Unclassified **SG/SD(2002)1/FINAL**

Organisation de Coopération et de Développement Economiques
Organisation for Economic Co-operation and Development

16-May-2002

English - Or. English

GENERAL SECRETARIAT

SG/SD(2002)1/FINAL
Unclassified

Sustainable Development

INDICATORS TO MEASURE DECOUPLING OF ENVIRONMENTAL PRESSURE FROM ECONOMIC GROWTH

English - Or. English

JT00126227

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NOTE BY THE SECRETARIAT

This report has been prepared by the OECD Secretariat in response to the request issued by the OECD Council at Ministerial level (May 2001) that the Organisation assist its Member countries in realising their sustainable development objectives. Inter alia, the Council suggested that the OECD undertake the specific task of developing agreed indicators to measure progress across all three dimensions of sustainable development. This includes indicators that can measure the decoupling of economic growth from environmental degradation and that might be used in conjunction with other indicators in OECD's economic, social, and environmental peer review processes.

This report does not recommend a specific list of decoupling indicators for use in the peer review processes, but rather seeks to establish an analytical basis to facilitate agreement by Member countries on a list of indicators to be used in peer reviews. It also identifies gaps in the statistical and scientific data needing to be filled.

The OECD Environment Directorate prepared this report with the assistance of a Contact Group drawn from across OECD Directorates, and further reinforced by suggestions provided by a Group of External Advisers. Its successful completion depended on the co-operation of national Delegates from many OECD Committees, Working Parties and Working Groups and of many administrations within Member countries; their contributions have been invaluable. Our sincere thanks are therefore extended to all concerned.

The report was derestricted by the OECD Ad Hoc Group for Sustainable Development at its meeting on 16-17 April 2002, and is published as a general distribution document on the responsibility of the Secretary-General.

Data in this report largely come from "OECD Environmental Data - Compendium 1999" and from "OECD Environmental Indicators 2001 – Towards Sustainable Development", two documents prepared by the OECD Working Group on Environmental Information and Outlooks. Some were updated or revised on the basis of comments received from national Delegates.

It should be noted that, for organisational reasons, figures and tables included in this report do not fully reflect the most recent data updates provided by Member countries, to be published in the 2002 OECD Compendium.

In many countries, systematic collection of environmental data has a short history; sources are typically spread across a range of agencies and levels of government, and information is often collected for other purposes. When reading this report, one should therefore keep in mind that definitions and measurement methods vary among countries and that intercountry comparisons require great caution. One should also note that indicators presented in this report refer to the national level and may conceal major sub-national differences.

INDICATORS TO MEASURE DECOUPLING OF ENVIRONMENTAL PRESSURE FROM ECONOMIC GROWTH

EXECUTIVE SUMMARY

Decoupling environmental pressure from economic growth…

The term *decoupling* refers to breaking the link between "environmental bads" and "economic goods." Decoupling environmental pressures from economic growth is one of the main objectives of the OECD Environmental Strategy for the First Decade of the 21st Century, adopted by OECD Environment Ministers in 2001.

... may be either absolute or relative and. . .

Decoupling occurs when the growth rate of an environmental pressure is less than that of its economic driving force (e.g. GDP) over a given period. Decoupling can be either *absolute* or *relative*. Absolute decoupling is said to occur when the environmentally relevant variable is stable or decreasing while the economic driving force is growing. Decoupling is said to be relative when the growth rate of the environmentally relevant variable is positive, but less than the growth rate of the economic variable.

… can be measured by decoupling indicators.

Decoupling can be measured by *decoupling indicators* that have an environmental pressure variable for numerator and an economic variable as denominator. Sometimes, the denominator or driving force may be population growth or some other variable.

Except for some pressures, decoupling is common in OECD countries and further progress seems possible.

The evidence presented in this OECD report shows that relative decoupling is widespread in OECD Member countries. Absolute decoupling is also quite common, but for some environmental pressures little decoupling is occurring. The evidence also suggests that further decoupling is possible, since absolute decoupling was recorded in at least one OECD country for all but two of the decoupling indicators examined at the national level.

Some indicators in this report relate to decoupling environmental pressure from total economic activity, while others concern specific sectors…

This report explores a set of 31 decoupling indicators covering a broad spectrum of environmental issues. 16 indicators relate to the decoupling of environmental pressures from total economic activity under the headings of climate change, air pollution, water quality, waste disposal, material use and natural resources. The remaining 15 indicators focus on production and use in four specific sectors: energy, transport, agriculture and manufacturing.

… and several indicators have been decomposed to show the contribution of various factors to decoupling.

Some indicators have also been *decomposed* to highlight the extent to which various factors (e.g. technological factors, structural changes) have contributed to reducing or adding to environmental pressures in recent years. As may be seen from the figure next page, SOx emissions have exhibited absolute decoupling from GDP growth in OECD countries. This has been due in the past to an overall reduction in energy intensity with total final consumption of energy growing much slower than GDP. But it has also resulted from policies which have caused the energy sector to sharply reduce emissions per unit of energy produced.

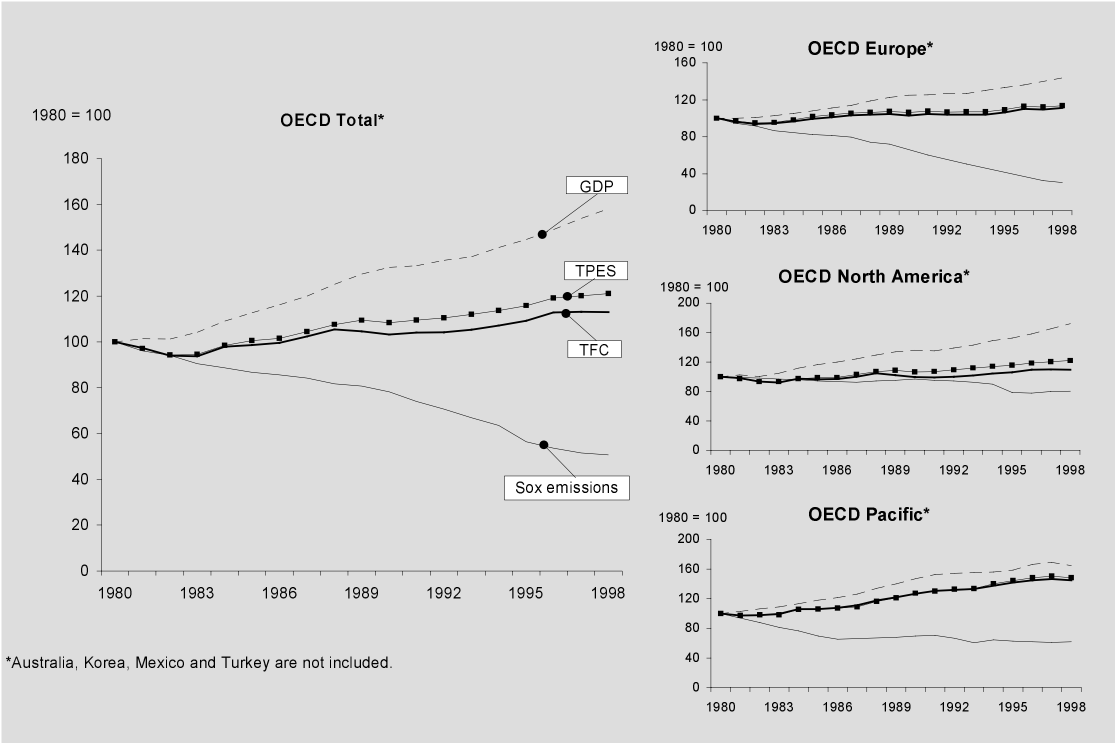
Good data are available for some indicators, but data gaps remain important and further conceptual work is needed.

The report presents information through graphs and tables and, for each indicator, provides a brief explanatory text to help interpretation. An attempt was made to maximise the country and time period coverage for each indicator, but data gaps remain important. Of the 31 indicators, ten are considered conceptually sound and data are available for at least 20 of the 30 Member countries from at least 1990. A further 12 indicators are also considered conceptually sound, but suffer from statistical data gaps. Finally, nine indicators are assessed as needing further work for a variety of reasons (e.g. concept, definition, measurement).

The interpretation of decoupling indicators must take account of absolute levels of environmental pressures and …

Decoupling indicators measure *changes over time.* Interpretation of the message conveyed by these indicators should take account of *absolute levels* of environmental pressures and economic driving forces. If these pressures need to be reduced, to below what threshold? If they are allowed to rise, to what ceiling? Moreover, the initial level of an environmental pressure and choice of time period considered can affect the interpretation of the results, because in their efforts to reduce environmental pressures countries do proceed according to different timetables.

SO_x emissions from energy use versus GDP, 1980-1998



Source: OECD

… country comparisons need to consider national circumstances.

When decoupling indicators are used to compare environmental performance among countries, the national circumstances of each country must also be taken into account. These include factors such as country size, population density, natural resource endowments, energy profile, (changes in) economic structure and stage of economic development.

Decoupling indicators tell only part of the story and do not take account of the environment's capacity to withstand pressures or …

Decoupling indicators, like all other types of indicators, shed light on particular aspects of a complex reality but leave out other aspects. For example, the decoupling concept lacks an automatic link to the environment's capacity to sustain, absorb or resist pressures of various kinds (deposition, discharges, harvests). In the case of renewable natural resources, a meaningful interpretation of the relationship of environmental pressure to economic driving forces will also require information about harvesting rates compared to renewal rates.

… cross-border flows of pollutants. Therefore, …

Also, decoupling indicators, when evaluated at a country level, do not capture the cross-border flow of various pollutants embodied in the international trade of goods.

… they should be seen as a complement to other approaches.

The approach used in this paper should be seen as a complement to other analytical frameworks. Moreover, to draw conclusions for policy from the evidence presented in this paper would also require consideration of the specific policy measures required to achieve decoupling in a cost effective way. From such a perspective, establishing an efficient level of decoupling, for a particular environmental resource or sink, ideally would involve ensuring that all external environmental costs are reflected in product prices, and then allowing the market to determine the appropriate level of use at the established price.

Some decoupling indicators need further work, but others are ready for use.

Therefore, while some of the indicators presented here are suitable for use in various OECD peer reviews, others need further development in terms of underlying concepts, choice of variables and data availability and quality.

INDICATORS TO MEASURE DECOUPLING OF ENVIRONMENTAL PRESSURE FROM ECONOMIC GROWTH

TABLE OF CONTENTS

INTRODUCTION

Decoupling environmental pressures from economic growth is one of the main objectives of the OECD Environmental Strategy for the First Decade of the 21st Century. The strategy was adopted by OECD Environment Ministers in May 2001 and subsequently endorsed by the OECD Council at Ministerial level. The Ministerial Council Communiqué, adopted at the latter meeting, asked the OECD to continue to assist its member governments in their efforts to achieve sustainable development. In particular, Ministers asked the organisation to develop agreed indicators to measure progress across all three dimensions of sustainable development, including *indicators that can measure the decoupling of economic growth from environmental degradation*. Ministers also asked for these indicators to be incorporated into OECD's economic, social, and environmental peer review processes, as well as to identify gaps in the statistical and scientific data needing to be filled.

The second objective of the OECD Environmental Strategy states that decoupling environmental pressures from economic growth requires an integrated effort to address consumption and production patterns, including by encouraging more efficient resource use. The strategy says this must involve increasing resource productivity and structural changes to reduce the demand for natural resources and promote waste minimisation. The strategy further states that policies to promote greater resource productivity and reduce negative environmental impacts should address both producers and consumers.

Chapter 1 of this paper explores the concept of decoupling and presents a list of "decoupling indicators". Chapter 2 examines the decoupling of environmental pressures from total economic activity under the headings of climate change, air pollution, water quality, waste disposal, material use and natural resources. Chapter 3 focuses on production and use in four specific sectors: energy, transport, agriculture and manufacturing. In both chapters, information is presented through graphs and tables. An attempt was made to maximise the country and time period coverage for each indicator, but data gaps remain important.

The first cycle of OECD Environmental Performance Reviews (1992-2000) presented a few decoupling indicators, notably relating to pollutant emissions to air, in most of the individual reviews. Second-cycle reviews, which will assess individual countries' implementation of the OECD Environmental Strategy, will include a broader range of indicators measuring the decoupling of environmental pressures from continued economic growth.

The scope of this paper is limited to highlighting, for selected indicators (energy, transport), the extent to which various factors (e.g. technological parameters, structural changes) have contributed to reducing environmental pressures in recent years. The approach used in this paper should therefore be seen as a complement to other analytical frameworks, such as the extended national balance sheets for "Green GDP" and material flow analysis. These methodologies could also provide data and insights for the development of further decoupling indicators. Moreover, to draw conclusions for policy from the evidence presented in this paper would require consideration of the specific policy measures required to achieve decoupling in a cost effective way. From such a perspective, establishing an efficient level of decoupling, for a particular environmental resource or sink, ideally would involve "getting the prices right", and then allowing the market to determine the appropriate level of use at the established price. In turn, getting the prices right will involve ensuring users and producers pay the full costs of their use of environmental resources, through the removal of environmentally harmful subsidies and the full internalisation of environmental costs.

1. RATIONALE AND PRESENTATION OF DECOUPLING INDICATORS

1.1 The Concept of Decoupling

The term "decoupling" has often been used to refer to breaking the link between "environmental bads" and "economic goods." In particular, it refers to the relative growth rates of a pressure on the environment and of an economically relevant variable to which it is causally linked. For example, at the national level, the growth rate of emissions of sulphur dioxide may be compared with the growth rate of GDP; at a sectoral level, the growth rate of emissions of carbon dioxide from the energy use may be compared to the growth rate of total primary energy supply (TPES).

Environmental indicators are often based on the Driving Force-Pressure-State-Impact-Response (DPSIR) framework, which evolved from the OECD Pressure-State-Response (PSR) model. Decoupling indicators describe the relationship between the first two components of the DPSIR model, i.e. a change in environmental pressure as compared to the change in driving force over the same period. Thus, indicators comprising variables belonging to other dimensions of the DPSIR framework (i.e. state, impact or response), are not described in this paper as decoupling indicators. From a policy perspective, "pressure" indicators and the decoupling indicators derived from them are attractive because they are apt to change over shorter time periods than "state" indicators under the influence of, for example, environmental or economic policy.

Environmental variables in a decoupling indicator are most often expressed in physical units, and the economic variable either in monetary units at constant base-year prices or in physical volumes. However, the notion of "driving force" suggests that relevant variables may sometimes include others, such as population growth[1].

Much of the evidence presented in this paper is expressed in terms of *changes over time.* Decoupling occurs when the growth rate of the environmentally relevant variable is less than that of its economic driving force (e.g. GDP)[2] over a given period. In most cases, however, *absolute* changes in environmental pressures are of fundamental concern. Hence the importance of distinguishing between *absolute and relative decoupling.* If GDP displays positive growth, "absolute decoupling" is said to occur when the growth rate of the environmentally relevant variable is zero or negative — i.e. pressure on the environment is either stable or falling. "Relative decoupling" is said to occur when the growth rate of the environmentally relevant variable is positive, but less than the growth rate of GDP[3]

1.2 Principal Findings

This document explores a set of 31 decoupling indicators covering a broad spectrum of environmental issues. Each indicator has been assigned a provisional rating in terms of its suitability for use in OECD peer review processes (Table 1.1). Indicators have been classed into one of three categories. Ten indicators have been provisionally classed as being conceptually sound with data available for at least 20 Member countries from at least 1990. A further 12 indicators are also considered conceptually sound, but suffering from statistical data gaps. Finally, nine indicators are assessed as needing further work for a variety of reasons (e.g. concept, definition, measurement). Table 1.1 also lists some proposals of additional or alternative indicators that could be considered.

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1. *Population growth becomes relevant when demand for certain environmentally relevant goods or services becomes saturated at high levels of per capita income.*
2. *NB.: the term decoupling is not used when the environmental pressure variable increases at a higher rate than the economic driving force.*
3. *In the literature, the terms strong and weak are sometimes used as synonyms for absolute and relative, respectively.*

Table 1.1 **Potential decoupling indicators**

	Robust[4]	Robust, but statistical gaps[5]	Stat. Gaps + further work required[6]	Comments
ECONOMY-WIDE DECOUPLING INDICATORS				
CLIMATE CHANGE				
Total greenhouse gas (GHG) emissions per unit of GDP and per capita	V			Could be complemented with indicator including land use change and forestry
Total CO_2 emissions per unit of GDP and per capita	V			
AIR POLLUTION				
Total NO_x emissions per unit of GDP	V			Possible aggregation in terms of acidification, eutriphication or ozone forming potential. Heavy metals and persistent organic pollutants (POPs) also ought to be considered
Total SO_x emissions per unit of GDP	V			
Total emissions of fine particulate matter per unit of GDP		V		
Total VOC emissions per unit of GDP		V		
WATER QUALITY				
Population NOT connected to sewage treatment plants versus total population	V but			Emissions of BOD would be a better indicator. Heavy metals and POPs should also be considered
Discharges of nutrients from households into the environment versus total population			V	
WASTE MANAGEMENT				
Municipal waste going to final disposal versus private final consumption (PFC)	V but			All waste should be considered; biogas extraction should be considered eventually
Amount of glass NOT collected for recycling versus PFC		V		Other materials than glass (e.g. steel, non-ferrous metals) would serve better as environmental pressures
MATERIAL USE				
Direct Materials Input (DMI) per unit of GDP		V		
Ecological Footprint (minus energy component) per unit of GDP.			V	
NATURAL RESOURCES				
Water resources Total freshwater abstraction per unit of GDP		V		
Forests and forest products				
Decoupling indicator				Appropriate decoupling indicator still to be defined e.g. concerning biodiversity loss per unit of production, or use of old-growth forests
Amount of paper/cardboard NOT recycled versus GDP	V			
Fisheries Capture fisheries production versus food consumption			V	Further indicators still to be explored
Biodiversity Pressure version of the Natural Capital Index per unit of GDP			V	Alternative indicators still to be explored

4 *Conceptually sound AND data available for at least 20 Member countries from at least 1990.*
5 *Conceptually sound but data not available for sufficient number of countries and/or time period.*
6 *Statistical gaps as well as measurement problems and/or definitional issues (incl. in relation to decoupling) still to be resolved*

	Robust[4]	Robust, but statistical gaps[5]	Stat. Gaps + further work required[6]	Comments
DECOUPLING INDICATORS FOR SPECIFIC SECTORS				
ENERGY				
CO_2, SO_x, and NO_x emissions from energy use per unit of GDP	V			
CO_2 emissions from electricity generation	V			
Energy-related CO_2 emissions from residential and commercial sectors per m^2 of floor area		V		
TRANSPORT				
Emissions of CO_2, NO_x, VOCs from passenger cars and freight vehicles (combined) per unit of GDP	V			
Passenger car-related emissions of NO_x and VOCs per unit of GDP			V	
Freight road transport-related emissions of NO_x and VOCs per unit of GDP			V	
AGRICULTURE				
Soil surface nitrogen surplus versus agricultural output		V		
Methane and nitrous oxide emissions from agriculture versus agricultural output			V	
Water intensity: total agricultural water use versus agricultural output		V		
Apparent consumption of commercial fertiliser (NPK) versus final crop output		V		
Apparent consumption of pesticide versus final crop output			V	Preferable to define a hazard-adjusted primary indicator
MANUFACTURING				
NO_x emissions from manufacturing industry versus manufacturing value-added		V		
Waste generated by manufacturing industry versus manufacturing value-added			V	
CO_2 emissions from energy-intensive industries versus value-added		V		
Freshwater abstraction by manufacturing industry versus manufacturing value-added		V		

The evidence presented in this document shows that although for some environmental pressures little decoupling is occurring, relative decoupling is widespread (Table 1.2). Absolute decoupling is also quite common. Moreover, the table suggests that further decoupling is possible, since absolute decoupling was recorded in at least one OECD country for all but two of the decoupling indicators examined at the national level. Readers should keep in mind that in this paper the emphasis is on describing *changes* in variables in percentage terms. These changes in decoupling over time tell only part of the story since in most cases changes in the absolute *levels* of environmental pressures are of fundamental importance. The description of individual indicators in Chapters 2 and 3 therefore includes a discussion of some of the caveats relevant to each indicator.

