-	-	-
Portugal	-	-	-	-	-	-	-	-	-	-	-	-
Spain	60	110	120	160	203	206	235	191	187	160	410	37.5
Sweden	100	100	245	238	296	236	250	190	230	250	2 115	23.6
Switzerland	60	60	60	85	85	80	85	85	85	85	715	2.2
Turkey	-	-	-	-	-	-	-	-	-	-	-	-
UK	b) 900	820	775	775	843	919	884	910	1 022	1 022	1 377	150.5
North America	1 956	1 946	2 270	2 720	3 000	3 121	3 200	3 300	3 413	3 483	709	12.5
OECD - Europe	c) 1 925	1 731	1 887	2 120	2 781	2 814	2 896	2 946	3 345	3 425	690	8.1
EC	c) 1 703	1 509	1 518	1 732	2 328	2 422	2 488	2 598	2 956	3 027	700	9.2
OECD	c) 4 400	4 200	4 787	5 465	6 441	6 995	6 926	7 036	7 446	7 903	657	9.4

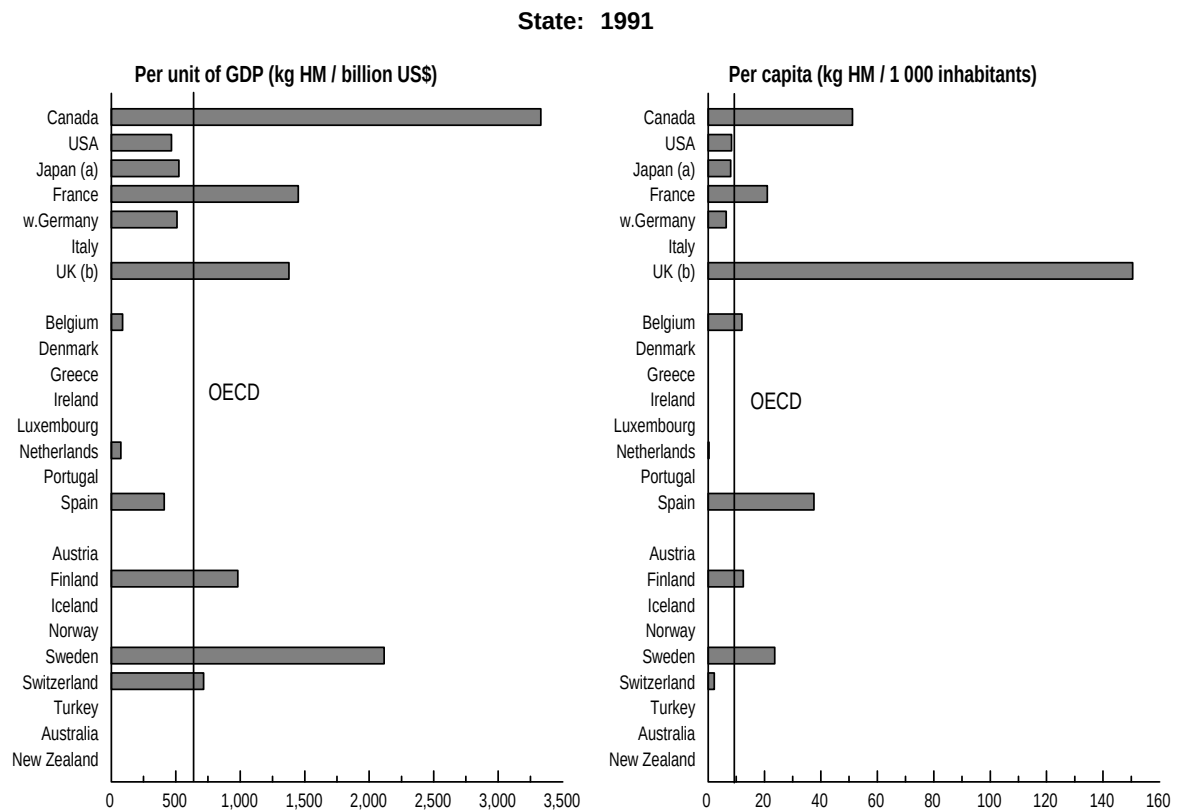
Notes:

a) For fiscal year.

b) OECD estimates.

c) Includes western Germany only.

Source: OECD

Figure 4.5. **Radioactive Waste**

Notes:

- a) For fiscal year.
 b) OECD estimates.