Table 1.2 **Decoupling in OECD countries**

	Australia	Austria	Belgium	Canada	Czech republic	Denmark	Finland	France	Germany	Greece	Hungary	Iceland	Ireland	Italy	Japan	Korea	Luxembourg	Mexico	Netherlands	New Zealand	Norway	Poland	Portugal	Slovak republic	Spain	Sweden	Switzerland	Turkey	United Kingdom	United States
ECONOMY-WIDE DECOUPLING INDICATORS																														
CLIMATE CHANGE																														
Total GHG-emissions per unit of GDP and per capita	V X	V V	V X	V X	**V** V	V X	**V** **V**	**V** **V**	**V** **V**	V X	V V	V X	V X	V X	V X	.. ..	V V	.. ..	V X	V V	V V	**V** **V**	V X	**V** **V**	V X	V V	V V	.. ..	**V** **V**	V X
Total CO_2 emissions per unit of GDP and per capita	V X	V X	V X	V X	**V** **V**	V X	V V	V X	**V** **V**	V X	**V** **V**	X X	V X	V X	V X	.. ..	V V	.. ..	V X	V X	V X	**V** **V**	X X	**V** **V**	V X	V V	V V	.. ..	**V** **V**	V X
AIR POLLUTION																														
Total NO_x emissions per unit of GDP	..	**V**	V	**V**	**V**	**V**	**V**	**V**	**V**	X	**V**	V	V	**V**	**V**	V	**V**	..	**V**	..	**V**	**V**	X	**V**	V	**V**	**V**	..	**V**	V
Total SO_x emissions per unit of GDP	..	**V**	**V**	**V**	**V**	**V**	**V**	**V**	**V**	V	**V**	V	**V**	**V**	**V**	**V**	**V**	..	**V**	V	**V**	**V**	V	**V**	**V**	**V**	**V**	..	**V**	**V**
Total emissions of fine particulate matter per unit of GDP	..	..	..	X	V	..	V	V	V	..	**V**	..	..	..	..	V	..	..	**V**	V	V	**V**	..	**V**	..	..	**V**	..	**V**	**V**
Total VOC emissions per unit of GDP	V	**V**	V	**V**	**V**	**V**	**V**	**V**	**V**	X	**V**	**V**	V	**V**	**V**	..	**V**	..	**V**	V	V	**V**	X	..	**V**	**V**	**V**	..	**V**	**V**
WATER QUALITY																														
Population NOT connected to sewage treatment plants versus total population	..	**V**	**V**	**V**	**V**	**V**	**V**	**V**	**V**	..	**V**	..	..	**V**	**V**	**V**	..	..	**V**	**V**	**V**	..	**V**	**V**	**V**	**V**	**V**	..	**V**	..
Discharges of N and P from households into the environment versus total population	.. ..	**V** **V**	.. ..	V **V**	.. ..	**V** **V**	**V** **V**	.. ..	.. ..	.. ..	**V** **V**	X **V**	V **V**	.. ..	V **V**	.. ..	.. ..	.. ..	**V** **V**	.. ..	**V** **V**	.. ..	.. ..	.. ..	.. ..	**V** **V**	**V** **V**	V V	.. ..	.. ..
WASTE MANAGEMENT																														
Municipal waste going to final disposal versus PFC	..	**V**	**V**	..	..	**V**	V	..	**V**	..	X	V	..	**V**	V	V	V	V	V	X	V	V	X	..	X	V	V	X	V	V
Amount of glass NOT collected for recycling versus PFC	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	V	..	..	..	..	..	..	..	..	..	..	V
MATERIALS USE																														
Direct Materials Input (DMI) per unit of GDP	..	V	V	..	..	V	V	V	V	X	..	..	V	V	..	..	V	..	V	..	..	..	V	..	V	V	..	..	V	..
NATURAL RESOURCES																														
Total freshwater abstraction per unit of GDP	..	V	..	V	**V**	**V**	**V**	**V**	V	..	X	V	..	..	V	V	..	..	V	..	..	V	..	V	V	V	V	X	..	V
Amount of paper/cardboard NOT recycled versus GDP	V	V	X	X	..	X	V	V	**V**	X	X	..	V	X	V	V	X	X	X	X	**V**	X	X	..	X	V	V	X	X	V

V = decoupling (absolute when infilled); X = no decoupling; .. = data not available. N.B. The information presented in this table relates to varying time periods. For details, refer to individual graphs in this document.
Source: OECD.

Table 1.2 **Decoupling in OECD countries** (continued)

	Australia	Austria	Belgium	Canada	Czech republic	Denmark	Finland	France	Germany	Greece	Hungary	Iceland	Ireland	Italy	Japan	Korea	Luxembourg	Mexico	Netherlands	New Zealand	Norway	Poland	Portugal	Slovak republic	Spain	Sweden	Switzerland	Turkey	United Kingdom	United States
DECOUPLING INDICATORS FOR SPECIFIC SECTORS																														
ENERGY																														
Energy-related emissions per unit of GDP of CO_2, NO_x and SO_x	∨. . ..	∨ ∨ ∨	∨ ∨ ∨	∨ ∨ ∨	∨ ∨ ∨	∨ ∨ ∨	∨ ∨ ∨	∨ ∨ ∨	∨ ∨ ∨	X X X	∨ ∨ ∨	∨ ∨ ∨	∨ ∨ ∨	∨ ∨ ∨	∨. ...	∨. . ..	∨ ∨ ∨	∨. ...	∨ ∨ ∨	X ∨. .	∨ ∨ ∨	∨ ∨ ∨	X X X	∨ ∨ ∨	∨ ∨ ∨	∨ ∨ ∨	∨ ∨ ∨	X X ..	∨ ∨ ∨	∨ ∨ ∨
Energy-related CO_2 emissions per m^2 of floor area from the *residential* and *commercial* sectors	∨. .	.. ..	.. ..	∨ ∨	.. ..	∨. .	.. ..	X ∨	.. ..	.. ..	.. ..	.. ..	.. ..	∨. .	X X	.. ..	.. ..	.. ..	.. ..	.. ..	∨. .	.. ..	.. ..	.. ..	.. ..	∨. .	.. ..	.. ..	∨. .	∨ X
CO_2 emissions from electricity generation	∨	X	∨	X	∨	∨	∨	∨	∨	X	∨	∨	∨	X	∨	∨	∨	∨	∨	X	X	∨	X	∨	∨	∨	∨	X	∨	∨
TRANSPORT																														
Road transport-related emissions per unit of GDP of CO_2, NO_x and VOCs	∨ ∨ ∨	∨ ∨ ∨	X X X	∨. .∨	X ∨ X	X ∨ ∨	∨ ∨ ∨	X ∨ ∨	X ∨ ∨	X X X	X.. ∨	∨ ∨ ∨	∨ ∨ ∨	X ∨ ∨	X.. ∨	X	X ∨ ∨	X	∨ ∨ ∨	∨ ∨ X	∨ ∨ ∨	X.. ∨	X X X	∨ ∨ ∨	X ∨ ∨	∨ ∨ ∨	X ∨ ∨	∨. ...	∨ ∨ ∨	∨ ∨ ∨
Passenger car-related emissions per unit of GDP of NO_x and VOCs	.. ..	∨ ∨	∨ ∨	.. ..	∨ ∨	∨ ∨	∨ ∨	∨ ∨	∨ ∨	∨ ∨	∨ ∨	.. ..	∨ ∨	∨ ∨	.. ..	.. ..	∨ ∨	.. ..	∨ ∨	.. ..	∨ ∨	∨ ∨	∨ ∨	.. ..	∨ ∨	∨ ∨	∨ ∨	∨ ∨	∨ ∨	.. ..
Freight road transport-related emissions per unit of GDP of NO_x and VOCs	.. ..	X X	∨ ∨	.. ..	X X	∨ ∨	∨ ∨	X X	X X	∨ ∨	∨ ∨	.. ..	∨ ∨	∨ ∨	.. ..	.. ..	∨ ∨	.. ..	∨ ∨	.. ..	∨ ∨	X X	∨ ∨	.. ..	X X	∨ ∨	X X	X X	∨ ∨	.. ..
AGRICULTURE																														
Soil surface nitrogen surplus versus agricultural output	∨	∨	∨	X	..	∨	∨	∨	∨	∨	..	..	X	∨	∨	..	..	..	∨	..	X	..	..	..	∨	∨	∨	∨	∨	∨
Emissions from agriculture of methane and nitrous oxide vs agricultural output	∨ ∨	∨ X	∨ ∨	∨ X	.. ..	∨ ∨	X ∨	∨ ∨	∨ ∨	∨ ∨	.. ..	.. ..	X X	∨ ∨	∨ ∨	.. ..	.. ..	.. ..	∨ X	.. ..	X X	.. ..	.. ..	.. ..	X ∨	X X	X ∨	.. ..	∨ ∨	∨ ∨
Water intensity: total agricultural water use versus agricultural output	..	X	..	∨	..	∨	X	∨	..	X	..	..	..	..	∨	..	..	..	..	..	..	..	..	..	∨	X	..	..	X	..
Apparent consumption of commercial fertiliser (NPK) vs final crop output	X	∨	∨	∨	..	∨	∨	∨	∨	∨	..	..	∨	∨	∨	..	..	..	∨	..	∨	..	..	..	X	∨	∨	X	∨	∨
Apparent consumption of pesticide versus final crop output	..	∨	∨	..	..	∨	∨	∨	∨	X	..	..	X	..	..	..	..	..	∨	..	∨	..	..	..	∨	∨	∨	..	∨	..
MANUFACTURING																														
NO_x emissions from manufacturing industry vs manufact. VA	..	∨	∨	∨	∨	..	∨	∨	∨	X	..	X	∨	∨	..	..	..	..	∨	X	∨	..	X	..	∨	..	..	..	∨	∨
Waste generated by manufacturing industry vs manufact. VA	..	..	..	..	..	X	X	..	..	..	∨	∨	X	X	∨	∨	..	..	X	..	X	..	∨	..	..	..	..	..	..	..
CO_2 emissions from energy-intensive industries versus VA	..	..	..	X	..	..	..	∨	∨	..	..	..	..	∨	X	..	..	..	..	..	..	..	..	..	..	..	..	..	∨	∨
Freshwater abstraction by manufacturing industry versus VA	..	∨	..	..	∨	..	..	∨	..	..	..	∨	..	..	..	..	..	..	..	..	..	∨	..	∨	..	..	..	..	X	..

∨ = decoupling (absolute when infilled); X = no decoupling; .. = data not available. N.B. The information presented in this table relates to varying time periods. For details, refer to individual graphs in this document.
Source: OECD.

1.3 Understanding Changes in Decoupling Indicators

The choice of decoupling indicator depends on the problem to be elucidated. In this report, we use the term decoupling indicator to describe the indicator containing the particular environmental pressure (preferably a "bad") and the particular driving force (preferably a "good") of interest. Numerator and denominator will usually be several steps removed from each other in the cause-effect chain of events. In some cases, it may be possible to decompose the main or *primary* indicator into two or more *intermediate* indicators, as follows:

Primary indicator	=	*Intermediate indicator 1*	*	*Intermediate indicator 2*	*	*Intermediate indicator n*

For instance, if in the case of emissions of air pollutants by the energy sector per unit of GDP, the following relationship can be written:

Emissions/GDP	=	Emissions/TPES[7]	*	TPES/TFC[8]	*	TFC/GDP
		Depends on emission factors and fuel mix		depends on conversion efficiency and the fuel mix		depends on end-use energy intensities, fuel mix, activity and structure of the economy

In other words, the decomposition of the relationship between emissions from the energy sector and economic growth allows to distinguish among scale (or volume), sector composition and technology effects. Each of these factors may, in turn, be influenced by policies, and may be further decomposed, e.g., by fuel or by end-use sector. When such systematic decomposition into intermediate indicators is not possible, one or more *context indicators* are proposed as relevant background for the interpretation of the primary indicator.

Many of the variables that feature in decoupling indicators also appear in the concepts of resource efficiency, resource intensity, and resource productivity. These synthetic measures may be calculated as ratios of averages, marginal quantities, or rates of change (to yield elasticities). For example, resource efficiency and resource intensity are calculated as ratios of resource use to economic value-added, while resource productivity is the inverse ratio. Decoupling is usually conceived as an elasticity focusing on changes in volumes, whereas efficiency and intensity are more concerned with the actual values of these ratios. Which usage is chosen depends on the context and, often, on the audience being addressed[9]. When such indicators can be assembled on a time-series basis, mathematical functions can be fitted to the data and used to compute other parameters useful for policy analysis. Decoupling indicators can also be formulated at the product or enterprise level, as is being attempted at present by the Global Reporting Initiative (GRI).

Decoupling indicators are primarily intended to track, for a single country, temporal changes in the relationship between environmental pressures and economic driving forces. The need to also consider absolute values (i.e. not only changes) of a decoupling indicator has already been mentioned. When decoupling indicators are used to compare environmental performance among countries, the national circumstances of each country must also be taken into account. These include factors such as country size, population density, natural resource endowments, energy profile, (changes in) economic structure

7. *TPES = Total primary energy supply*
8. *TFC = Total final consumption of energy*
9. *These terms appear to draw on the vocabulary of economics and business, but do not always have the same meaning. For example, resource productivity will be expressed in agricultural economics as the yield per hectare. As a marginal concept—the ratio of the addition to total value-added to an additional unit of an input to production—this is, of course, simply marginal productivity, and is widely used. The term efficiency is used quite differently. In economics, the term is used most often to refer to allocative efficiency. This refers to a situation where resources are deployed in such a way that the value-added per unit of resource use is the same in all sectors. This type of efficiency (if adjusted to take into account environmental externalities) is a necessary, but not sufficient condition for achieving environmentally sound use of natural resources—which also requires respecting environmental sustainability criteria I and II—as defined in the OECD Environmental Strategy-- at the lowest economic cost to society. In the business community, a term widely promoted by the World Business Council on Sustainable Development is eco-efficiency, which refers to adding value while reducing the intensity of resource use, in other words, achieving those improvements in resource efficiency which are also commercially profitable.*

and stage of economic development. Moreover, the initial level of an environmental pressure and the choice of time period considered can affect the interpretation of the results, because countries do proceed according to different timetables.

1.4 Limitations of the Decoupling Concept

The concept of decoupling is attractive for its simplicity. Graphs displaying a rising GDP juxtaposed with diminishing pollutant emissions, or pollutant emissions rising faster than GDP, convey a very clear message. However, graphs of synthetic decoupling indicators often convey mixed, or double, messages. In a growing economy, relative decoupling will imply that environmental pressures are still rising. Equally, if economic activity is falling, relative or even absolute decoupling may not imply a positive development for society as a whole.

Furthermore, the decoupling concept has no automatic link to the environment's capacity to sustain, absorb or resist pressures of various kinds (deposition, discharges, harvests). In the case of renewable natural resources, a meaningful interpretation of the relationship of environmental pressure to economic driving forces will require information about the intensity of use of the resource in question, i.e. of harvesting rate compared to renewal rate. In this paper such information is presented, where possible, through a range of context indicators (e.g. water abstraction as a share of available resources, forest harvesting versus annual growth increment). Also, prices are an important factor influencing environmental pressure or natural resource use. The absence of price information in the decoupling approach can be considered a weakness. Of course, in the DPSIR framework, observed market prices reflect the response of economic agents to scarcity and of public policy interventions.

Others have pointed to the cross-border flow of environmental externalities, which are not captured by most country-based indicators (but material flow analysis and the Ecological Footprint methodologies do address this issue explicitly). Often quoted in this respect are the GHG-emissions embodied in a country's imports and exports. A different type of example can be found in the fisheries sector, when fisheries are not confined within national boundaries[10]. The indicators presented in this paper do not account for such cross-border externalities, although they are surely relevant in explaining observed trends in decoupling.

Finally, the relationship between economic driving forces and environmental pressures, more often than not, is complex. Most driving force have multiple environmental effects, and most environmental pressure are generated by multiple driving forces, which, in turn, are affected by societal responses. The PSR/DPSIR model will not reveal all such linkages and hence the need to use decoupling indicators within a more complete analytical framework.

1.5 Policies to Achieve Decoupling

As mentioned in Section 1.3, changes in decoupling may be decomposed in a number of intermediate steps. These may include changes in the scale of the economy, in consumption patterns, and in economic structure — including the extent to which demand is satisfied by domestic production or by imports. Other mechanisms in the causal chain include the adoption of cleaner technology, the use of higher-quality inputs, and the post-facto clean-up of pollution and treatment of waste.

Over time, these mechanisms will change for a variety of reasons. Many of them can be influenced, directly or indirectly, by sectoral and environmental policies. For example, consumer behaviour can be changed through the promotion of ecolabels or the imposition of product taxes. Incentives can be provided to enterprises to cover the cost of a life cycle analysis of products. Cleaner Production Technologies can be promoted through measures that internalise environmental externalities and by favourable tax treatment of environmental research and development. Toxic additives in petrol can be banned and minimum energy performance standards can be imposed for cars or electrical appliances.

10 . Information about the intensity of resource use can only be presented on the basis of discrete stocks of particular fish species. But where fish stocks are exploited by foreign fishing fleets, it becomes difficult to link such information to country-based decoupling indicators.

Table 1.3 **Selected multinational pollution targets**

Mandate	Target
♦ UN Framework Convention on Climate Change Kyoto Protocol	Aggregate reduction of GHG emissions by developed (Annex 1) countries of 5% over 2008-12 (base year 1990). Not all OECD Members are Annex 1 countries.
♦ UN-ECE Convention on Long-Range Transboundary Air pollution:	
– 1985 Helsinki Protocol on the Reduction of Sulphur Emissions or their Transboundary Fluxes by at least 30 per cent	Reduction of SO_x emissions of 30% by 1993 (base year 1980)
– 1988 Sofia Protocol concerning the Control of Nitrogen Oxides or their Transboundary Fluxes	Stabilisation NO_x emissions compared to 1987 (1978 for US)
– 1991 Geneva Protocol concerning the Control of Emissions of Volatile Organic Compounds or their Transboundary Fluxes	Generally, a reduction of VOC emissions of 30% by 1999 (base year 1984-90). Commitments vary by country.
– 1994 Oslo Protocol on Further Reduction of Sulphur Emissions (2nd Sulphur Protocol)	Targets differentiated by country
– 1999 Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-level Ozone	Country-specific emission ceilings to be achieved by 2010 for sulphur, NO_x, VOCs and ammonia
♦ Proposed EU National Emission Ceilings Directive (NECD), setting reduction targets for 2010 (compared to 1990 emission levels) as follows:	
– Sulphur dioxide	77%
– Nitrogen oxides	51%
– Non-methane VOCs	60%
– Ammonia	18%
♦ International Conferences on the Protection of the North Sea	Reductions in the total discharges and emissions of nutrients (in the order of 50%) and 36 hazardous substances (of between 50 and 70%).
♦ EU Fifth Environmental Action Plan: stabilise municipal waste generation	300kg/capita by 2000
♦ EU Directive 1999/31/EC to reduce amount of biodegradable municipal waste (BMW) going to landfill	By 2006: landfill a maximum of 75% by weight of BMW produced in 1995 (certain derogations apply); By 2009: maximum of 50%; by 2016, maximum of 35%.

Source: OECD, UN/ECE, EU

An example of the different role of these mechanisms is provided by emissions of sulphur dioxide. Indicators presented in this report show an absolute decoupling of sulphur dioxide emissions from energy production (e.g., as a result of regulations on and incentives for the use of low-sulphur fuels) in nearly all OECD countries. This partly reflected the reduction in energy use from GDP (e.g., through greater energy efficiency, and/or shifting demand to less energy-intensive goods and services). Another example of the role of these different mechanisms is provided by discharges of nitrogen; these, in the future, could be decoupled from conventional agricultural production (aiming at less and better use of nitrogenous fertilisers) as demand shifts towards eco-labelled products and/or low-meat diets. Similarly, the negative environmental impacts of waste can by reduced by technologies which minimise the release of dioxins from incineration and the leaching of hazardous substances and methane from landfills; however, they can also be reduced by waste prevention policies designed to reduce the "demand" for waste disposal, and its growth relative to GDP or total consumption.

1.6 Targets, Thresholds and Ceilings

Most discussions concerning decoupling will sooner or later raise questions about the projected trajectories for environmental pressures if economic growth continues. The OECD Environmental Strategy links this question to the capacity of the environment to sustain human activity in the long term; it points to the need to "reverse unsustainable trends and guarantee vital environmental functions by 2010 and beyond." How can we judge whether, for any particular issue, environmental pressures need to be reduced (absolute decoupling) or can be allowed to grow, albeit at rates less than that of overall GDP (relative decoupling), for development to be sustainable? If pressures need to be reduced, to what threshold? If they are allowed to rise, to what ceiling?

These questions point to the need to compare trends in decoupling with explicit policy targets, where they exist. For pollution pressures, most OECD countries have addressed these questions by setting both environmental quality standards (e.g. receiving water and ambient air quality standards) and effluent/emission limits. These targets are generally based on a scientific assessment of environmental quality objectives and associated levels of maximum environmental pressure. Some countries also apply benefit-cost analysis to ensure that the costs to society of ensuring compliance with the limits do not exceed the benefits of doing so. At the regional and international levels, there are now several legally-binding conventions and agreements setting targets (emission ceilings) for particular environmental pressures (e.g. sulphur dioxide, volatile organic substances) (Table 1.3).

For natural resources, "uses" can be viewed either as a driving force (and expressed in value terms) or as a pressure on the environment (and measured in physical units). The use of non-renewable resources (e.g., fossil fuels) is often treated as a driving force, whereas the use of renewable resources (e.g. water, fish, wood) is mostly considered a pressure. For some resources, many countries have imposed constraints on natural resource use because of the environmental pressure they generate. For example, the abstraction of surface water is sometimes regulated in order to maintain minimum flows in rivers for the protection of aquatic ecosystems. These targets, however, are less well developed than for pollution pressures.

Pressure reduction targets at a national or international level have so far been expressed in absolute (e.g. tonnes of sulphur dioxide per annum) rather than relative terms (emissions per unit of GDP, or resource use per unit of GDP). However, in some cases only decoupling targets may be politically feasible even where the long-term objective may be a reduction in the absolute levels of environmental pressure[11]. Applied to products, decoupling targets, usually called performance standards, are increasingly used (e.g. minimum energy performance standards for electrical appliances). Where possible, trends in decoupling can be compared to policy targets to show the "distance to go". In this context, targets for decoupling indicators themselves may usefully be seen as intermediate objectives of environmental policies. However, even in the absence of defined thresholds, ceilings or targets, decoupling indicators are useful to compare countries, to identify similarities and differences, and as a starting point to assess the potential for improved performance.

1.7 Presentation of Decoupling Information

The most direct manner of displaying decoupling between an environmental pressure and an economic driving force is to plot two indexed (e.g. 1980=100) time-series on the same graph. From such a graph, it is immediately clear whether the economic driving force is growing or shrinking, whether decoupling – absolute or relative – is occurring, when it started and whether it continues. This method is used here when displaying overall trends for all OECD countries and for the three main OECD regions (i.e. Europe, North America and Pacific). Some of these qualities are lost if decoupling is presented as a single line (i.e., a time-series of the ratio of environmental pressure to driving force), although the idea of improvement in efficiency or intensity is better communicated this way.

However, neither of the above presentations lends itself well to numerical displays of decoupling trends for the 30 individual OECD countries. To compare decoupling among countries, the ratio of the value of the decoupling indicator at the end and the start of a given time period is defined as follows:

$$Ratio = \frac{(EP/DF)_{\text{end of period}}}{(EP/DF)_{\text{start of period}}}$$

where EP = Environmental Pressure
and DF = Driving Force.

11. Such targets (sometimes called "dynamic") were used in voluntary agreements on CO_2 emission reductions in Germany.

If the ratio is less than 1, decoupling has occurred during the period — although it does not indicate whether decoupling was absolute of relative. To avoid displaying (on a bar graph), small values when decoupling is significant, a decoupling factor is defined as:

Decoupling factor = 1 – decoupling ratio

The decoupling factor is zero or negative in the absence of decoupling and has a maximum value of 1 when environmental pressure reaches zero[12]. This decoupling factor is displayed on the right panel of all figures in this paper.

1.8 Aggregation and Clustering of Indicators

When several pollutants have similar effects, aggregation can reduce the information load. For example, to construct a single indicator accounting for the overall effect of all six greenhouse gases (GHG) on the climate system, conversion factors (based on the relative radiative force of the individual gases) are used to construct the decoupling indicator "GHG emissions from all sources per unit of GDP" (section 2.1). Similarly straightforward procedures have been used elsewhere to construct indicators for acidification, toxic contamination, ozone depletion or low-level ozone formation. Such aggregated indicators can often be linked to an appropriate driving force to obtain aggregated decoupling indicators.

In other cases, more complex aggregation procedures may be required. One approach used to produce a weighted index of local air pollution is based on the health effects from exposure to specific levels of individual pollutants. A variety of other aggregated environmental indicators have been proposed in recent years, some of which are used for communication (e.g. various urban air pollution indices) and/or policy making (e.g. the indicators associated with the Dutch National Environmental Policy Plan). Other indicators push the aggregation even further, using a common numeraire (such as tonnes) to aggregate measures across a variety of environmental and natural resource issues. Nevertheless, aggregated indicators are still far from being universally accepted. Because of this, most indicators presented in this paper are based on individual pollutants and natural resources.

1.9 Gaps in the Statistical and Scientific Data

Despite efforts over the past few decades to improve coverage, gaps in statistical data remain pervasive, definitions often differ across countries (e.g. for waste management) and change over time. More work in estimating missing data points could extend the time periods and number of countries covered for some indicators presented in this document. Even more important are the gaps resulting from some data not being collected at all. This first attempt to assemble a comprehensive set of decoupling indicators is necessarily based on existing data. However, existing data were collected for a range of purposes. This underscores the importance of reviewing the information needs associated with the decoupling perspective, determining what other information would be required and assessing whether it would be worthwhile collecting it.

Beyond statistical gaps are science gaps. Many ecological systems are still poorly understood. Scientists have pointed to the need for caution when setting "sustainable limits" to environmental pressures, as ecological processes are non-linear and we know little about thresholds and trajectories. Certain pressures can continue to grow without apparent effect and then, after crossing some unsuspected threshold or ceiling, suddenly show dramatic discontinuities or even complete collapse (as has happened with some fisheries). Policy makers need to be aware of these gaps when using environmental indicators. This is particularly true for decoupling indicators, which can convey a positive message (i.e. relative decoupling) while in reality a country's ecosystems may be heading towards breakdown. More often than not, the complex nature of these thresholds cannot be shoehorned[13] into the format of a decoupling indicator. In these cases, caution is needed when interpreting decoupling indicators.

12. *Note that the decoupling factor will generally not change linearly, even if both environmental pressure and driving force do.*
13. *Differences of scale are another reason why country-based decoupling indicators are not well suited to take account of ecosystem constraints. Neither environmental pressures nor ecological "carrying capacity" are evenly distributed across a country's surface area and local ecosystem collapses are likely to occur long before nationally-averaged pressures will approach critical values.*

Table 1.4 **OECD environmental indicator selection criteria**

Policy relevance and utility for users*	An environmental indicator should: ♦ provide a representative picture of environmental conditions, pressures on the environment or society's responses; ♦ be simple, easy to interpret and able to show trends over time; ♦ be responsive to changes in the environment and related human activities; ♦ provide a basis for international comparisons; ♦ be either national in scope or applicable to regional environmental issues of national significance; ♦ have a threshold or reference value against which to compare it, so that users can assess the significance of the values associated with it.
Analytical soundness*	An environmental indicator should: ♦ be theoretically well founded in technical and scientific terms; ♦ be based on international standards and international consensus about its validity; ♦ lend itself to being linked to economic models, forecasting and information systems.
Measurability*	The data required to support the indicator should be: ♦ readily available or made available at a reasonable cost/benefit ratio; ♦ adequately documented and of known quality; ♦ updated at regular intervals in accordance with reliable procedures.

* *These criteria describe the 'ideal' indicator; not all of them will be met in practice*

1.10 Relationship to Other Indicator Sets

Although each of the indicator sets currently used by various international organisations was developed for a different purpose or from a different perspective, they are all based on the long-established data collection efforts of the OECD, IEA, United Nations or the FAO. Most of these indicators are also based on a common set of selection criteria for environmental indicators, such as those published by the OECD in 1993 (Table 1.4). These criteria are also valid for decoupling indicators. It is therefore no surprise that many variables in the present set of decoupling indicators also show up in other indicator sets (Appendix 1). In many cases, this reflects more necessity rather than choice; while more suitable indicators would be preferred, the required data are simply not collected.

Decoupling indicators can also enrich the set of sustainable development indicators proposed in Chapter 3 of the OECD publication "Sustainable Development: critical issues" (2001), as they help link selected environmental resource and outcome indicators with economic variables and indicators (such as GDP or sectoral outputs). Decoupling indicators help reveal prospects for longer term developments that are essential for progressing towards sustainable development, both at macro and at sectoral level. Decoupling indicators hence are a useful tool to complement the proposed extended national balance sheets and the development of underlying frameworks.

The indicators proposed for use in EDRC reviews in response to the request in the Ministerial Council Communiqué of May 2001, are grouped in seven policy areas. Five of these concern environmental policy (global warming, air pollution, water pollution, natural resource use and waste treatment) and include several environmental pressure indicators. Most of these pressure indicators use the same variables, and are taken from the same data sets, as the decoupling indicators discussed in this paper (Table 1.5).

Table 1.5 **Environmental pressure indicators suggested for the EDRC reviews compared to decoupling indicators**

Policy area	*Pressure indicators*	*Comparable decoupling indicator in this paper*
Global warming	Gross GHG emissions per capita	Gross GHG emissions per unit of GDP;
	CO_2 emissions from: - electricity generation per kWh - industry relative to index of manufacturing production - residential sector per capita - road transport per vehicle	CO_2 emissions from: - electricity generation per kWh, - the residential and commercial sectors per m^2; - road transport per unit of GDP - energy-intensive industries versus value added;
		Methane and nitrous oxide emissions from agriculture versus final agricultural output
Air pollution	Change in per capita emissions of SO_x, NO_x, VOCs and particles Level of per capita emissions of SO_x, NO_x, VOCs	Emissions of SO_x, NO_x, particulates and VOCs per unit of GDP
	SO_x-emissions per unit of electricity output NO_x-emissions per vehicle	Emissions from: – energy production (SO_x and NO_x) versus GDP, – transport(NO_x and VOCs) versus GDP, and – manufacturing (NO_x) versus manufacturing value added
Water pollution	Connection of households to public or private sewerage systems	Population NOT connected to sewage treatment plants versus total population
	Annual % change in nitrate and phosphate fertiliser use	Nutri ent discharges from households versus population
Natural resource use	Marine fisheries production	Capture fisheries production versus food consumption
	Production of roundwood Intensity of use of forest resources	Intensity of use of forest resources (context indicator)
	Water withdrawals as a % of available resources	Freshwater abstraction per unit of GDP Water withdrawals as a % of available resources (context indicator)
	Fossil fuel production	–
	Mineral production	–
Waste treatment	Per capita generation of waste Annual growth in total municipal waste generation Municipal waste generation relative to final consumption Disposal of municipal waste to landfill and incineration	Municipal waste going to final disposal versus private final consumption

Source: OECD.

References

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2. ECONOMY-WIDE DECOUPLING INDICATORS

2.1 CLIMATE CHANGE

Virtually all sectors of the economy give rise to greenhouse gas emissions. The energy sector, including transport, is the most pervasive and largest source of emissions, but agriculture, forestry, industrial processes and waste management also contribute significantly. Among the six greenhouse gases (carbon dioxide, methane, nitrous oxide and the three fluorinated gases hydrofluorocarbons, perfluorocarbons, and sulphur hexafluoride), carbon dioxide (CO_2) is the most important with 82% of the total in terms of global warming potential (GWP). Methane (CH_4) has a GWP 21 times that of CO_2; nitrous oxide (N_2O) has a GWP of 310.

In OECD countries, methane emissions account for 9.7% of total GHG emissions. The largest sources are the natural gas and oil industry (leaks and deliberate releases), livestock enteric fermentation (the normal digestive process of livestock), and landfilling of solid waste (the decomposition of organic matter in landfills) – together accounting for 75% of total methane emissions. Nitrous oxide emissions account for 6.6% of total GHG emissions in the OECD area. The largest emission source of N_2O is agricultural soil (over 60%), whereas industrial processes account for another 15%. N_2O emissions from transport grew rapidly (over 20%) during the last decade as a result of the introduction of the catalytic converter. The three fluorinated gases (HFCs, PFCs and SF) account for about 2% of total emissions in OECD countries. Anthropogenic emissions and removals from land-use and forestry have at this stage not yet been included in the figures presented here, pending agreement on calculation methods.

In 1998, 44% of total OECD CO_2 emissions emanated from the energy transformation and supply sector, 27% from the transport sector, and 15% each from industry and other sectors. The decoupling of energy-related CO_2 emissions from economic growth is discussed in section 3.1 below. CO_2 emissions from transport are treated in section 3.2 and those related to energy-intensive industries in section 4.4. GHG emissions from agriculture are discussed in section 3.3.

Effective policy-making must pay attention to the underlying drivers of emission trends. For example, growth in energy sector CO_2 emissions is a function of several key underlying factors. The general picture is one of increasing scale (population and GDP/capita) offset to some degree by reduced intensity of environmental emissions per unit of production. In the case of energy-related CO_2, scale effects have outweighed intensity improvements, so that the overall level of emissions has been increasing. In other sectors, this may not be the case. For example, recent improvements in some industrial processes have been rapid enough for CO_2 emissions to have fallen in some sectors, despite increases in the scale of activity (Figure 3.4.3). Finally, the CO_2 emissions embedded in imported products are not accounted for in the statistics used here, but such analysis is receiving growing interest and would enrich our understanding of changes in GHG emissions in different countries. A project that seeks to quantify these effects and, more generally, the significance of imported emissions has recently been proposed within the OECD.

♦ ***Total GHG emissions per unit of GDP and per capita***

Total OECD country emissions[14] (excluding land-use change and forestry) of all greenhouse gases exhibited relative decoupling from economic growth over the 1990-99 period: emissions increased by about 4% (reaching 14 132 Mt CO_2 equivalent), whereas GDP grew by almost 23% (Figure 2.1.1). Six Member Countries (Czech Republic, Germany, Hungary, Poland, Slovak Republic and the United Kingdom) showed a significant absolute decoupling, while Finland and France more or less stabilised emissions. On the whole, emissions are still rising, although the pace of emission growth has tapered off in the last few years. The five largest emitters in the OECD (the United States, Japan, Germany, Canada and the UK) account for around 75% of OECD country greenhouse gas emissions, which means that OECD trends are dominated by changes in these countries.

The decoupling of GHG emissions from population growth was much less pronounced. Per capita emissions for OECD Total were more or less the same in 1999 as in 1990, thanks to a 10% decrease in OECD Europe. In the OECD America and OECD Pacific regions, per capita emissions actually increased during the 1990s.

14 . Figures in this section do not include data for Korea, Luxembourg, Mexico and Turkey.

Of the total of the GHG emissions in the OECD area, methane emissions decreased by 6.5% from 1990–1998, with fugitive fuel emissions down 15%, and waste emissions down 9.8%. Nitrous oxide emissions for OECD decreased over this period by 0.4% **-** while industrial process emissions decreased by 33%, fuel production emissions were up by 5.5%, and emissions from agriculture were up 6.4%. The contribution of CO_2 emissions will be discussed separately in the next section.

♦ ***Total CO_2 emissions per unit of GDP and per capita***

Total emissions of CO_2 in OECD countries[15] (excluding land-use change and forestry), like those of total GHG, showed relative decoupling from economic growth during 1990-99: emissions increased by almost 6%, reaching 11,599 Mt CO_2, while GDP grew by almost 23% (Figure 2.1.2). In the OECD regions, the highest rates of growth in CO_2 emissions occurred in North America (13% from 1990 to 1999) and Pacific (12%). Emissions in Europe decreased by 6% due the absolute decoupling observed in the Czech Republic, Germany, Hungary, Poland, the Slovak Republic (caused by economic restructuring) and in the United Kingdom. On a per capita basis, CO_2 emissions remained constant during the 1990s for the whole of the OECD, with the 9% drop in OECD Europe being offset by a growth of almost 4 and 8% in OECD North America and Pacific, respectively.

References

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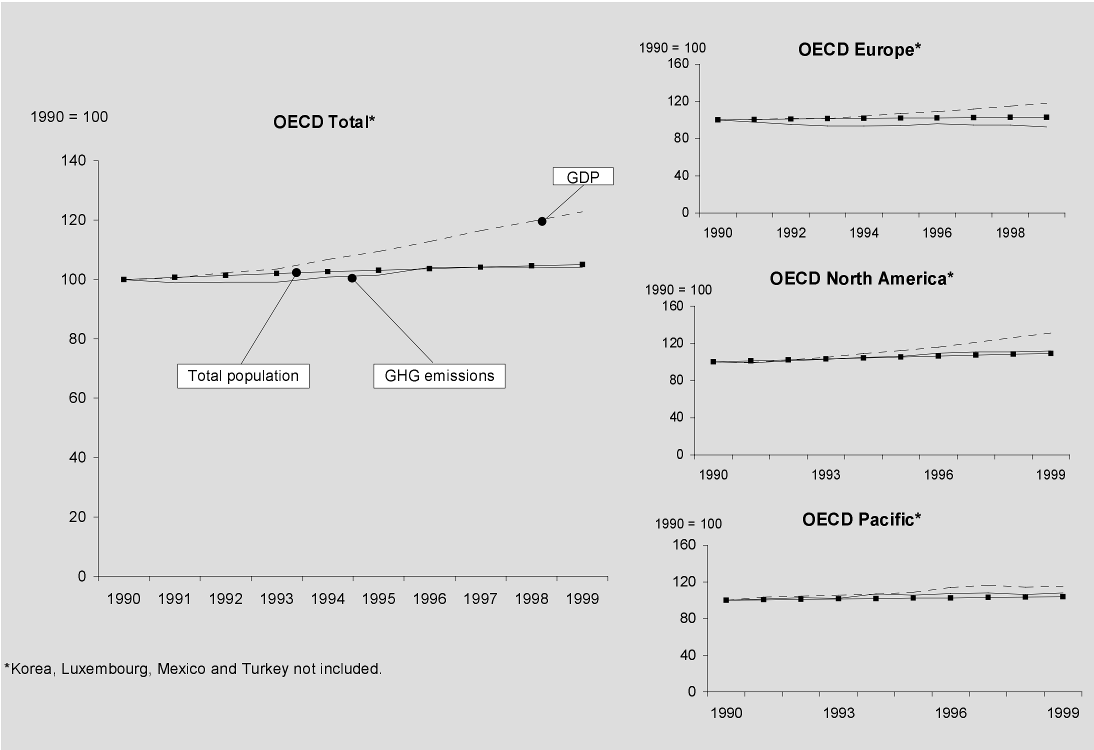
OECD (2001), *OECD Environmental Indicators: Towards Sustainable Development 2001*, OECD, Paris

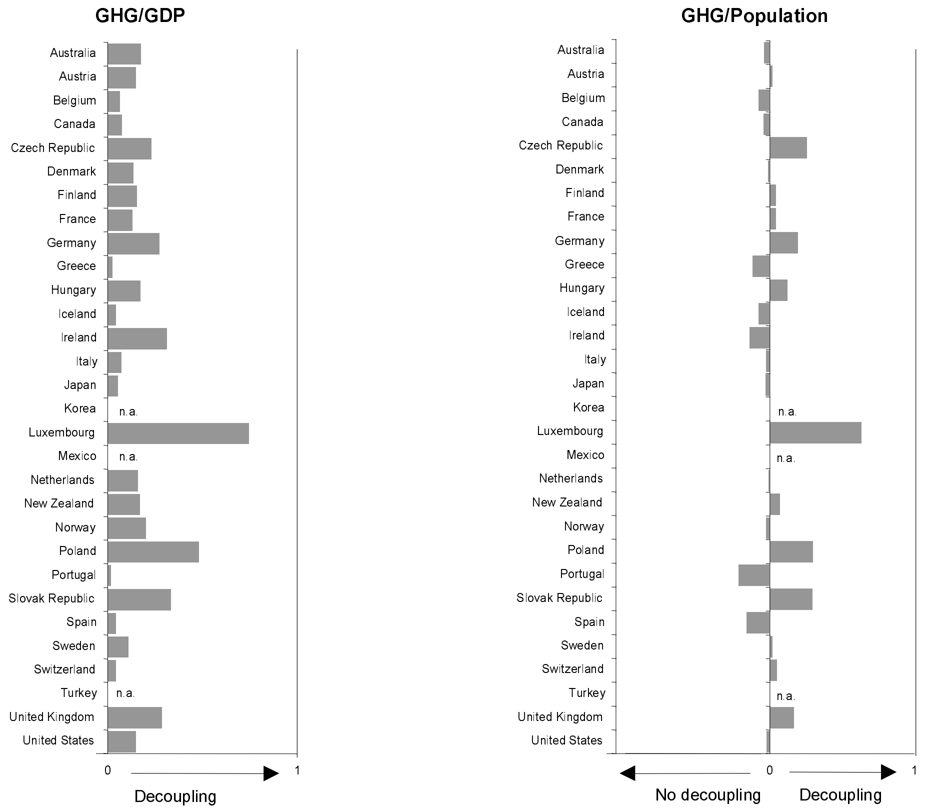
EEA (2001), *Environmental Signals 2001*, European Environment Agency, Copenhagen.