Source: OECD

4.6. Energy Pricing

Relevance to energy and environmental policies

Price signals play a key role in determining the ability to achieve an efficient allocation of energy resources, by internalising environmental costs. Energy end-use prices influence overall energy demand levels and the fuel mix, which in turn largely determine environmental pressures caused by energy activities. Though price elasticities vary considerably from one end-use sector to another, historical and cross country experience suggests that the overall price effect on energy demand is strong and that increases in energy prices have affected levels of energy use and therefore reduced environmental impacts.

Definition - Conceptual base

The evolution of real total energy end-use prices provides a measure of the incentive given to end-users to improve the efficiency of energy use as a whole. The evolution of real end-use prices for individual end-use energy forms (electricity, natural gas, coal and oil products) reflects the effect relative price levels are likely to have on the fuel mix used by energy consumers. Real energy end-use prices are obtained by deflating end-use prices with country specific producer and consumer price indices.

Presentation: Indices of real total energy end-use prices, 1978-1992

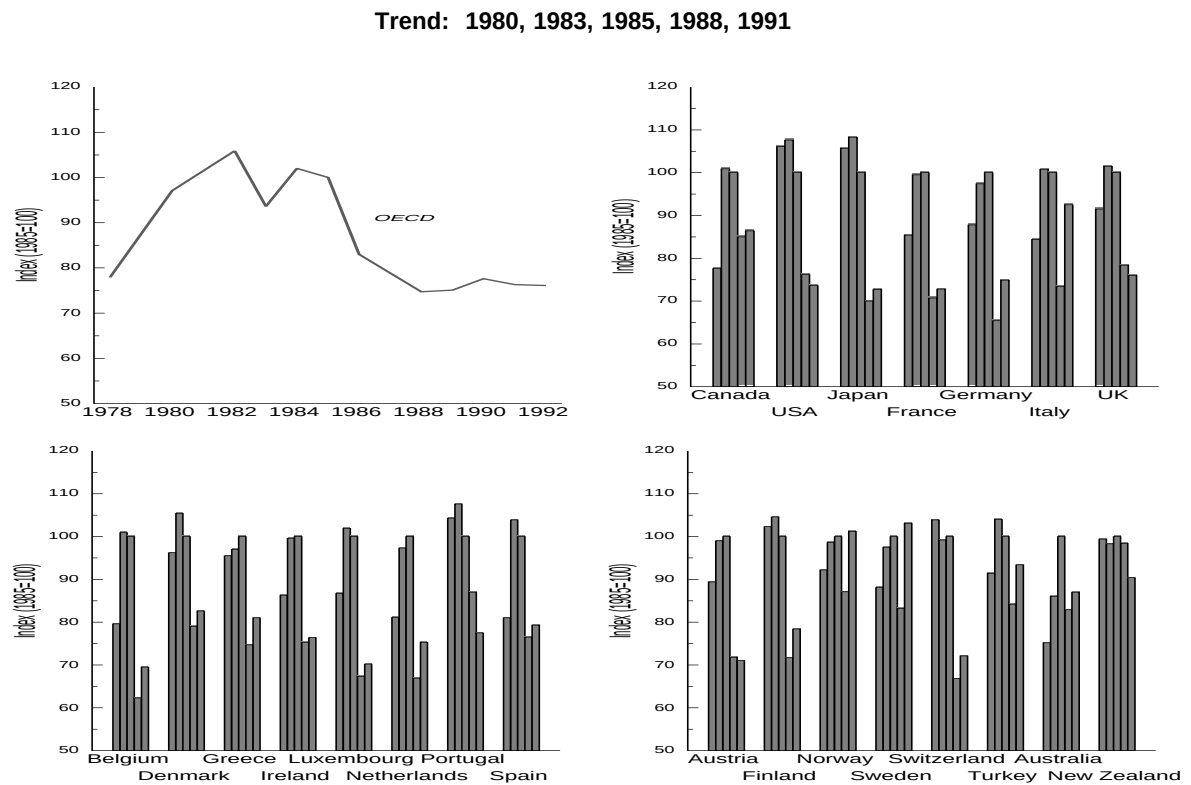
Statistical basis

Source: IEA *Energy Prices and Taxes*, 1992

Table 4.6. **Indices of Real Energy Prices for End-Users**

	Index (1985=100)											
	1978	1980	1982	1983	1984	1985	1986	1988	1989	1990	1991	1992
Canada	78.7	77.6	96.8	100.9	99.8	100.0	92.8	85.0	81.4	84.4	86.4	79.2
USA	83.0	106.1	109.4	107.6	104.0	100.0	82.5	76.2	75.7	77.9	73.6	74.5
Japan	81.4	105.7	117.7	108.3	103.5	100.0	84.3	70.0	71.5	74.9	72.7	71.9
Australia	61.7	75.2	86.4	86.0	99.0	100.0	94.5	82.9	80.4	81.0	87.0	79.2
New Zealand	83.3	99.4	101.4	98.3	99.6	100.0	94.8	98.4	92.0	89.2	90.4	91.4
Austria	76.5	89.4	104.4	99.0	98.9	100.0	86.0	71.8	69.7	71.8	71.0	70.0
Belgium	58.7	79.6	101.1	100.9	99.3	100.0	74.7	62.3	65.3	67.6	69.5	67.2
Denmark	61.9	96.2	111.2	105.4	100.1	100.0	84.2	79.0	81.3	76.4	82.6	81.4
Finland	83.7	102.3	107.7	104.6	100.7	100.0	78.6	71.7	71.7	77.7	78.4	76.1
France	71.0	85.4	100.2	99.5	98.7	100.0	79.9	70.7	71.8	72.8	72.8	68.4
Germany	73.0	87.8	103.9	97.4	99.8	100.0	76.2	65.4	71.5	72.4	74.9	74.8
Greece	71.8	95.5	95.9	97.0	95.6	100.0	93.7	74.7	66.2	74.8	81.0	76.9