15 . Figures in this section do not include data for Korea, Luxembourg, Mexico and Turkey.

Figure 2.1.1 **Total GHG emissions per unit of GDP and per capita,** 1990-1999

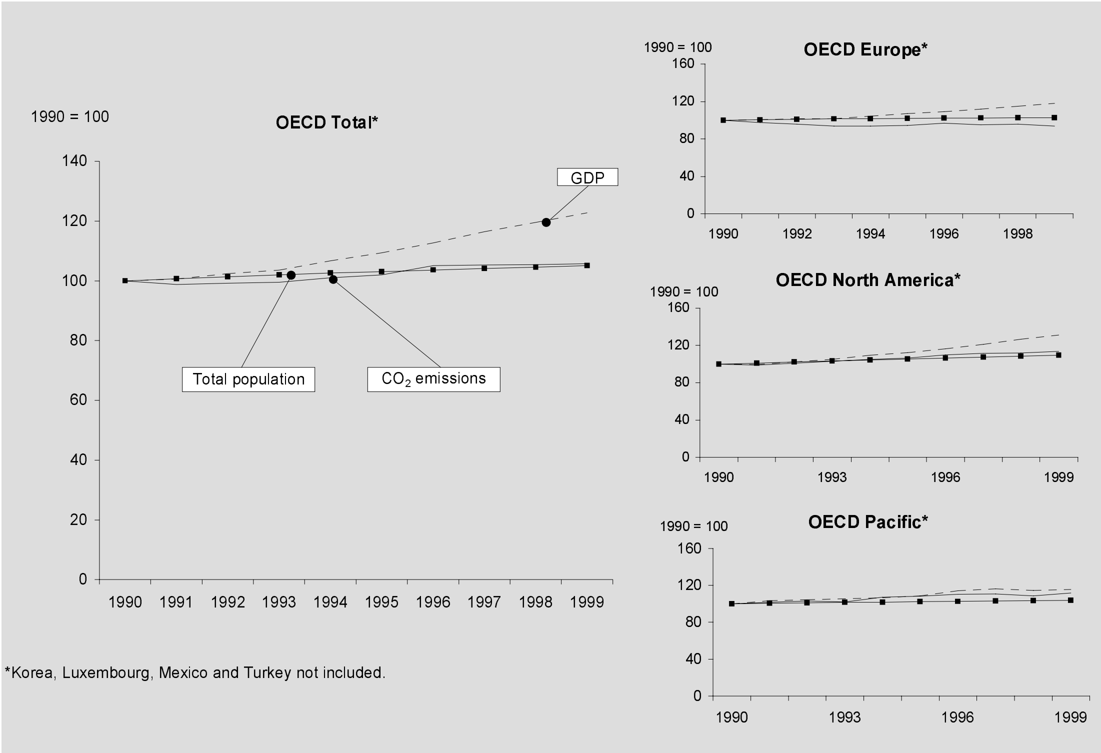


Decoupling factor[a)]

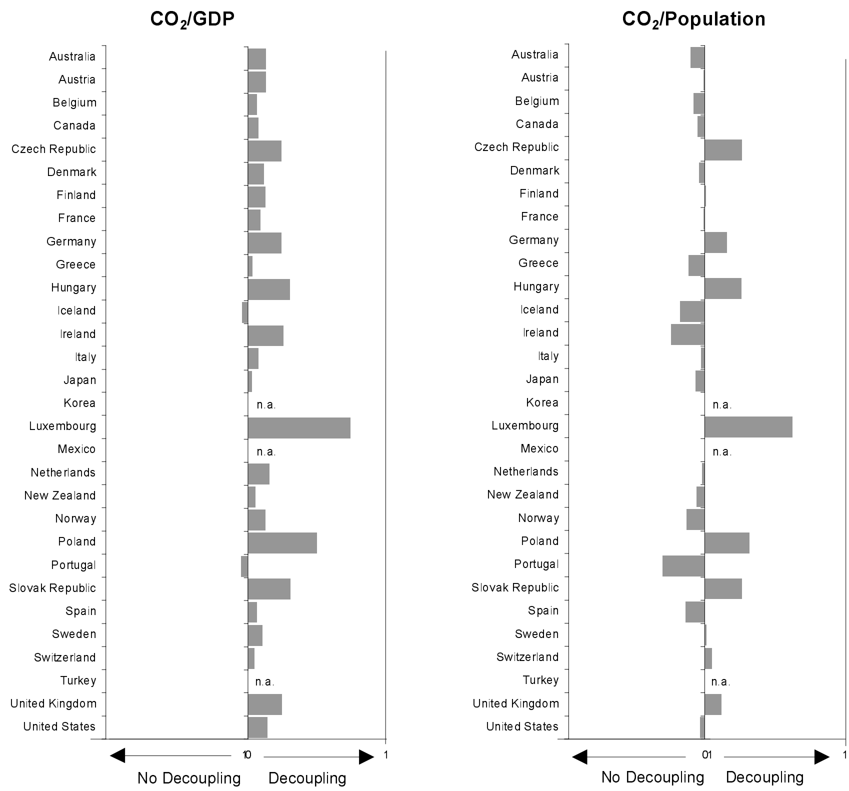


a) Decoupling factor is defined as 1-(EP/DF)end of period/(EP/DF)start of period where EP = environmental pressure and DF = driving force. Decoupling occurs when the value of the decoupling factor is between 0 and 1.
Source: OECD, UNFCCC.

Figure 2.1.2 **Total CO_2 emissions per unit of GDP and per capita,** 1990-1999



Decoupling factor[a)]



a) Decoupling factor is defined as 1-(EP/DF)end of period/(EP/DF)start of period where EP = environmental pressure and DF = driving force. Decoupling occurs when the value of the decoupling factor is between 0 and 1.
Source: OECD, UNFCCC.

2.2 AIR POLLUTION

Air pollution problems continue to be a serious health concern in the densely populated urban areas of most OECD countries. Problems related to pollutant emissions from motor vehicle and summer smog have largely replaced earlier concerns about winter smog caused by sulphur dioxides, carbon monoxide and particulate matter. Some of these pollutants are also greenhouse gases (e.g. methane, nitrous oxide). Others are persistent pollutants and compounds (e.g. heavy metals and organic compounds) that can bio-accumulate in the environment and have long-term effects. In some cases, rural areas can also be affected by up-wind nearby or remote emissions sources. Very small particles (PM_{10} and $PM_{2.5}$) are receiving increasing attention as a human health concern.

Emissions of air pollutants contribute to the formation of secondary pollutants. This is because pollutants, once emitted, are dispersed in the atmosphere and sometimes transported over long distances before they are deposited. During this atmospheric transport they undergo complex transformation processes that result in the formation of secondary pollutants (e.g., secondary aerosols, oxidants like ozone, and atmospheric acid compounds). The deposition of acidifying substances can damage sensitive natural ecosystems and the productivity of agricultural land.

Driving forces of emission of air pollutants can be found in all sectors of the economy (industry, energy, transport, agriculture and the residential) depending on the structure of the economy, the fuel base and the level of control technology used. The contribution of various sectors to total emissions varies among the different pollutants, but the use of fossil fuels is a dominant element in most.

For instance, stationary combustion facilities are a major source of SO_x and NO_x emissions in OECD countries. Mobile sources (transport vehicles) account for most CO and NO_x emissions, and consequent peaks in localised ozone concentrations. Non-methane volatile organic compounds (NMVOC) are generated by a range of sources and comprise a large number of compounds with very different toxicity, reactivity, emission rates, etc. Emissions of particulate matter from fossil fuel combustion are also significant, but declining rapidly under strict regulations and the introduction of more effective control technology.

This section comprises four decoupling indicators, presenting separate information about four substances (SO_x, NO_x , VOCs and particulate matter). At a later stage, it would be better to present this information in terms of the role played by these and other gases in relation to various environmental problems such as acidification and low-level ozone formation. In addition, emissions of heavy metals and persistent organic pollutants (POPs) also ought to be considered.

♦ ***Total NO_x emission per unit of GDP***

Emissions of nitrogen oxides (NO_x) seriously affect health and contribute to the formation of ground-level ozone, acidification and eutrophication. Ground-level ozone and acidification have adverse effects on human health, and vegetation (including crops and forests). Eutrophication has adverse effects on terrestrial and aquatic ecosystems. The sectors responsible for the bulk of NO_x emissions in OECD countries are transport (50%), energy (28%) and industry (11%). Within the OECD area, the United States and Canada were responsible for 60% of total OECD (without Australia and Mexico) NO_x emissions. OECD Europe and OECD Pacific (without Australia) accounted for 32 and 8%, respectively.

Emissions of nitrogen oxides from all sources were decoupled from economic growth for all three OECD regions[16] during 1980-98: emissions decreased slightly (3%), while GDP grew by almost 62% (Figure 2.2.1). Of the three OECD regions, decoupling was absolute in Europe, where emissions fell by 19% and GDP grew by 46%. In OECD Pacific (without Australia) emissions grew by 11% and GDP by 81%. In OECD North America (without Mexico), the corresponding figures were 7% and 72%, respectively. Most OECD Europe and North America countries are party to the various protocols of the UN/ECE Convention on Long-range Transboundary Air Pollution (CLRTAP), which binds these countries to meeting

[16] *Figures in this section do not include data for Australia and Mexico.*

various emission reduction targets. Such targets can be shown on the standard decoupling graphs used in this paper (Figure 2.2.2).

Emission reductions have been due mainly to the use of control technology in stationary combustion plants (e.g., selective catalytic reduction SCR) and catalytic converters in petrol-driven vehicles. Projections from the OECD's reference scenario for stationary and mobile sources suggest that emissions may continue to decrease across the OECD to 2020, primarily due to continuous efforts to tighten motor vehicle emissions. Large reductions are expected in OECD Europe (60%) and in North America (30%), where emissions from motor vehicles are dominant. The target set by the EU, if wholly implemented, will reduce total emissions by 50% by 2010 compared to the base year of 1990. At the world level, emissions of nitrogen oxides are projected to increase substantially due to economic growth and rise in motor vehicle traffic.

♦ ***Total SO_x emissions per unit of GDP***

Emissions of sulphur oxides (SO_x) contribute to winter smog and acidification. SO_x also has adverse effects on human health, particularly in cities, where concentrations tend to be highest. Anthropogenic emissions of SO_x originate mainly from the combustion of sulphur-containing fuels. The sectors responsible for the bulk of SO_x emissions in OECD countries are industry (65%), energy (23%) and the residential sector (6%). OECD countries contributed about 40% to global emissions in 1995. Within the OECD area, the United States and Canada were responsible for 61% of total OECD 1998 SO_2 emissions. OECD Europe and OECD Pacific accounted for 32 and 7%, respectively.

Emissions of sulphur dioxide from all sources were absolutely decoupled from economic growth for all three OECD regions[17] during 1980-98: emissions decreased by over 50%, while GDP grew by almost 61% (Figure 2.2.1). Of the three OECD regions, decoupling was most pronounced in Europe, where emissions fell by 70% and GDP grew by 44%. In OECD Pacific emissions fell by 17% and GDP increased by 81%. In OECD North America, the corresponding figures were 27% and 72%, respectively.

Emission reductions have been due mainly to a switch from high sulphur solid and liquid fuels to natural gas in the energy industries, industry and domestic sectors, the construction of new power plants, and the use of low-sulphur coal and flue gas desulphurisation. The fall in SO_x emissions has reduced the formation of winter smog in urban areas and atmospheric acids and their deposition to surface waters and forest ecosystems.

In order to obtain an overall indicator of the decoupling of emissions of acidifying substances from GDP, it would be possible to aggregate emissions of SO_x, NO_x and ammonia in terms of their acidifying effect. Data on ammonia emissions are currently not available, but a weighted sum of the emissions of the first two gases is shown by way of illustration (Figure 2.2.1).

♦ ***Total emissions of fine particulate matter per unit of GDP***

Emissions of fine particulate matter (PM) have significant negative impacts on public health in urban areas. Breathing in fine particles, particularly those under 10μm in diameter (PM_{10}), can increase the frequency and severity of pulmonary and cardiovascular disease and even trigger premature death. Combustion of coal and oil-fired power plants, smelters, automobiles, and diesel vehicles represent the largest source of fine particulate matter. Apart from being directly emitted into the atmosphere, PM_{10} is also created from precursors such as nitrogen oxides, sulphur dioxide and ammonia.

Emission reductions over the past decades have been due mainly to stringent dust control for stationary sources. Concern is growing, however, about fine and ultra-fine particles, as conventional control systems have not been able to remove them from exhaust gas.

In the mid-90s, OECD countries contributed less than 25% to global emissions of particulate matter (OECD North America 16%, OECD Europe 7% and OECD Pacific less than 0.5%). Emission projections are difficult to make for OECD countries, as emissions of fine and ultra-fines particles will depend on the introduction of high-efficiency filter equipment for mobile sources. In other parts of the world, particulate

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[17] *Figures in this section do not include data for Australia, Mexico and Turkey.*

matter is likely to increase due to growth in energy and transport demand, and the lack of efficient emission controls.

The available information about particulate emissions in OECD countries is not sufficient to permit presentation of data for the various OECD regions. In several countries, there was a significant absolute decoupling of particulate emissions from economic growth. For example, in the United States emissions fell by 17% during 1990-98 and GDP increased by 27% (Figure 2.2.3). In the United Kingdom, the corresponding figures are 35% and 18%. A relative decoupling took place in Norway, with particulate emissions increasing by 6% and GDP by 34%. No decoupling occurred in Italy, where the growth in emissions (24%) exceeded that of GDP (11%).

Emissions of primary PM_{10} and secondary PM_{10} precursors are expected to fall as improved vehicle engine technologies are adopted and stationary fuel combustion emissions are controlled through abatement or the use of low sulphur fuels such as natural gas. Currently there are no national or international emission reduction targets in OECD countries.

♦ ***Total emissions of volatile organic compounds per unit of GDP***

Emissions of non-methane volatile organic compounds (NMVOC) contribute to the formation of ground-level ozone. Certain NMVOC substances or groups of substances such as benzene, 1,3 butadiene and polycyclic aromatic hydrocarbons (PAH) are particularly hazardous to human health. Most NMVOC emissions stem from incomplete combustion, the use of industrial solvents and evaporative losses during fuel production and distribution. The latter sector is also an important source of methane emissions from oil production (e.g. gas flaring) and natural gas distribution systems. The sectors responsible for the bulk of NMVOC emissions in OECD countries are transport (44%), industry (29%), and the residential sector (17%). In Europe, the transport sector is the second largest source after the solvent industry.

Emissions of non-methane volatile organic compounds (NMVOCs) from all sources were absolutely decoupled from economic growth for all three OECD regions[18] during 1990-98: emissions decreased by over 15%, while GDP grew by almost 20% (Figure 2.2.3). Of the three OECD regions, decoupling was most pronounced in Europe, where emissions fell by almost 24% and GDP grew by more than 15%, and OECD North America, where the corresponding figures were 11% and almost 27%, respectively. In OECD Pacific emissions fell by 1% and GDP increased by just over 14%.

Emission reductions have been due mainly to the use of catalytic converters for petrol road vehicles and increased penetration of diesel cars. In some countries, solvent manufacturing processes and uses (in paints, glues and other products, and printing and vehicle spraying) are now better controlled through best practice schemes, substitution with water-based products and abatement technology.

Despite the overall emission reductions achieved in the 1990s, the large amount of emissions from motor vehicles has led to increased formation of ground-level ozone (summer smog) in most OECD countries. Emission projections anticipate that volatile organic compounds will continue to decrease in the OECD area between 35% and 55% until 2020, primarily due to emission controls for motor vehicles. The emission ceilings set for EU countries are expected to reduce emissions by 53% in 2010 compared to 1990 levels. In the rest of the world the emissions are likely to substantially increase, especially in those parts with modest or no controls.

References

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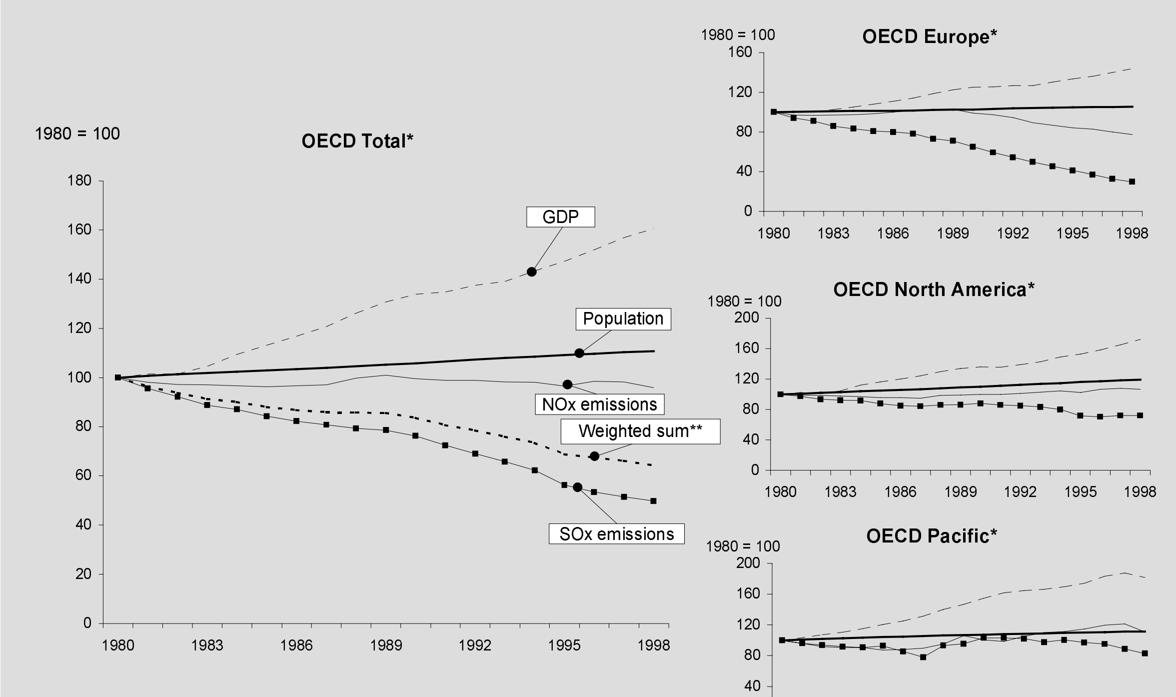
EEA (2001), *Emissions of primary particulates and secondary particulate precursors, Indicator fact sheet* www: http://www.eea.eu.int/themes/air pollution/indicators/emissions of particulates. European Environment Agency, Copenhagen.

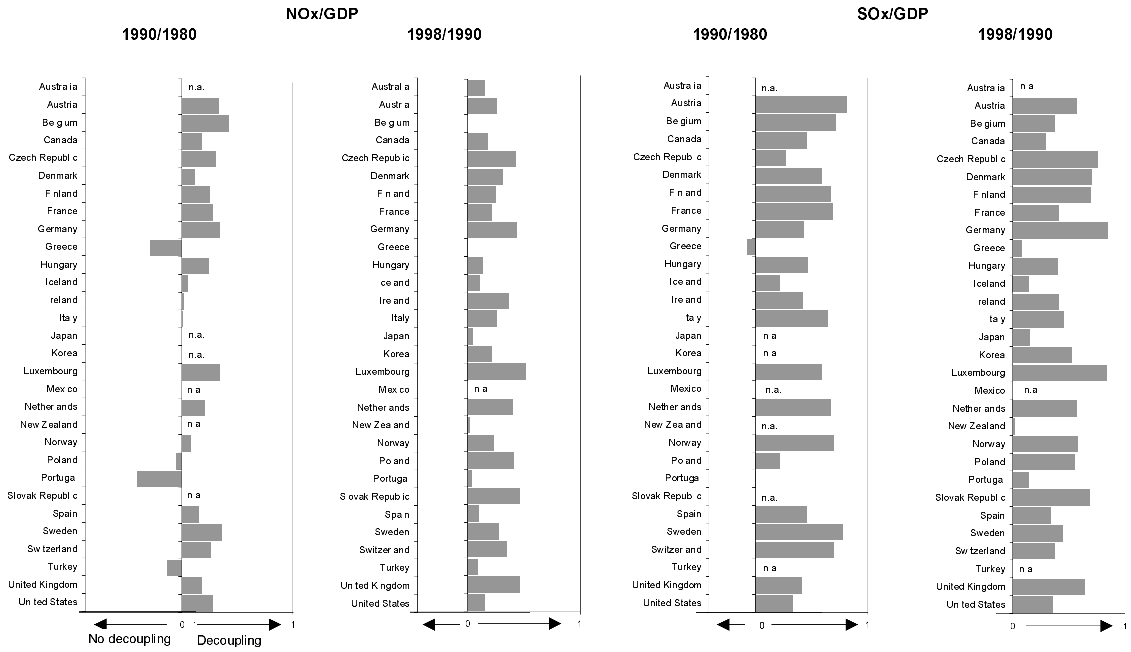
[18] Figures in this section do not include data for Korea, Mexico, Slovak Republic and Turkey.

Figure 2.2.1 **Total emissions of nitrogen and sulphur oxides per unit of GDP**, 1980-1998



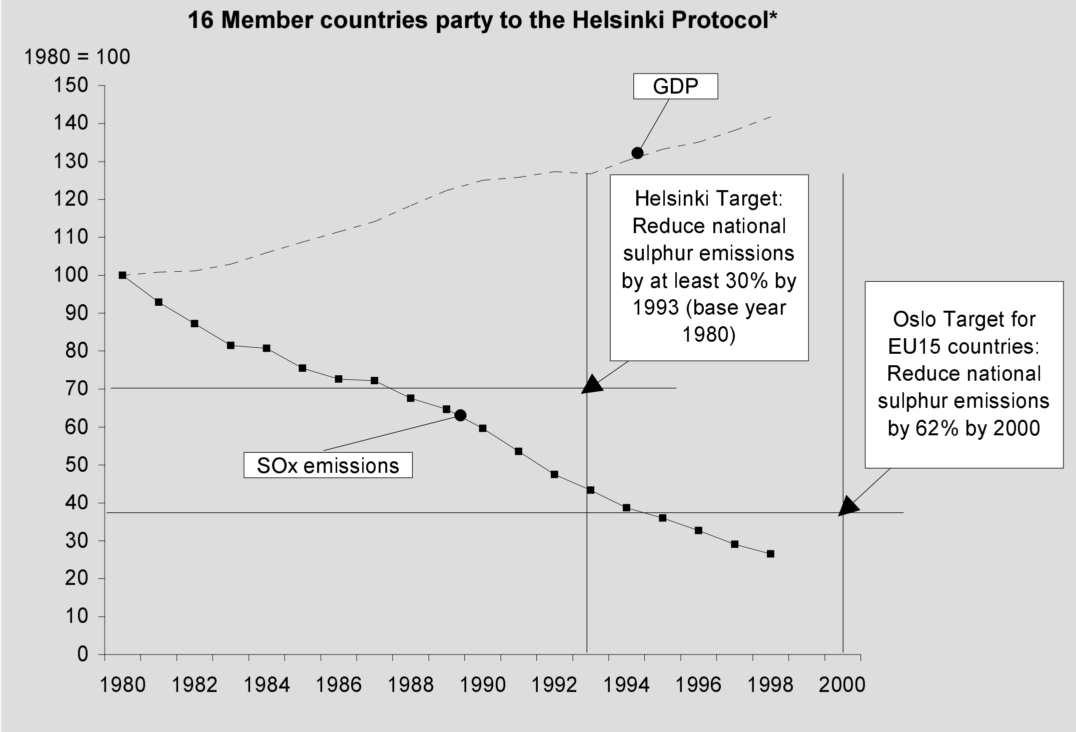
* Australia, Mexico and Turkey are not included.
** Sum of SOx (1/32) and NOx (1/46) emissions weighted in terms of their acidifying effect. Data on emissions of ammonia, another significant acidifying gas, are not available.

Decoupling factor[a)]

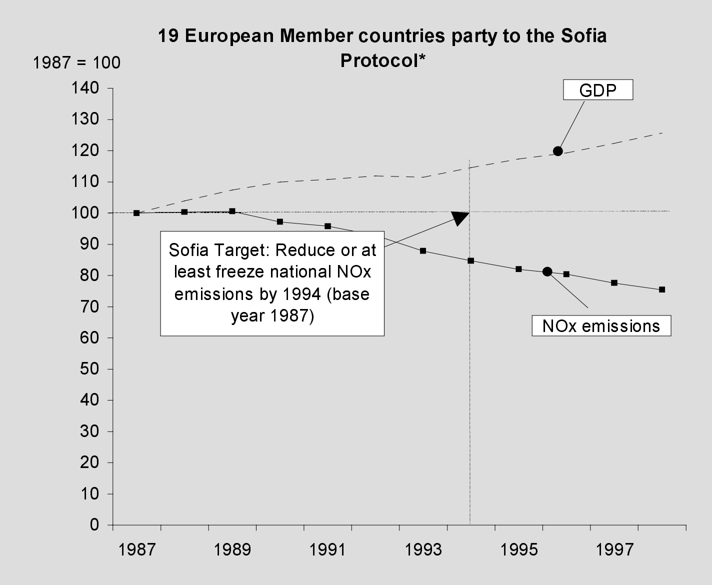


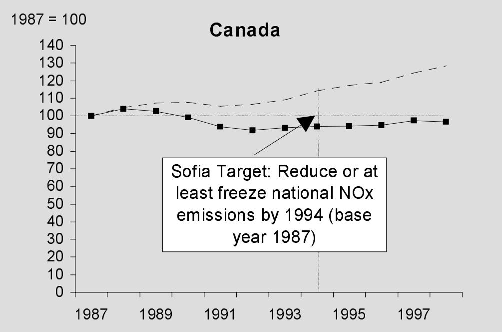
a) Decoupling factor is defined as 1-(EP/DF)end of period/(EP/DF)start of period where EP = environmental pressure and DF = driving force. Decoupling occurs when the value of the decoupling factor is between 0 and 1.
Source: OECD

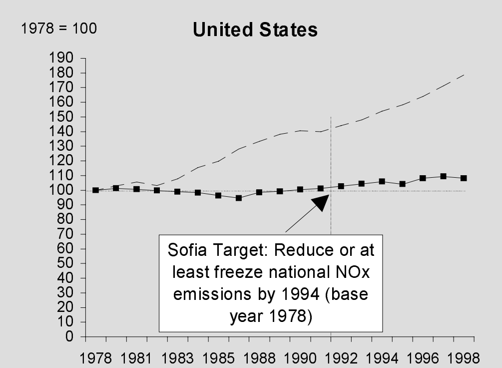
Figure 2.2.2 **Achievement of targets of UN-ECE convention on long range transboundary air pollution (CLRTAP)**



*Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Hungary, Italy, Luxembourg, Netherlands, Norway, Slovak Republic, Sweden and Switzerland.



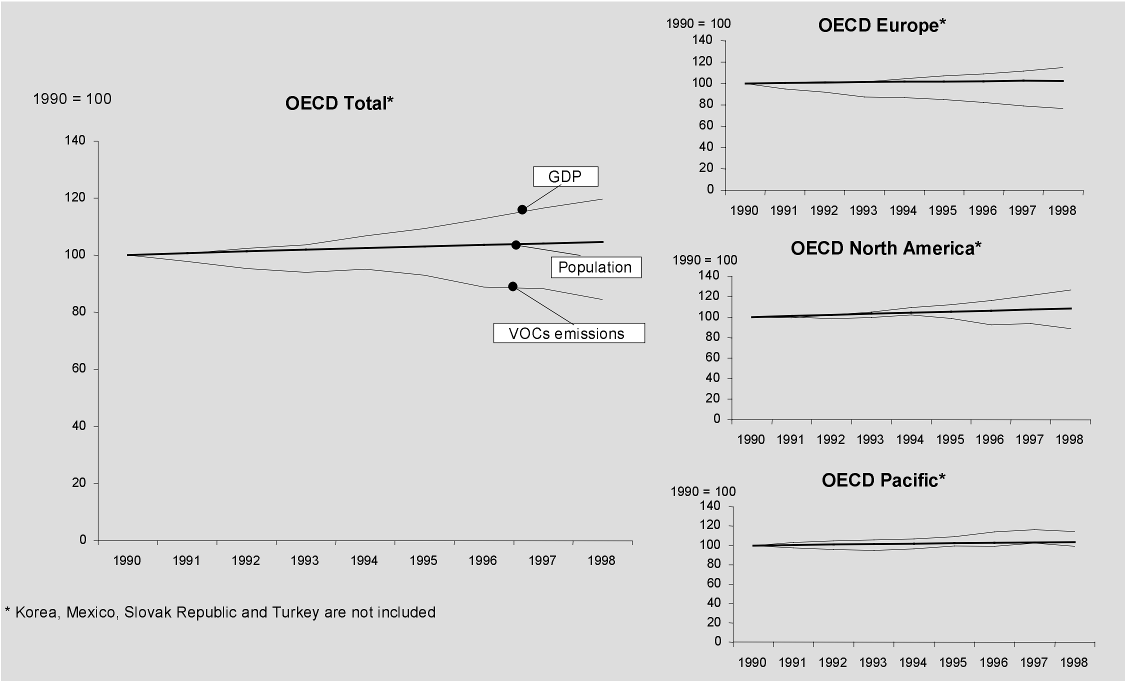




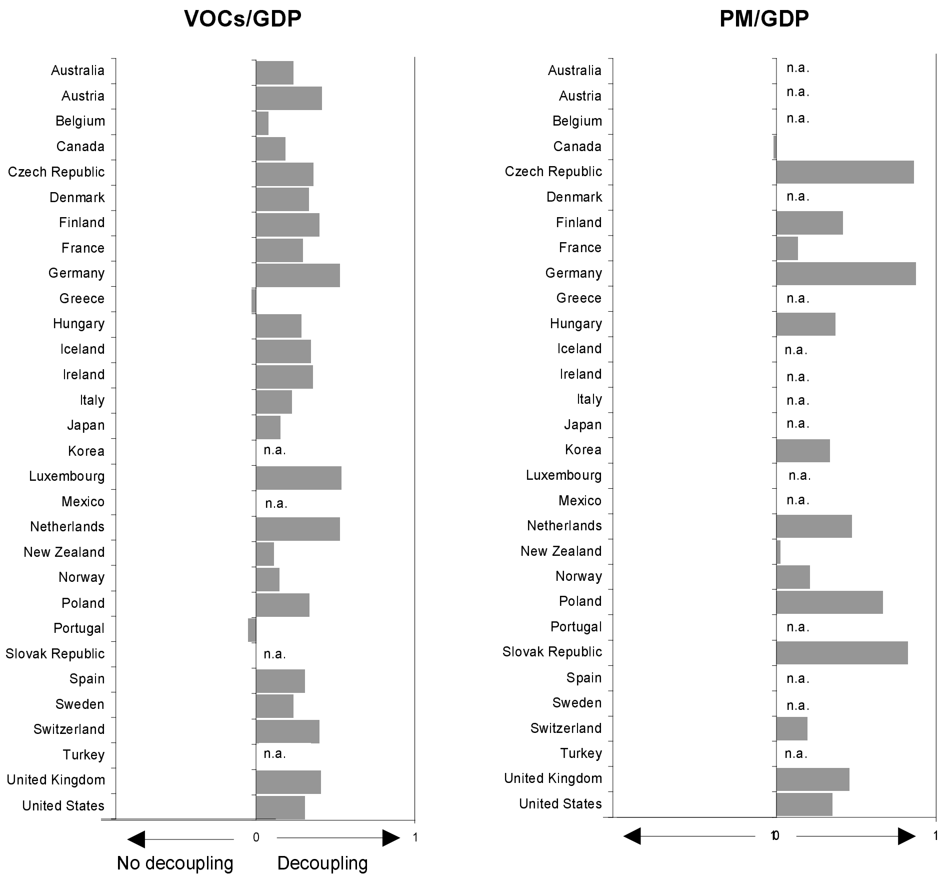
*Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, Netherlands, Norway, Slovak Republic, Spain, Sweden, Switzerland and United Kingdom.

Source: OECD

Figure 2.2.3 **Total emissions of VOCs and particulate matter per unit of GDP,** 1990-1998



Decoupling factor[a)]



a) Decoupling factor is defined as 1-(EP/DF)end of period/(EP/DF)start of period where EP = environmental pressure and DF = driving force. Decoupling occurs when the value of the decoupling factor is between 0 and 1.
Source: OECD.

2.3 WATER QUALITY

Many OECD countries have by now cleaned up the conspicuously polluted waters that first caused public concern in the 1970s. Dissolved oxygen content in larger rivers is satisfactory most of the year and bacterial contamination has also been much reduced, but for several other parameters it is not possible to discern widespread and general trends of improvement in water quality. Despite two decades or more of major efforts to reduce end-of-pipe discharges, few OECD countries can claim to satisfactorily meet the baseline quality standard for inland waters (e.g. suitability for fishing and swimming).

In order to restore receiving waters to their former good health, both point and diffuse discharges need to be further reduced. Diffuse pollution will be discussed in the section on agriculture. Reducing pollutant discharges from municipal and industrial wastewater treatment plants therefore remains a central element of decoupling pressures on the aquatic environment and human activity. This is particularly true for discharges of phosphorus and nitrogen.

Water quality is also affected by freshwater abstractions (see section on natural resources). For OECD countries overall, total abstractions rose by just 4.5% between 1980-97, but the figure was much higher worldwide. The use of water for agriculture is dominant in many OECD countries, exceeding 60% of total abstractions in seven Member Countries, followed by industry and domestic use.

Municipal wastewater treatment plants typically receive a mixture of waste water from households and from small and medium-sized industries. Inflows from the latter often are already partially treated. Large industries mostly operate their own treatment plant before discharging their effluent directly to receiving waters. In some cases, industrial wastewater treatment stations receive waste water from a mix of industries co-located on the same industrial site.

The decoupling indicators presented in this section have several shortcomings. The first indicator (i.e. population not connected to sewage treatment plants) should be seen as a surrogate for an indicator measuring the amount of biochemical oxygen demand (BOD) from households and industry still discharged into surface waters after treatment. The second indicator is limited to discharges of nutrients from households because little information is available about discharges of nutrients from industry. In part this is because a large part of industrial waste water gets mixed with household sewage. Also, few data exist about effluents from industrial wastewater treatment plants. As with air pollution, the decoupling indicators ideally also should cover heavy metals and persistent organic pollutants (POPs). Finally, indicators also should cover diffuse pollution of surface and groundwater.

♦ ***Population NOT connected to sewage treatment plants versus total population***

The construction of municipal sewage treatment plants, which began in earnest in the early 1970s, has been wholly or almost completed in many OECD countries; in some others, new treatment capacity is still being installed at a great pace. Nevertheless, due to varying settlement patterns, economic and environmental conditions, starting dates, and the rates at which the work was done, considerable differences in the share of population connected to municipal treatment installations still exist among OECD countries. Furthermore, much improvement is needed in terms of levels of sewage treatment; for some countries this will involve secondary treatment, and for most it will mean nutrient removal in sensitive areas. To meet receiving water quality objectives in densely populated areas, it is becoming necessary to treat urban stormwater and wet-weather overflows from combined sewerage systems.

In the group of 18 Member Countries[19] considered here, the number of people not connected to a public wastewater treatment plant fell by 45% during 1975-1998, whereas the population increased by almost 12% (Figure 2.3.1). In OECD Europe, progress was steady throughout the period considered, while in OECD Pacific (mainly Japan and Korea) decoupling was initially slow, but accelerated after the mid-1980s.

The presentation of this indicator in terms of the share of total population not connected to sewage treatment plants is not intended to imply that this share should approach zero. Large centralised treatment

19 . Figures in this section do not include data for Australia, Belgium, France, Greece, Iceland, Ireland, Italy, Luxembourg, Mexico, Poland, Turkey and the United States.

plants are not an economically and environmentally optimum solution for small, dispersed communities. In fact, in many OECD countries, the proportion of the population that can reasonably be connected to a community sewerage and sewage treatment system is approaching its economic optimum. Several countries (Austria, Denmark, France, Hungary, Japan, Luxembourg, Norway) have done well in providing small treatment systems for isolated settlements, and the application of appropriate technology can bring further progress at reasonable cost.

♦ ***Discharges of nutrients from households into the environment versus total population***

Waste water generated by households contains phosphates as well as nitrates. These nutrients will end up in rivers and coastal waters, unless they are removed in sewage treatment plants. Three levels of wastewater treatment are commonly distinguished. Primary wastewater treatment removes part of the suspended solids and about 5% of phosphorus. Secondary (biological) treatment uses aerobic or anaerobic micro-organisms and removes most suspended solids, BOD (biochemical oxygen demand) and bacteria, about 20% of nitrogen, 25% of phosphorus and around 75 % ammonium. Tertiary treatment removes around 80% of phosphorus and, in some cases, nitrogen as well. It is assumed that individual treatment facilities (e.g. septic tanks) do not remove any nutrients.

This indicator traces the amount of phosphorus and nitrogen per head of population that is discharged into natural waters because it is not removed by collective or individual treatment facilities. The calculation follows that used for one of the Eurostat Environmental Pressure Indicators. Time series data about changes in connection rates to municipal wastewater treatment plants, combined with per capita emissions factors (expressed as kg P/inhabitant and kg N/inhabitant) and the theoretical treatment efficiency of the respective levels of treatment, are used to calculate the per capita emissions to the environment after treatment.

For the group of 13 countries[20] considered here, there has been an absolute decoupling of discharges of phosphorus from households into the water environment from population growth during the period 1975-98 (Figure 2.3.2). Decoupling was absolute in 12 of the 13 countries in this group. In Turkey, a population growth of more than 60%, combined with a connection rate to wastewater treatment plants of just 12%, caused a 14% rise in discharges of phosphorus.

For the group of 13 countries considered here, during the period 1975-98 a relative decoupling occurred of discharges of nitrogen from households into the water environment from population growth (Figure 2.3.2). For the group as a whole, total nitrogen discharges grew by almost 4% and population increased by more than 21%. For 8 countries, decoupling was absolute; for the remaining five it was relative.