Ireland	69.2	86.3	108.8	99.6	96.4	100.0	86.9	75.3	75.2	75.3	76.4	73.1
Italy	68.4	84.4	98.6	100.8	102.1	100.0	76.1	73.4	76.0	85.5	92.5	89.8
Luxembourg	69.1	86.7	101.8	101.9	102.1	100.0	72.9	67.3	71.5	70.0	70.2	71.9
Netherlands	63.2	81.1	99.3	97.3	100.2	100.0	84.8	66.9	66.8	71.5	75.3	74.4
Norway	79.1	92.2	98.6	98.6	99.1	100.0	90.6	87.1	90.8	96.5	101.2	98.4
Portugal	90.3	104.3	102.4	107.6	101.3	100.0	95.4	87.0	81.8	79.2	77.5	71.6
Spain	68.8	81.0	97.8	103.9	101.4	100.0	86.0	76.5	75.2	77.3	79.3	78.5
Sweden	66.8	88.1	100.4	97.5	101.6	100.0	86.6	83.2	89.7	101.0	103.1	105.3
Switzerland	77.3	103.9	105.1	99.2	99.2	100.0	75.9	66.8	71.4	72.9	72.1	67.4
Turkey	54.5	91.4	105.9	104.0	98.3	100.0	98.7	84.2	93.3	96.1	93.4	94.9
UK	78.9	91.5	101.2	101.5	100.5	100.0	87.6	78.4	77.2	76.2	76.0	76.9
OECD - Europe	70.7	86.8	100.6	99.1	99.4	100.0	80.8	71.7	73.9	73.9	76.6	77.5
OECD	77.9	97.1	105.9	93.6	102.0	100.0	83.0	74.7	75.1	77.6	76.3	76.1

Source: IEA-OECD

Figure 4.6. **Indices of Real Energy Prices for End-Users (1985=100)**

Source: IEA-OECD

4.7. Energy Taxation

Relevance to energy and environmental policies

Until recently, energy taxation has been developed primarily to raise revenue and promote reduced energy dependence. Environmental policy objectives have not usually been a driving force in the elaboration of the often complex fiscal structure of energy products in OECD countries. Many Member countries are in the process of rationalising and re-structuring their fiscal policies. At the same time, the use of taxation to influence energy consumer behaviour and to internalize environmental costs is increasing. This is reflected in the introduction of tax differentials in favour of unleaded gasoline in many Member countries and the implementation of environmental taxes (related to pollutant emission levels, for instance of SO₂) on energy products in some Member countries. Carbon, CO₂ or related taxes on energy products have been enacted in Denmark, Finland, the Netherlands, Norway and Sweden. Irrespective of their purpose, taxes in general influence overall energy demand and the fuel mix, which in turn affects environmental pressures caused by energy activities.

Definition - Conceptual base

Indicators of energy taxation are expressed in terms of the percentage of taxes in the overall end-use price of different energy forms.