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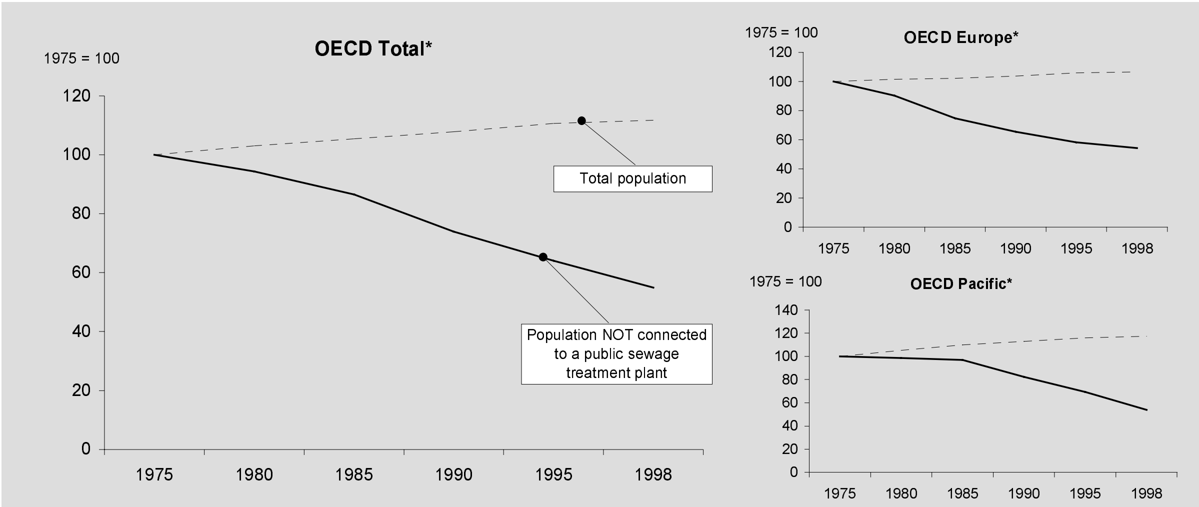
20 . Austria, Canada, Denmark, Finland, Hungary, Iceland, Ireland, Japan, Netherlands, Norway, Sweden, Switzerland and Turkey.

Figure 2.3.1 **Population NOT connected to public sewage treatment plants versus total population,** 1975-1998



*Australia, Belgium, France, Greece, Iceland, Ireland, Italy, Luxembourg, Mexico, Poland, Turkey and United States are not included.

Population NOT connected to a public sewage treatment plants

Country	Population NOT connected		Population		Pop. NOT connected/Pop.		Decoupling factor[a)]
	Late 1990s (thousand)	Late 1990s (1975 = 100)	1998 (thousand)	1998 (1975 = 100)	1998	1998 (1975 = 100)	
Austria	1503	27	8078	107	0.19	25	0.75
Canada	7562	76	30248	131	0.25	58	0.42
Czech Republic	3953	64	10294	102	0.38	63	0.37
Denmark	583	27	5301	105	0.11	26	0.74
Finland	1082	47	5153	109	0.21	43	0.57
Germany[b)]	9351	48	82029	104	0.11	46	0.54
Hungary	7484	82	10114	96	0.74	85	0.15
Japan	48065	56	126486	113	0.38	49	0.51
Korea	15833	49	46430	132	0.34	37	0.63
Netherlands	361	6	15703	115	0.02	5	0.95
New Zealand	758	56	3792	123	0.20	45	0.55
Norway	1196	41	4431	111	0.27	37	0.63
Portugal	4491	49	9979	107	0.45	46	0.54
Slovak Republic	2760	72	5391	115	0.51	63	0.37
Spain	20355	67	39371	110	0.52	60	0.40
Sweden	620	40	8851	108	0.07	37	0.63
Switzerland	320	11	7110	111	0.05	10	0.90
United Kingdom[c)]	7035	69	54117	106	0.13	65	0.35
Total	133311	55	472878	112	0.28	49	

a) Decoupling factor is defined as 1-$(EP/DF)_{1998}/(EP/DF)_{1990}$ where EP = environmental pressure and DF = driving force. Decoupling occurs when the value of decoupling factor is between 0 and 1.
b) Before 1990, Germany comprises only West Germany.
c) United Kingdom comprises only England and Wales.
Shaded figures indicate absolute decoupling.
Source: OECD

Decoupling factor[a)]

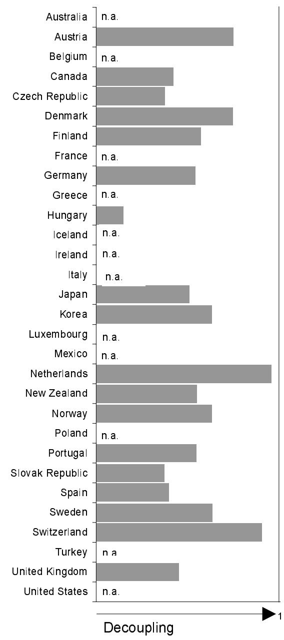
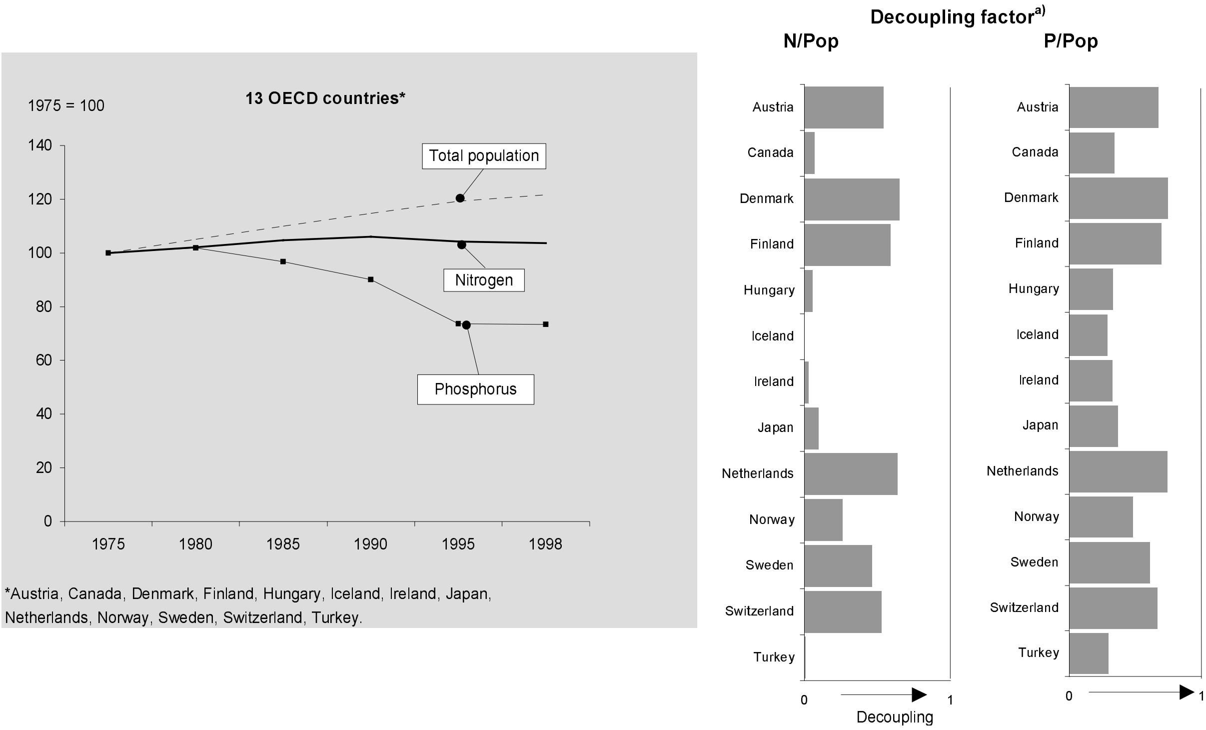


Figure 2.3.2 **Discharges of nutrients from households into the environment versus total population**, 1975-1998



Discharges of nutrients from households into the environment, population

Country	Discharge				Population	
	Nitrogen		Phosphorus			
	1998 (tonnes)	1998 (1975=100)	1998 (tonnes)	1998 (1975=100)	1998 (000)	1998 (1975=100)
Austria	16208	49	3612	35	8078	107
Canada	91567	122	20175	86	30248	131
Denmark	7489	37	1689	27	5301	105
Finland	8344	45	1896	33	5153	109
Hungary	41653	91	9350	64	10114	96
Iceland	1205	126	273	89	274	126
Ireland	15454	113	3399	79	3705	117
Japan	478623	102	105616	72	126486	113
Netherlands	23215	42	5122	30	15703	115
Norway	11503	82	2566	57	4431	111
Sweden	11372	58	2558	42	8851	108
Switzerland	11700	52	2577	37	7110	111
Turkey	282791	161	63896	114	64789	162
Total	1001123	104	222729	73	290243	122

Shaded figures indicate absolute decoupling.

a) Decoupling factor is defined as $1-(EP/DF)_{1998}/(EP/DF)_{1975}$ where EP = environmental pressure and DF = driving force. Decoupling occurs when the value of the decoupling factor is between 0 and 1.
Source: OECD, Eurostat

2.4 WASTE MANAGEMENT

The amount of waste generated in an economy is an indicator of the efficiency of resource use in production and the quantities of goods produced and consumed. Also, the need to manage waste imposes pressures on the environment, such as the leaching of heavy metals and other toxic compounds from landfills or the emission of greenhouse gases. Other pressures are the land take for landfills and other waste management facilities, air pollution and toxic by-products from incinerators, increased transport with heavy vehicles. These matters cannot be viewed purely from a quantitative perspective, since the presence of even small quantities of hazardous substances can be of major concern.

A dearth of data makes it difficult to determine with confidence the total generation of waste within the OECD area. It is estimated, however, that within the OECD area in the mid-1990s the aggregated annual generation of non-hazardous waste amounted to some 4.3 billion tonnes. Of this, the largest shares are industrial waste (22%), agricultural waste (19%), mining waste (13%), construction & demolition waste (13%) and municipal waste (12 %). The estimate also includes dredge spoils and sewage sludge. In addition, an estimated 115 million tonnes of hazardous waste was generated annually.

♦ ***Municipal waste going to final disposal versus Private Final Consumption***

The primary decoupling indicator for waste disposal should preferably take account of all the major environmental pressures associated with waste management, such as leachates and GHG emissions from the landfilling of all types of waste and emissions to air from the incineration of waste. The amount of total waste going to final disposal (i.e. landfill plus incineration without energy recovery[21]) can be regarded as representing a significant part of these environmental pressures. The scope of the indicator is limited for now to municipal waste only because time-series data about other types of waste are currently not available for a sufficient number of countries.

OECD-wide[22], there has been a relative decoupling of waste going to final disposal from private final consumption (PFC) since 1995 (Figure 2.4.1). The amount of waste going to final disposal increased by 5% between 1995-99, whereas PFC increased by 15%. In OECD Europe and North America the corresponding figures were 6 and 7%, respectively, for the amount of waste going to final disposal and 12 and 18% for the growth in PFC.

The above regional figures do not reveal the fact that nine OECD Europe countries (Austria, Belgium, Denmark, Germany, Italy, Luxembourg, Netherlands, Norway and Switzerland) recorded a significant absolute decoupling with the amounts of waste going to final disposal falling by between 9 and 40% during the period concerned. In OECD Pacific, an absolute decoupling occurred in Korea, where the amount of waste going to final disposal fell by 27% while PFC grew by almost 9%. On the other hand, in four Member Countries (Hungary, New Zealand, Portugal, and Spain) no decoupling of final disposal and PFC took place during 1995-1999.

♦ ***Decomposing municipal waste going to final disposal***

The amount of municipal waste going to final disposal (MWFD) per unit of private final consumption (PFC) depends on the total amount of municipal waste (MW) generated and on the fraction of MW going to final disposal (not recycled) as follows:

Amount of waste going to final disposal (MWFD)/ private final consumption (PFC)	=	MWFD/Amount of municipal waste (MW) generated	*	MW generated/PFC

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21 . Incineration with energy recovery is not counted as final disposal because it partially recycles the energy content of waste. Strictly, allowance should be made of the growing trend towards biogas extraction from landfills for energy production. However, no data are available as yet to do this here.

22 . Figures in this section do not include data from Australia, Canada, Czech Republic, France, Greece, Ireland, Japan and the Slovak Republic.

For the total of the 21 Member countries considered in this section, the *proportion of municipal waste going to final disposal* as a share of the amount generated declined from 65 to 62% during 1995-1998. This decline was not uniform for all countries concerned: several did not record any progress towards a smaller share of final disposal (Table 2.4.1).

Table 2.4.1 **Ratio of municipal waste (MW) going to final disposal per unit of MW generation**[a]

	Ratio MWFD/MW				Municipal waste generation [kg per capita]
	1995	1996	1997	1998[b]	1998[b]
Australia	..	..	..	..	..
Austria	0.36	0.27	0.25	0.25	530
Belgium	0.47	0.41	0.35	0.30	530
Canada	..	..	..	..	840
Czech Republic	..	..	..	..	290
Denmark	0.17	0.13	0.11	0.11	590
Finland	0.64	0.65	0.66	0.66	450
France	0.47	0.48	0.49	0.49	520
Germany	0.45	0.43	0.37	0.31	550
Greece	..	..	..	..	370
Hungary	0.91	0.79	0.82	0.79	490
Iceland	0.84	0.84	0.87	0.84	660
Ireland	..	..	..	..	560
Italy	0.93	0.83	0.80	0.77	470
Japan	..	..	..	..	410
Korea	0.72	0.68	0.62	0.56	350
Luxembourg	0.27	0.28	0.24	0.23	620
Mexico	0.99	0.99	0.99	0.99	320
Netherlands	0.23	0.19	0.16	0.14	590
New Zealand	1.00	..	..	..	380
Norway	0.73	0.67	0.62	0.64	650
Poland	0.98	0.98	0.97	0.98	310
Portugal	0.52	0.58	0.65	0.72	430
Slovak Republic	..	..	..	..	320
Spain	..	..	..	..	570
Sweden	0.36	0.35	0.34	0.33	450
Switzerland	0.13	0.12	0.11	0.11	610
Turkey	0.96	0.96	0.95	0.95	380
United Kingdom	0.83	0.85	0.85	0.82	540
United States	0.57	0.55	0.56	0.57	750
OECD Total	0.64	0.62	0.61	0.61	520
OECD Europe	0.65	0.62	0.60	0.59	480
OECD North America	0.63	0.62	0.62	0.63	650
OECD Pacific	0.72	0.68	0.62	0.56	390

a) In interpreting national figures, it should be borne in mind that survey methods and definitions of municipal waste may vary from one country to another. According to the definition used by the OECD, municipal waste is waste collected by or for municipalities and includes household, bulky and commercial waste and similar waste handled at the same facilities.
b) or latest year available.
Source: OECD

Municipal waste generation versus PFC and population. During the past two decades, the generation of municipal waste (MW) for the whole of the OECD[23], has not increased as strongly as GDP and private final consumption (PFC), but it did keep pace with population growth. In OECD Europe and OECD Pacific, this trend became apparent in the early 1980s, whereas in OECD North America it began in the mid-1990s. Waste management has received increasing attention since 1990. The available figures suggest that MW

23 . *Figures in this section do not include data for Australia, New Zealand and Spain.*

generation in the 23 OECD countries[24] considered here increased by just over 9% during 1990-98, whereas PFC increased by 22% and population by almost 7% (Figure 2.4.2). Two OECD countries (Germany and Korea) have reported a fall in MW generation in recent years. Per capita generation of waste fell in OECD Europe in the early 1990s as a result of a weak economy, but strongly increased again when the economy recovered. In OECD Asia, MW fell by 16% between 1990 and 1998, whereas the population increased by almost 4%.

♦ ***Amount of glass NOT collected for recycling versus PFC***

In order to reduce the amount of waste going to final disposal, waste recovery and materials recycling have greatly increased in OECD countries since the late 1980s, often despite highly volatile markets and prices. For example, metal recycling met with major problems in 1998 due to the very low raw material prices that hardly covered the collection and recycling costs. Thus, fluctuating markets and market prices can have a sudden and profound impact on recovery rates. Separate collection of several municipal waste streams has reinforced this trend.

The recycling of materials can have significant economic and environmental effects. For example, every tonne of iron or aluminium recycled not only replaces the tonne of metal that would have been mined, but also avoids several tonnes of "hidden" material flows associated with the extraction and processing of these metals and the associated environmental externalities. In addition, recycling requires only a fraction of the energy needed to produce these metals from primary ore. The following energy savings have been reported: aluminium 95%, copper 85%, lead 65%, zinc 60%, paper 64% and plastics 80%. The corresponding figure for glass is 20-25%.

Householders in most Member countries have demonstrated an interest in the better management of their waste. Many sorting schemes for household waste have been established, such as kerbside and centralised collection systems where glass, paper and metals are separately collected for recovery, either by or on the behalf of a municipality. On average, 13 % of waste from daily household and commercial activities is collected separately, indicating the level of recycling.

Recycling rates vary among countries as well as by waste stream. For instance, the recycling of construction and demolition waste is quasi-absent in some countries, but reached about 90% in the Netherlands in the mid-1990s. Japan recycles 38% of its non-hazardous industrial wastes.

In future it may be possible to present decoupling indicators showing the “distance to target” in terms of recovery and recycling for the major waste streams. Some information is available for several waste streams on the amounts of material recovered, but few data exist on the amounts that escape recovery efforts and, hence, still go to final disposal. By way of illustration, information is presented here in relation to glass, a material posing relatively few environmental problems.

This indicator shows the recovery for recycling rate of glass[25], a material that has been recycled for several decades in many Member Countries. The indicator shows the absolute decoupling of the amount of glass not recovered for recycling from private final consumption for the United States[26] and the Netherlands[27] (Figure 2.4.3). In the United States, the amount of glass not recovered diminished by almost 36% between 1980 and 1998 to 74% of the amount of waste glass generated. In the Netherlands, the amount of glass not recovered diminished by 77% between 1980 and 1997 to 19% of apparent consumption.