Presentation: Percentage of taxes in oil, gas, coal and electricity prices for industry, in oil, gas and electricity prices for households, and in gasoline and diesel prices for transport (latest year available).

Statistical basis

Source: IEA *Energy Prices and Taxes*, 1992

Table 4.7. **Percentage of Taxes in Selected Energy Prices**, latest year available

	Industry				Households			Transport	
	Oil (a)	Natural gas	Steam coal	Electricity	Oil (b)	Natural gas	Electricity	Gasoline (c)	Diesel
Canada	..	..	..	..	..	..	..	42.2	34.7
USA	0.0	..	..	..	..	..	..	32.9	34.1
Japan	2.9	2.9	3.0	5.6	2.9	2.9	7.7	44.9	35.1
Australia	..	..	..	..	..	..	..	46.8	48.8
New Zealand	11.1	16.7	..	16.7	..	15.5	10.8	45.4	11.8
Austria	7.3	0.0	0.0	..	33.7	16.7	16.9	58.1	46.5
Belgium	0.0	0.0	0.0	..	15.9	15.9	15.9	66.5	45.2
Denmark	0.0	0.0	..	..	63.6	20.0	50.7	67.8	20.9
Finland	6.0	2.1	6.4	..	21.4	19.8	18.0	61.2	51.5
France	21.7	0.0	0.0	0.7	30.1	13.6	19.8	75.0	54.3
Germany	17.2	10.8	0.0	6.7	25.8	17.4	18.0	67.6	51.8
Greece	46.0	..	..	..	54.0	..	15.3	67.6	42.2
Iceland	..	..	..	..	..	..	..	..	..
Ireland	15.2	0.0	..	2.4	26.6	11.1	10.8	66.2	49.8
Italy	31.2	8.5	..	13.8	71.3	40.7	16.1	76.0	63.9
Luxembourg	11.0	..	..	..	5.7	5.7	5.7	54.9	31.9
Netherlands	20.5	3.0	0.0	..	36.2	19.9	15.5	68.1	45.6
Norway	33.8	..	0.0	17.4	38.0	..	23.5	6.8	24.3
Portugal	44.8	..	..	7.4	64.4	..	14.9	72.2	56.3
Spain	14.6	..	..	..	36.4	..	..	65.4	51.1
Sweden	62.5	..	44.9	13.5	59.0	..	30.9	67.7	30.3
Switzerland	12.9	0.5	12.8	..	8.4	0.3	0.3	59.5	58.6
Turkey	45.2	5.7	10.7	11.6	57.9	5.7	15.0	59.6	52.6
UK	14.3	0.0	0.0	..	9.2	0.0	..	66.0	56.5
ČSFR	..	..	..	..	..	..	..	56.1	57.3
Hungary	56.9	23.3	0.0	..	0.0	25.3	..	65.3	48.6
Poland	0.0	0.0	..	..	..	0.0	..	51.2	17.5