24 . *Austria, Belgium, Canada, Denmark, Germany, Greece, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, Norway, Poland, Portugal, Sweden, Switzerland, Turkey, United Kingdom, and the United States.*
25 . *Paper and cardboard recycling is discussed in the section on forestry and forestry products.*
26 . *Data refer to the material diverted from the municipal waste stream and recycling rates are based on amounts of waste generated.*
27 . *Data refer to the apparent consumption of non-returnable packaging glass and recycling rates are based on the amounts of such glass recovered.*

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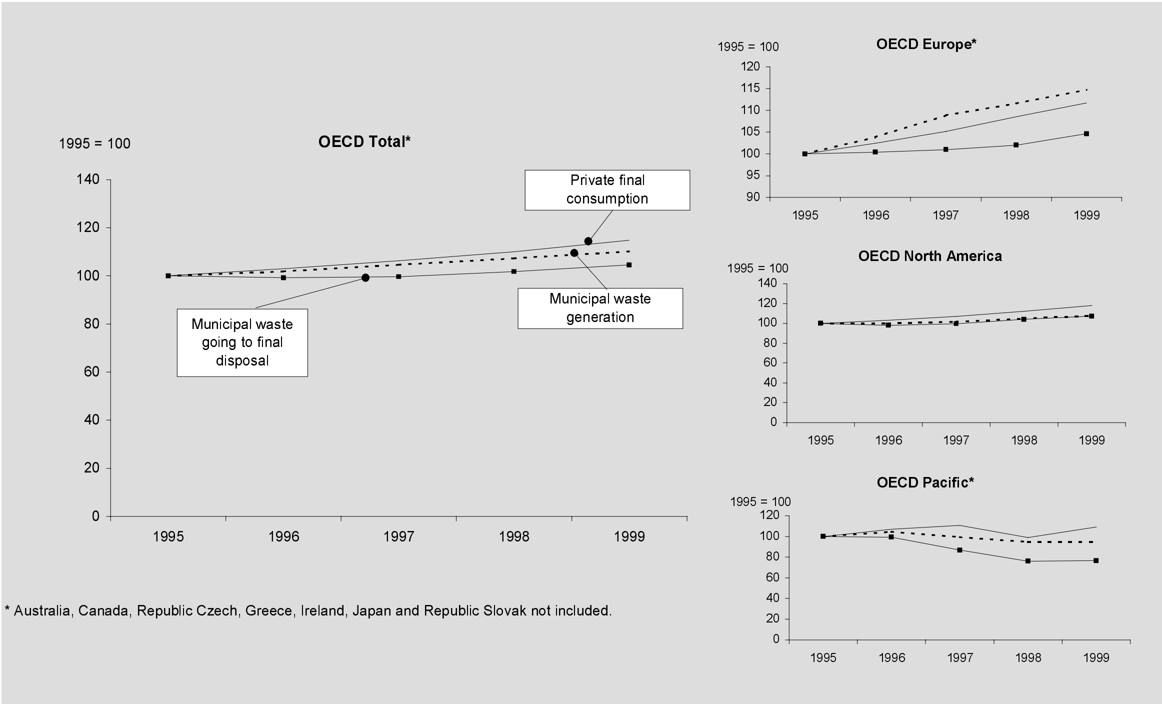
Figure 2.4.1 **Municipal waste going to final disposal versus PFC,** 1995-1999



Municipal waste going to final disposal per unit of PFC

Country	Municipal waste going to final disposal		Private final consumption		Mun. Waste going to final disposal/Private final consumption		Decoupling factor[a)]
	1999 10^3 tonnes	1999 (1995 = 100)	1999 10^9 USD	1999 (1995 = 100)	1999 tonnes/ 10^6 USD	1999 (1995 = 100)	
Austria	1104	87	106.73	110	10.34	79	0.21
Belgium	1902	80	129.57	108	14.68	74	0.26
Denmark	361	72	66.42	110	5.44	65	0.35
Finland	1446	106	58.57	118	24.69	90	0.10
France	14776	107	719.14	108	20.55	99	0.01
Germany	14136	74	1057.57	106	13.37	70	0.30
Hungary	4024	116	52.50	107	76.65	108	-0.08
Iceland	158	114	4.45	131	35.50	87	0.13
Italy	21745	91	746.66	110	29.12	82	0.18
Korea	9152	73	364.26	109	25.12	67	0.33
Luxembourg	60	92	7.66	115	7.83	80	0.20
Mexico	30344	100	498.78	120	60.84	84	0.16
Netherlands	1136	59	188.18	117	6.04	51	0.49
New Zealand	1450	114	40.98	112	35.39	102	-0.02
Norway	1459	74	57.88	115	25.21	64	0.36
Poland	12074	112	212.51	128	56.82	87	0.13
Portugal	3596	179	104.66	119	34.36	151	-0.51
Spain	17534	144	411.20	115	42.64	125	-0.25
Sweden	1300	106	97.44	110	13.34	96	0.04
Switzerland	472	85	114.65	107	4.12	80	0.20
Turkey	22960	115	281.64	115	81.52	100	0.00
United Kingdom	26850	112	813.44	117	33.01	96	0.04
United States	119678	109	5853.19	118	20.45	93	0.07
Total	307717	105	11988.06	115	25.67	91	

a) The decoupling factor is defined as $1-(EP/DF)_{1999}/(EP/DF)_{1995}$ where EP = environmental pressure and DF = driving force. Decoupling occurs when the value of the decoupling factor is between 0 and 1.

Shaded figures indicate absolute decoupling.

Source: OECD

Decoupling factor[a)]
Waste disposal/PFC

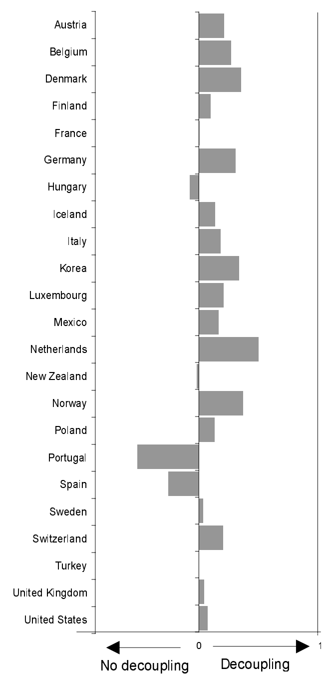
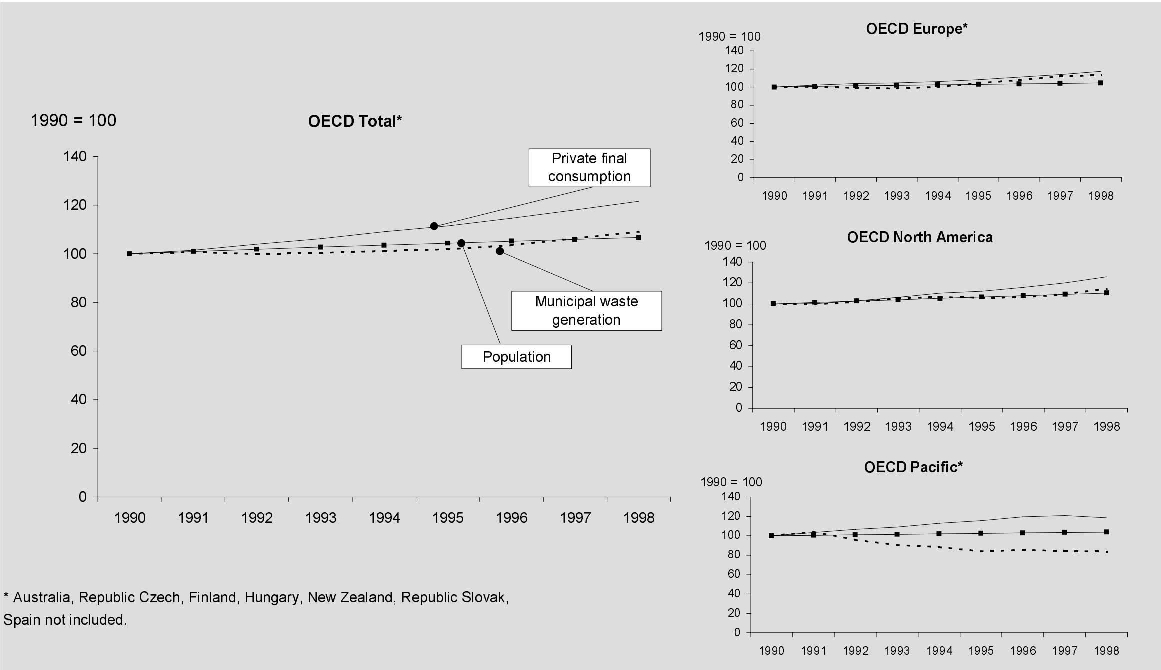


Figure 2.4.2 **Municipal waste generation versus PFC and population,** 1990-1998



* Australia, Republic Czech, Finland, Hungary, New Zealand, Republic Slovak, Spain not included.

Decoupling factor[a)]

Municipal waste generation

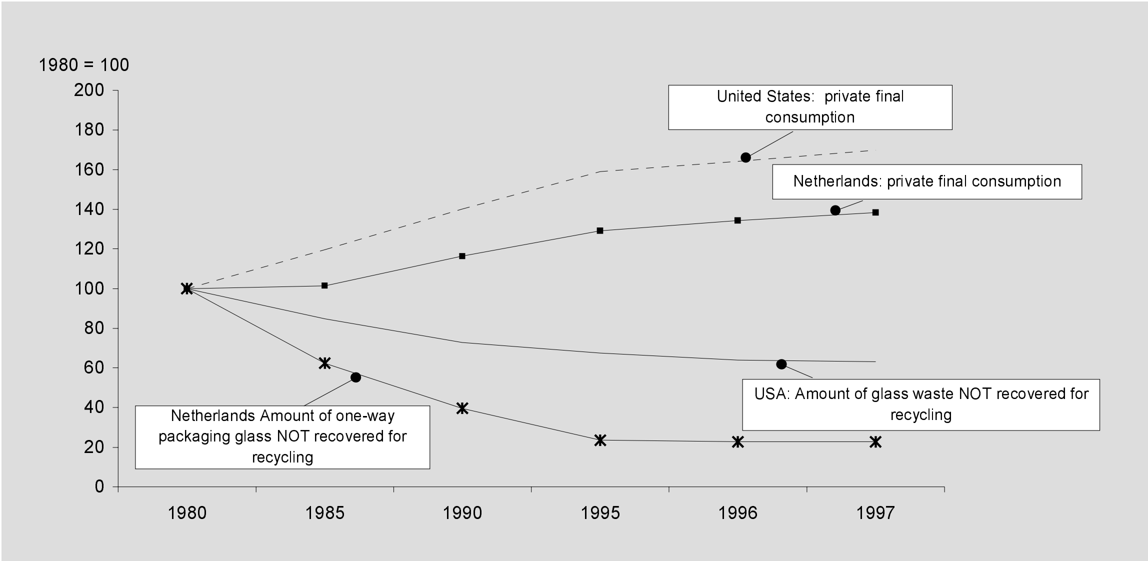
Country	Municipal waste generation		Private final consumption		Mun. Waste/PFC		Decoupling factor[a)] Mun. Waste/PFC
	1998 10^3 tonnes	1998 (1990 = 100)	1998 10^9 USD	1998 (1990 = 100)	1998 tonnes /10^6 USD	1998 (1990 = 100)	
Austria	4249	133	104.34	120	40.72	110	-0.10
Belgium	5453	129	127.10	114	42.90	114	-0.14
Canada	25415	141	430.95	119	58.98	119	-0.19
Denmark	3141	..	66.09	122	47.52	..	..
France	30402	115	700.37	109	43.41	105	-0.05
Germany	44995	90	1030.98	116	43.64	77	0.23
Greece	3900	130	106.27	119	36.70	109	-0.09
Iceland	180	113	4.16	122	43.25	93	0.07
Ireland	2057	..	44.96	145	45.75	..	..
Italy	26846	134	729.62	112	36.79	119	-0.19
Japan	51600	102	1674.67	115	30.81	89	0.11
Korea	16273	53	328.05	140	49.60	38	0.62
Luxembourg	266	119	7.35	125	36.12	95	0.05
Mexico	30551	145	478.38	121	63.86	120	-0.20
Netherlands	9221	124	180.17	124	51.18	100	0.00
Norway	2858	143	56.53	129	50.56	111	-0.11
Poland	11827	107	201.63	151	58.66	71	0.29
Portugal	4304	143	100.09	130	43.00	110	-0.10
Sweden	4000	125	93.88	105	42.61	119	-0.19
Switzerland	4372	107	112.17	107	38.98	100	0.00
Turkey	24176	124	289.18	135	83.60	92	0.08
United Kingdom	31900	118	779.04	119	40.95	99	0.01
United States	202342	109	5559.39	127	36.40	86	0.14
Total[b)]	540327	109	13205.38	122	40.92	90	

a) The decoupling factor is defined as 1-$(EP/DF)_{1998}/(EP/DF)_{1990}$ where EP = environmental pressure and DF = driving force. Decoupling occurs when the value of the decoupling factor is between 0 and 1.
b) Secretariat estimates have been used for calculating OECD trends.
Shaded figures indicate absolute decoupling.
Source : OECD

Decoupling factor[a)]

Municipal Waste/Population

Figure 2.4.3 **Amount of glass NOT collected for recycling versus PFC, in the Netherlands and United States,** 1980-1997



2.5 MATERIAL USE

The pressures exerted by human activity on the environment have most often been conceived of in terms of pollution such as emissions to air or discharges to water. Natural resource issues have not been addressed as much, at least until recently. However, a few aggregated physical measures, aiming to show human claims on the earth's mineral or living resources, have now been proposed. One of these methodologies, materials flow analysis (MFA), traces the mass flow of primary materials extracted from nature to support human activities. Another indicator aims to measure, expressed in energy units, the "human appropriation of net primary production". More widely known is the so-called Ecological Footprint methodology, which has the ambition of measuring (in units of area, so-called global hectares) the human use of nature in order to compare it with the earth's ecological productive capacity.

The environmental implications of resource exploitation and use depend on the characteristics of the resource (e.g., renewable or not, living or mineral). Three kinds of environmental effects arising from resource use can be distinguished. First, depletion of resources can cause scarcity that potentially imposes a cost on future potential users. Also, other than serving as input in economic development, many resources have additional functions such as supporting ecosystems and species habitat (e.g. forests and water). Thirdly, resource use generates downstream pollution streams and waste flows whose environmental costs usually are not borne by the resource users. Given these impacts of resource exploitation, processing and use, increasing the efficiency of resource use can generate significant environmental and economic benefits.

♦ ***Direct Material Input (DMI) per unit of GDP***

Materials flow analysis (MFA) distinguishes materials used for further processing (Direct Material Input or DMI) and so-called hidden flows, which are extractions that are not used further, but have an environmental impact (e.g. overburden and extraction waste). The two can be added up to calculate an economy's Total Material Requirement or TMR. MFA considers extraction both from domestic territory and of the resource requirements associated with imports. Water and air are not considered in MFA.

The DMI measures the direct input of materials for use into the economy, i.e. all materials of economic value that are used in production and consumption activities. DMI equals domestic (used) extraction plus imports.

The DMI per unit of GDP is used here as an indicator for the material input intensity (measured in tonnes per USD) of the economy. The DMI is easier to calculate than the TMR, but experience shows that a high DMI is associated with a high TMR and vice versa. The environmental significance of the DMI is still subject to debate. For example, all materials are treated equally (aggregation is by weight only), independent of their environmental impact or hazard. However, the methodology allows for weighting materials differently, should it be feasible to agree on suitable criteria. Moreover, at the enterprise level environmental reporting often includes changes in material intensity (or its inverse, resource productivity).

MFA uses statistics on industrial production, agriculture, forestry and fisheries on domestic material requirements, while foreign trade statistics give data on imports (grouped into raw materials, intermediate products and final products).

Eurostat, in association with the Wuppertal Institute, has developed provisional MFA accounts for all EU15 countries. The accounts suggest that for the group of EU15 countries, a relative decoupling occurred between DMI and economic growth during 1980-97: DMI increased by almost 9% while GDP grew by 42% over the period concerned (Figure 2.5.1). However, over the last decade or so, the DMI has remained at broadly the same level. Given the population increases over this period, DMI per capita decreased. The decoupling factors for individual EU 15 countries show no clear trends one way or another: trends vary from country to country, depending on the period considered. Japan has calculated its DMI for the five years between 1995-99 and showed an absolute decoupling (decoupling factor 0.10) over that period.

♦ ***Ecological Footprint (minus energy component) versus GDP***

The Ecological Footprint (EF), as presented in the WWF Living Planet Report 2000, aims to provide a conservative estimate of human pressure on global ecosystems. It estimates a population's consumption of food, materials and energy in terms of the area of biologically productive land or sea required to produce those natural resources or, in the case of energy, to absorb the corresponding carbon dioxide emissions.

Conceptually, the EF represents the biologically productive area required to produce the food and wood people consume, to give room for infrastructure, and to absorb the CO_2 emitted from burning fossil fuels. The EF is the sum of six separate components. These are: the area of cropland required to produce the crops that the citizens of that country consume; the area of grazing land required to produce the animal products; the area of forest required to produce the wood and paper; the area of sea required to produce the marine fish and seafood; the area of land required to accommodate housing and infrastructure; and the area of forest that would be required to absorb the CO_2 emissions resulting from that individual's energy consumption.

The EF unit of measurement is the "global hectare." Each global hectare corresponds to one hectare of biologically productive space with "world average productivity." Productivity is the yield obtained in a particular year from any particular land class with prevailing local technologies. Technology can alter the productivity of land, or the efficiency with which resources are used to produce goods and services.

It is possible to interpret the EF (without its energy component) as the appropriation of useful biomass expressed in global hectares. The global hectare thus becomes the aggregate measure that permits the addition of biomass production in its form of crops, animal products, timber and fish. Also included is the land taken up by human settlement and infrastructure, because it is equivalent to a claim on the planet's biological production. For the purposes of this tentative indicator, only the overall world biomass appropriation is presented, and world GDP is taken as the "driving force" (Figure 2.5.2). The tentative EF indicator is included here to illustrate the footprint concept, and data are presented only for the world as a whole and for a short time period. The EF's sponsors are continuing their efforts to improve the data, including trade data, used for the calculations, so that more detailed information might be presented at a later stage.

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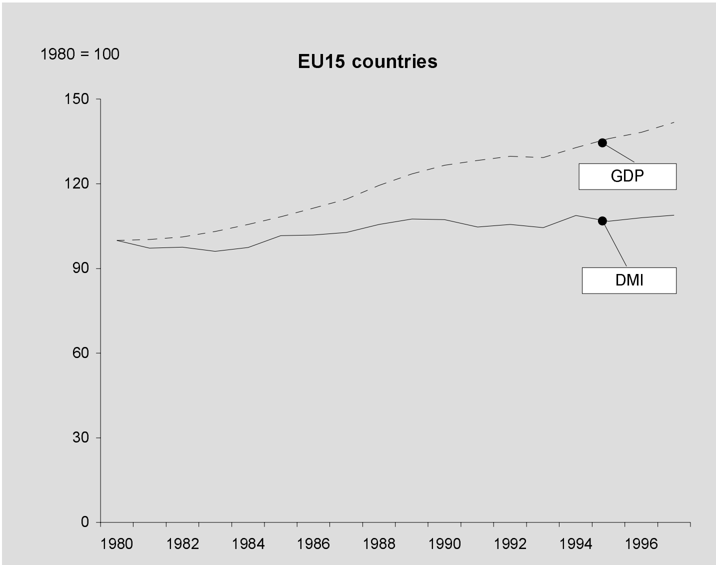
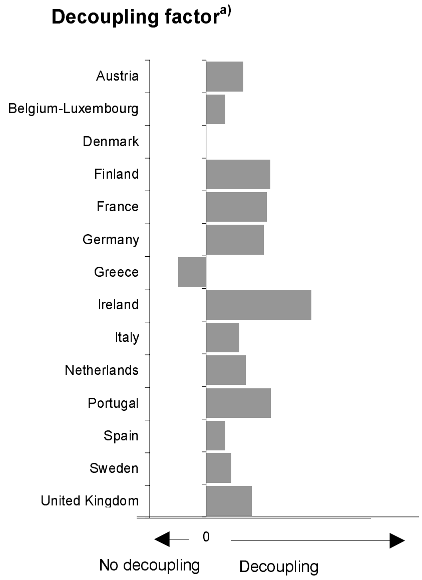
Figure 2.5.1 **Direct material input per unit of GDP,** 1980-1997





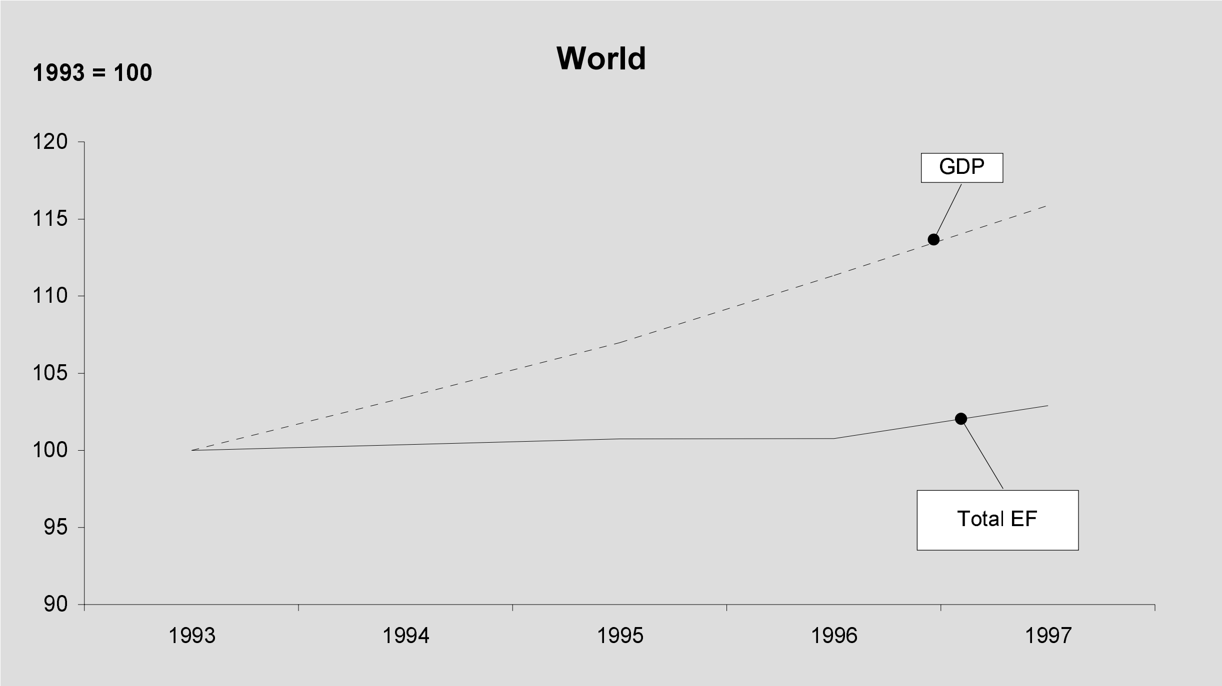
Direct material input versus GDP

Country	DMI		GDP		Decoupling factor[a)]
	1997 10^3 tonnes	1997 (1980 = 100)	1997 10^9 USD	1997 (1980 = 100)	
Austria	189801	120	178.4	144	0.17
Belgium-Luxembourg	347901	129	246.9	141	0.09
Denmark	179504	136	126.9	136	0.00
Finland	216312	103	106.5	145	0.29
France	1240616	101	1236.4	139	0.27
Germany	1935056	102	1785.8	137	0.26
Greece	213642	149	142.1	132	-0.13
Ireland	158826	113	77.8	214	0.47
Italy	899543	116	1186.6	136	0.15
Netherlands	450848	121	351.3	147	0.18
Portugal	138830	113	146.6	160	0.29
Spain	952207	139	635.3	152	0.08
Sweden	312863	115	181.7	130	0.11
United Kingdom	1111172	119	1159.1	150	0.20

a) The decoupling factor is defined as $1-(EP/DF)_{1997}/(EP/DF)_{1980}$ where EP = environmental pressure and DF = driving force. Decoupling occurs when the value of the decoupling factor is between 0 and 1.