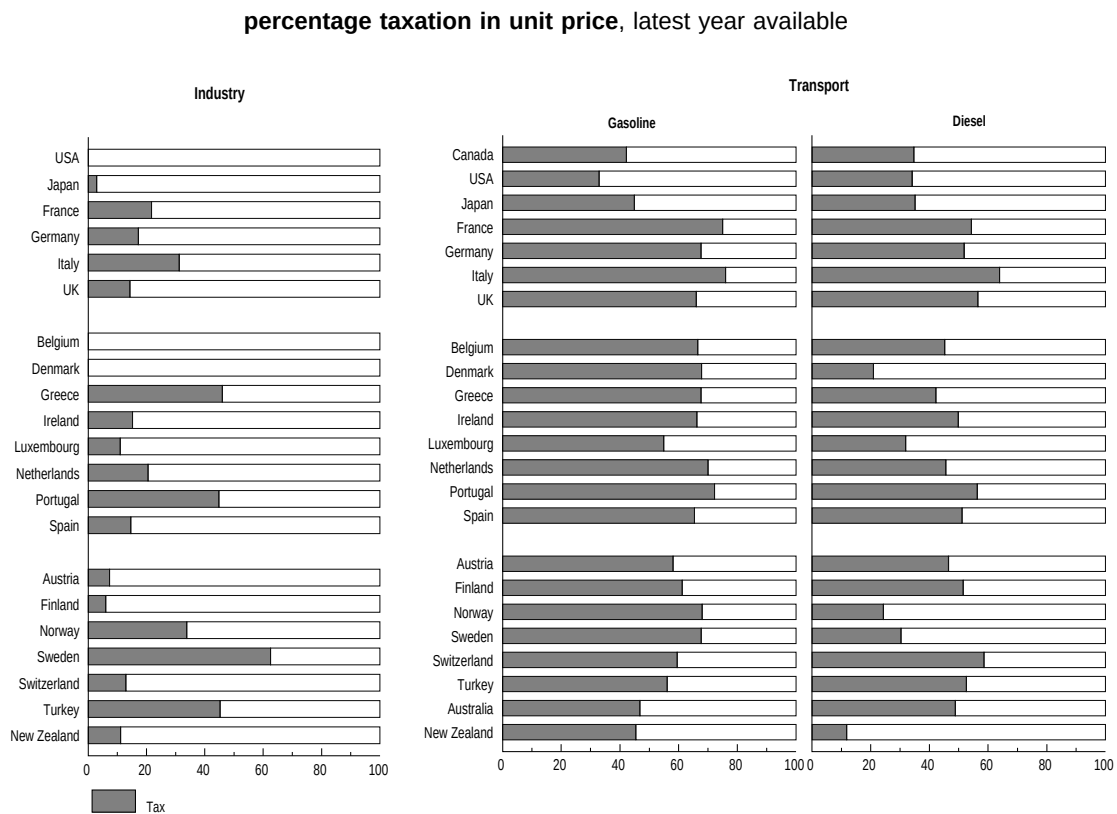
Notes:

a) Average of heavy fuel oil and light fuel oil.

b) Light fuel oil only.

c) Data refer to leaded premium except for Canada, U.S.A. and Japan (unleaded regular).

Source: IEA-OECD

Figure 4.7. **Energy Taxation: Oil Prices for Industry and Households (a)**

Note:

- a) Data refer to the latest year available. Prices for industry are based on the average of heavy fuel oil and light fuel oil; for households, data refer to light fuel oil only. Gasoline data refer to leaded premium except for Canada, the United States and Japan (unleaded regular).

Source: IEA-OECD

REFERENCES

- IEA (1985) *Electricity in IEA Countries, Issues and Outlook*, Paris.
- IEA (1987) *Coal Environmental Policies and Institutions*, Paris.
- IEA (1987) *Energy Conservation in IEA Countries*, Paris.
- IEA (1990) *Energy and the Environment: Policy Overview*, Paris.
- IEA (1991) *Energy Efficiency and the Environment*, Paris.
- IEA (1991) *Energy Policies of IEA Countries, 1990 Review*, Paris.
- IEA (1991) *Greenhouse Gas Emissions, The Energy Dimension*, Paris.
- IEA (1993) *Energy Balances of OECD Countries, 1990-1991*, Paris.
- IEA (1993) *Energy Prices and Taxes, Third Quarter 1992*, Paris.
- IEA (1993) *Energy Statistics of OECD Countries, 1990-1991*, Paris.
- NEA (1991) *Electricity, Nuclear Power and Fuel Cycle in OECD Countries, Main Data*, Paris.
- OECD (1991) *The State of the Environment*, Paris.
- OECD (1991) *Environmental Indicators, A Preliminary Set*, Paris.
- OECD (1993) *Environmental Data, Compendium 1993*, Paris.

Annex 1:
**Extract from the Communiqué of the Meeting of the Governing Board of the International
Energy Agency at Ministerial Level, June 1991**

ENERGY AND ENVIRONMENT

Ministers reaffirmed their strong commitment to address energy-related environmental problems nationally and internationally. They emphasised that action is needed, not only to address conventional pollutants and greenhouse gas emissions, but also the problems related to siting of new energy facilities. Ministers underscored the need to find the most cost-effective means for doing so, and to develop policies that harmonise approaches relating to the full range of environmental concerns, in a manner consistent with the need for diversified energy supplies and unfettered international trade in energy. Ministers instructed the IEA to continue to assess the possibilities and implications of intensified development and implementation of policies bearing upon energy and environment concerns, particularly policies to promote energy efficiency.

Ministers discussed the challenge that the global climate change issue poses for the energy sector, and reaffirmed their commitment to meet this challenge. They noted the significant work undertaken by the IEA and its contribution to the first assessment report of the Intergovernmental Panel on Climate Change (IPCC). They requested the IEA, working closely with the OECD, to continue to assist the IPCC and the Inter-governmental Negotiating Committee on a Framework Convention on Climate Change (INC) by providing the results of its analytical work. In this regard, they highlighted the importance of the IEA's ongoing work on emissions inventory methodologies and databases, and its analyses of policy instruments and technologies relating to major energy sectors, such as transport and electricity, and of important responses, such as energy efficiency.

Ministers encouraged the IEA to work closely with non-OECD countries to help them integrate energy-related environmental considerations into their energy policies and strategies. They therefore welcomed the up-coming United Nations Conference on Environment and Development (UNCED), and encouraged the active participation of the IEA with the OECD in the lead-up to the UNCED.

Ministers welcomed the fact that OECD countries have adopted targets or are developing national strategies for the stabilisation or reduction of greenhouse gas emissions.

Ministers acknowledged that concerted global action will be required and that OECD countries should take a leading role in this context. They found, however, that in most cases appropriate and effective policies to carry out the commitments still needed to be developed, as well as the data and analysis to enable Member governments to make informed choices. They requested the IEA to facilitate this process by both IEA-wide and individual country assessments of the technical potential for reducing greenhouse gas emissions, as well as the costs, benefits and relative cost-effectiveness of the various means for realising such potential. They recognised the need for governments to gather such information and provide it to the IEA and other Member countries. Ministers considered IEA analyses important to understanding when, and at what costs and benefits, stabilisation or reduction of greenhouse gas emissions could be achieved, and to examining possible approaches to assess comparability among OECD countries. In this regard, Ministers stressed that all nations would need to associate with any Framework Convention on Climate Change if it were to be effective.

Ministers urged the IEA to work with OECD in its analysis of the effects of economic instruments for environmental protection on trade, economic growth and income distribution, resource production and diversity of supply. They requested the IEA to assess the economic and energy security implications of measures, such as carbon tax, to abate greenhouse gas emissions, and to develop, on a global level and in a comprehensive manner, indicators of progress for the energy sector in mitigating greenhouse gas emissions. Ministers also requested the IEA to assist Member countries in developing concerted policies and approaches in responding to the global climate change problem, particularly in the context of the INC Framework Convention negotiations.

Ministers emphasised the important roles of industry and consumer awareness in the successful implementation of energy policies to achieve environmental goals. Ministers therefore urged concerted efforts in energy education and information on the part of government, industry and consumers. They urged the IEA to find more effective ways to bring industry's expertise into its analytical work and its collaboration on R&D and demonstration and transfer.

Annex 2:
**Extract from the Communiqué of the Meeting of the Governing Board of the International
Energy Agency at Ministerial Level, June 1993**

ENERGY AND ENVIRONMENT

Intensifying global environmental problems require internationally co-ordinated responses, which must balance the goals of energy security, environmental protection and economic growth. The adoption of a comprehensive approach to energy and environment issues and the integration of energy and environment policies have become central activities of IEA Member countries. National and global solutions to reduce pollutants and greenhouse gas emissions have implications for energy security, energy trade, economic growth, and IEA relations with non-Member countries.

How to meet the challenge that the global climate change issue poses for energy policy makers is the focus of continuing international debate. Despite the policy measures taken to date, without the rapid establishment and implementation of further effective policies and programmes to reduce emissions, OECD CO₂ emissions could rise by 15 per cent by the year 2000, according to the *World Energy Outlook*. Ministers, concerned about this prospect, discussed the full range of possible areas for action and policy instruments. They agree that greater efforts are required and that, to the extent necessary and practicable, the external costs of energy production and use should be reflected in prices. Ministers urge rapid ratification of the Framework Convention on Climate Change by all signatory countries and request the IEA to augment its contribution to the implementation of the Convention.

A. Areas for Improvement

Energy Efficiency: Accelerated gains in efficiency in energy production and use, including the transportation sector, can help reduce emissions and promote energy security. While there is a large technical potential for increased energy efficiency, there exist significant social and economic barriers to its achievement. Priority should be given to market forces in effecting efficiency gains. However, reliance on market forces alone is unlikely to overcome these barriers. Ministers agree that innovative and bold approaches are required by governments, in co-operation with industry, to realise the opportunities for energy efficiency improvements, and to accelerate the deployment of new and more efficient technologies.

Non-Fossil Fuels: Since the amount of energy that non-hydro-based renewable energy technologies contribute is quite small compared to the technical potential, increased government support of renewable technologies is warranted. Regarding nuclear power, a number of IEA countries are of the view that the use of nuclear energy, because it emits no sulphur dioxide, nitrogen oxides or greenhouse gases, provides an important response to the challenge of stabilising greenhouse gas emissions. A number of other IEA countries are of the opinion that those advantages do not offset the environmental concerns over the use of nuclear energy and have decided not to utilise nuclear power.

Technology: The development and adoption of improved technologies can significantly reduce and influence the nature of future energy requirements. Technology promotion by government can contribute significantly to mitigating and solving environmental problems. Intensified energy technology co-operation among IEA Member countries and with non-Member countries is an indispensable means to accelerate technology advances and to enhance long-term energy security and environmental protection. Ministers acknowledge the need to further integrate environmental objectives into national energy technology research, development and demonstration programmes and to promote international technology collaboration and co-ordination aiming at sustainable development and fully respecting intellectual property rights. In this respect, Ministers took note of the recent establishment of the IEA International Centre for Gas Technology Information. Ministers ask the IEA to analyse: the factors that influence new technology diffusion into the markets, identifying barriers and assessing policy options; the role international technology co-operation policies could have in meeting the objectives of the

Framework Convention on Climate Change; and the effect environmental and other government policies have on the penetration of new, more environmentally benign, technologies.

Access by individual developing countries and economies in transition to modern, cost-effective energy technologies appropriate to local circumstances will promote sustainable development. Adoption of clean, efficient technologies throughout the world will help to achieve needed gains in energy efficiency and reductions in greenhouse gas emissions and other pollutants. Ministers welcome the launching of the Greenhouse Gas Technology Information Exchange (GREENTIE) and call upon the IEA to step up its efforts to promote international co-operation in energy research and technology in this area.

Co-operation With Non-Member Countries: According to the *World Energy Outlook*, CO₂ emissions in the non-OECD regions could increase by over 60 per cent between 1990 and 2010. Thus, co-operation with non-Member countries becomes an increasingly important IEA priority, since the potential for slowing the rate of emissions growth in these countries without impairing their economic growth aspirations is great and can likely be achieved more cost effectively than in most IEA countries. In this context, Ministers request the IEA to assess the implications and benefits of reliable and measurable "joint implementation" activities with non-Member countries, in accordance with the Framework Convention on Climate Change. Member countries are also encouraged to strengthen bilateral co-operation with non-Member countries to this end.

B. Policy Instruments: A Mix of Measures

Taxes: Economic analysis of the potential effects of energy and carbon taxes yields important conclusions bearing on policy choices. Analysis suggests that it would take relatively high and substantially different levels of taxes between regions and countries to meet, in each IEA country separately, the goal of stabilisation of CO₂ and other greenhouse gas emissions. Nevertheless, a carbon tax could contribute effectively to the reduction of emissions by increasing efficiency and improving the competitiveness of non-fossil energy sources.

Financial Incentives: Fiscal and other financial incentives can be appropriate and effective instruments for various reasons, particularly to encourage the development and deployment of advanced technologies and to promote energy efficiency investment. But such incentives need to be designed to avoid negative effects on energy markets. Ministers agree, moreover, that elimination of certain subsidies that hold prices of fossil fuels below their costs of production or below their market value would result in a significant reduction in emissions and yield net economic benefits.

Regulations: Regulations to reduce emissions may in some situations be more cost-effective than taxes, but they need to be designed to facilitate not frustrate competition. Internationally co-ordinated norms and standards may be helpful in this regard. Voluntary agreements between the government and the private sector can also be efficient and even preferable approaches. Ministers request that the IEA develop methodologies to analyse the effectiveness of relevant regulations and voluntary agreements.

Action: A Mix of Measures: The effectiveness of individual policy measures will vary among IEA Member countries. Therefore, the response by each country will be a complex mix of possible measures, designed to deal with the circumstances that nation faces. Ministers agree that concerted actions by IEA Member countries are needed taking account of the stage of economic development of each country and regional arrangements among countries. The effects of individual IEA country efforts to reduce emissions should be comparable to the extent possible. Ministers call on the IEA to accentuate its efforts to analyse the effectiveness of the various policy instruments, and their effects on energy markets, and to develop criteria and methodologies to permit an assessment of the comparability of country responses. Ministers agree to supply within the existing IEA procedures the information necessary to evaluate the comparability of actions taken.