Source: Eurostat, Wuppertal Institute and OECD

Figure 2.5.2 **Tentative decoupling indicator: Ecological Footprint (minus energy component) versus GDP**



Ecological Footprint (EF) (minus energy component)
GDP

Year	Average per capita EF	World population (millions)	Total EF	World GDP (billion
1993	1.49	5452.6	8124.4	32488.3
1995	1.46	5606.5	8185.5	34758.2
1996	1.44	5684.6	8185.8	36169.5
1997	1.45	5764.6	8358.7	37646.9

Source: IEA, WWF

2.6 NATURAL RESOURCES

2.6.1 Water Resources

Both water and population are unevenly distributed over the globe. While freshwater resources may appear abundant when measured on a global scale, demand for water – driven by population growth, rising living standards and economic development – is putting pressure on resources in numerous countries or regions within countries.

The pressure on freshwater resources from both abstraction and pollution (see section on water quality) affects economic development as well as the ability of local communities to provide water for human consumption and sanitation. Moreover, water abstraction from rivers and lakes puts pressure on aquatic ecosystems.

While access to clean water for drinking, cooking and bathing is now commonly regarded as a basic human right, increasing competition for water from various economic sectors demands that water is also recognised as an economic good. The momentum for reform of water pricing is building in most OECD countries and water tariffs, particularly for industrial and domestic use, have been moving towards reflecting the full cost of providing water services.

♦ ***Total freshwater abstraction per unit of GDP***

Although socio-economic development is linked to the exploitation of water resources, no simple relationship exists between water use and standard of living. Thus, several OECD countries have stabilised or reduced per capita and even total water abstractions since the late 1980s. In fact, while per capita water consumption decreased across OECD countries by 6.5% between 1980-1997, per capita GNP increased by 36% over the same period, indicating a strong decoupling of water consumption levels from income growth.

In the OECD area, significant variation exists in total freshwater abstraction per unit of GDP and per capita. For instance, in Denmark, Finland and the Netherlands abstractions are less than 10 litres per USD of GDP, whereas in Turkey they amount to about 90 litres/USD and in the United States to 60 litres/USD of GDP.

For the group of 17 Member Countries considered here[28], a pronounced decoupling occurred between total freshwater abstractions and economic growth during 1980-98: abstractions remained broadly constant, whereas GDP grew by two-thirds (Figure 2.6.1). This decoupling was absolute in 9 of the 17 countries. The expansion of irrigation caused abstraction to increase by more than 130% in Turkey, but this growth was matched by an equal increase in GDP.

♦ ***Context indicator: Freshwater abstraction as a share of available resources***

The term “water stress” is defined as the ratio of water withdrawal to annual water availability. OECD countries, like other countries and regions, are exposed to differing degrees of water stress. Not all water uses put equal stress on water resources, but hydrologists usually consider that when the ratio of water withdrawal to annual water availability is less than 10%, water stress is low. A ratio in the range of 10 to 20% indicates that water availability is becoming a constraint on development and significant investments are needed to marshal adequate supplies. When the ratio is greater than 20%, both supply and demand need to be managed and conflicts among competing uses will need to be resolved. This indicator should ideally be evaluated on the scale of a river basin.

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28. Austria, Canada, Czech Republic, Denmark, Finland, Germany, Hungary, Iceland, Japan, Korea, Poland, Slovak Republic, Spain, Sweden, Switzerland, Turkey and the United States.

Table 2.6.1 **Freshwater abstractions as a share of available resources**

	Renewable resources (billion m³)	Abstractions % of renewable resources		
		1980	1990	1998[a]
Australia	352	3.1	..	4.3
Austria	84	4.0	4.4	4.2
Belgium	17	..	..	45.1
Canada	2792	1.3	1.6	1.7
Czech Republic	16	22.7	22.7	14.3
Denmark	6	19.7	14.8	12.3
Finland	110	3.4	2.1	2.1
Germany[b]	182	23.2	26.3	22.3
Greece	72	7.0	..	12.1
Hungary	120	4.0	5.2	4.7
Iceland	170	0.1	0.1	0.1
Ireland	46	2.3	..	2.6
Italy	175	32.1	32.1	32.1
Japan	421	20.9	21.4	21.2
Korea	70	25.1	29.6	35.6
Luxembourg	2	..	3.6	3.4
Mexico	463	12.1	..	17.1
New Zealand	327	0.4	..	0.6
Norway	393	..	..	0.7
Poland	63	22.5	22.6	18.0
Portugal	72	..	11.9	15.3
Slovak Republic	80	2.8	2.6	1.5
Spain	111	36.0	33.2	36.8
Sweden	179	2.3	1.7	1.5
Switzerland	53	4.9	5.0	4.8
Turkey	234	6.9	13.8	16.0
United Kingdom[c]	147	9.2	8.2	6.7
United States	2478	20.9	18.9	19.9

a) or latest year available; b) For 1980, western Germany only; c) England and Wales only.
Source: OECD

Fourteen OECD countries currently exhibit water stress in excess of 10%, of which six show water stress above 20% (Table 2.6.1). In eight countries, the intensity of water use has increased over the last few decades, but in several others the intensity of water use has fallen. This is of little consequence where water stress is low (e.g. Canada), but some countries combine an already high level of water stress with increasing demands on water resources (Korea, Mexico, Turkey). Worldwide, population growth and pollution have reduced the per capita availability of freshwater from 17 000 to 7 300 cubic metres over the period 1950-95[29] and this trend is expected to continue.

References

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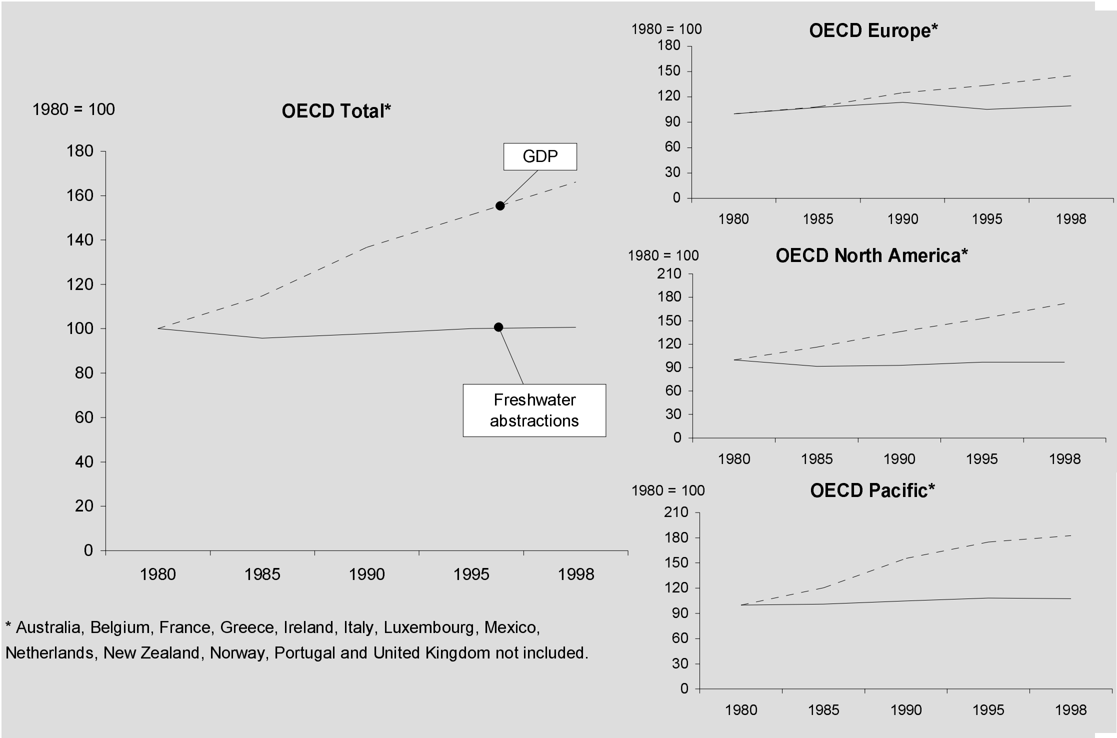
OECD (2001), *OECD Environmental Indicators: Towards Sustainable Development 2001*, OECD, Paris

[29] *Check whether pollution is really part of this calculation*

Figure 2.6.1 **Total freshwater abstraction per unit of GDP,** 1980-1998



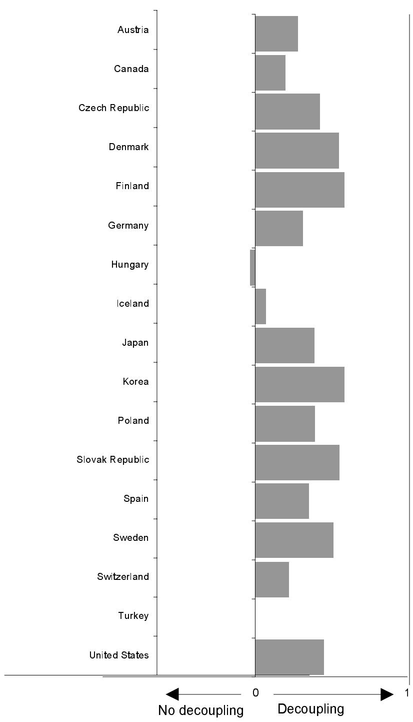
* Australia, Belgium, France, Greece, Ireland, Italy, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Portugal and United Kingdom not included.

Freshwater abstractions per unit of GDP

Country	Freshwater abstractions		GDP		Freshwater abstractions/GDP		Decoupling factor[a)]
	Late 1990s Millions m^3	Late 1990s (1980 = 100)	1998 10^9 USD	1998 (1980 = 100)	1998 m^3 /10^3USD	1998 (1980 = 100)	
Austria	3561	107	184.2	149	19.33	72	0.28
Canada	47250	126	736.0	157	64.20	80	0.20
Czech Republic	2277	63	129.6	110	17.57	57	0.43
Denmark	754	63	130.1	140	5.79	45	0.55
Finland	2328	63	112.2	153	20.75	41	0.59
Germany[b)]	40591	96	1822.5	140	22.27	69	0.31
Hungary	5653	118	103.0	114	54.88	103	-0.03
Iceland	157	145	6.9	157	22.75	93	0.07
Japan	89100	101	2958.5	165	30.12	61	0.39
Korea	24800	142	641.6	343	38.65	41	0.59
Poland	11313	80	321.3	131	35.21	61	0.39
Slovak Republic	1225	55	53.9	124	22.74	44	0.56
Spain	40855	102	662.7	158	61.65	65	0.35
Sweden	2668	65	188.2	134	14.18	48	0.52
Switzerland	2566	99	188.7	128	13.60	78	0.22
Turkey	37490	231	412.3	231	90.93	100	0.00
United States	492260	95	8292.8	174	59.36	55	0.45
Total	804848	101	16944.5	166	47.50	61	

a) The decoupling factor is defined as 1-$(EP/DF)_{1998}/(EP/DF)_{1980}$ where EP = environmental pressure and DF = driving force. Decoupling occurs when the value of the decoupling factor is between 0 and 1.
b) Before 1990, Germany comprises only West Germany.
Shaded figures indicate absolute decoupling.
Source: OECD

Decoupling factor[a)]



2.6.2 Forests and Forest Products

Population and income levels drive the demand for wood consumption, which is also affected by competition from substitutes in many applications. In most OECD countries, population growth is slowing down and populations are ageing. With the exception of paper and board, OECD demand for many types of wood-using products, such as housing, can therefore be expected to remain stable or become weaker through time. Thus, the pressure on forests from commercial logging due to demand from the OECD countries, is unlikely to grow substantially.

The temperate forests in the OECD area are experiencing modest growth in area and significant increases in volume of wood, in spite of the removal of growing wood volumes over the past half-century. The net annual increment (NAI) depends principally on growing conditions, but also upon forest management practices. NAI of over 30 cubic metres/ha/year is possible with intensive management and good growing conditions, as in some Brazilian and New Zealand plantation forests.

It is difficult to define a decoupling indicator for the forestry sector expressed as an environmental pressure versus an economic good. Biodiversity loss per volume of production would, conceptually, be an appropriate decoupling indicator for the forestry sector, but lack of data prevents the presentation of such an indicator for the moment. Production of roundwood from natural forests relative to GDP would also be a suitable indicator, since maximum sustainable yields from such forests tend to grow very slowly. Instead, the decoupling indicator presented here concerns the amount of paper and cardboard not recovered for recycling. In addition, two context indicators provide information about the sustainability of the management of the resource base.

♦ ***Amount of paper/cardboard NOT recycled versus GDP***

Paper use has tripled over the past 30 years and is predicted to double again by 2010. This steady expansion has raised concerns over the growing amount of paper disposed of at landfills. This indicator measures the amounts of paper and paperboard potentially ending up for final disposal in landfills per unit of GDP. Also, the use of recycled fibre reduces the demand for virgin fibre, thereby reducing pressures on forests. The indicator is calculated (using FAO statistics) by adding net imports of paper and paperboard and net imports of recovered paper to national production and subtracting the amounts of paper recovered as secondary feedstock.

For the OECD as a whole[30], the amount of paper and cardboard not recovered for recycling has been relatively decoupled from economic growth during 1980-99: the amount not recovered increased by around 42% while GDP grew by 66% (Figure 2.6.2). This result is largely due to developments in OECD North America and, to a lesser extent OECD Pacific. Although decoupling was absolute for three OECD Europe countries (Germany, Norway and Sweden), the region as a whole did not record any significant decoupling. Imports and exports of paper products as well as of recovered paper and cardboard strongly influence the above figures.

Notwithstanding the increasing paper recycling rates, the amounts of paper not recovered continued to grow in the period considered due to the growing paper consumption (Figure 2.6.2). The widening gap between paper and board production and pulp output reflects the growing importance of recovered fibre and fillers in papermaking. There are economic, technical and quality limits to the quantities of waste paper that can be recycled. As such, incineration with energy recovery is increasingly singled out as the alternative option to address both waste paper generation and greenhouse gas emissions.

♦ ***Context indicator: Intensity of use (harvest/annual growth)***

This indicator is a measure of the harvesting pressure on forests. Annual growth is a function of forest management practices and of the total forest area. Forest harvesting in all OECD countries has remained on the whole well below the annual growth increment (Table 2.6.2). When interpreting these figures,

30 . Figures in this section do not include data for the Czech Republic, Iceland and the Slovak Republic.

however, readers should note that commercial logging *per se* is rarely the driving force causing deforestation. This is true for both temperate and tropical regions. Permanent forest loss is typically driven by the desire to convert forest land to other uses, usually agriculture. Conversely, forest expansion in the temperate regions is largely driven by the abandonment of agricultural pursuits on marginal land and its natural reversion to forest. This trend is accentuated by conscious investment in reforestation in many OECD countries and elsewhere.

Over the last three decades, roundwood removals have increased at only half the rate of wood consumption, both in the OECD area and in the rest of the world. This is partly because the pulp and panel industries are now making greater use of sawmilling residues. Increased waste paper recovery has led to more recycling for paper and paperboard production. Production process methods in the forest industry have improved, for example through the use of thermo-mechanical pulp in partial replacement of chemical pulp.

Table 2.6.2 **Intensity of forest use: harvest/annual growth rate**, 1980-99

	1980	1985	1990	1995	1996	1997	1998	1999
Australia	..	0.40	..	0.57	..	..	..	..
Austria	0.65	..	0.60	0.60	0.67	..	..	..
Belgium	..	1.03	..	1.26	..	..	..	..
Canada	0.43	0.45	..	0.44	..	..	..	..
Czech Republic	0.72	..	0.68	0.72	..	..	..	..
Denmark	0.75	..	0.60	..	..	..	..	..
Finland	0.93	0.79	0.73	..	0.74	..	..	..
France	0.81	0.78	0.82	0.70	..	..	..	..
Germany[a]	..	..	..	..	..	..	..	..
Greece	0.71	0.62	..	0.65	..	..	..	..
Hungary	0.70	0.75	0.67	0.54	0.57	0.58	0.57	0.59
Iceland	-	-	-	-	-	-	-	-
Ireland	0.35	..	0.68	..	..	..	..	..
Italy	0.43	0.80	..	0.46	..	..	..	..
Japan	..	0.36	0.35	0.42	..	..	..	..
Korea	..	0.14	0.07	0.07	..	0.06	..	..
Luxembourg	..	0.49	1.21	0.52	..	..	..	..
Mexico	0.23	..	0.24	0.17	..	..	..	..
Netherlands	..	0.41	0.42	0.60	..	..	..	..
New Zealand	..	..	0.63	..	..	..	..	..
Norway	0.55	..	0.62	..	0.49	..	..	..
Poland	0.59	..	0.50	..	0.59	..	..	..
Portugal	0.98	0.94	1.11	0.83	..	..	..	..
Slovak Republic	0.71	0.44	0.44	0.38	0.50	..	..	..
Spain	0.46	0.40	0.40	..	..	..	..	..
Sweden	0.81	0.64	0.63	0.78	0.72	..	..	..
Switzerland	0.71	0.66	1.01	0.78	..	..	..	..
Turkey	0.82	0.59	0.52	..	0.51	..	..	0.43
United Kingdom	0.48	0.50	0.59	0.65	..	..	..	..
United States	0.56	0.59	0.60	0.60	..	..	..	..

a) For 1980 and 1985, western Germany only.
Source: OECD, FAO, national statistical yearbooks

♦ ***Context indicator: Share of plantation & sustainably managed forests in total forest area***

Intensification of wood production – through a combination of more active forest management and greater use of plantation forests – can satisfy world demand for forest products without increasing recourse to remote and inaccessible forest areas. Plantation forests have already deflected a significant portion of commercial logging away from natural forests. The commercial logging of the last major "frontier" forests of the world (Amazon, Russia and Canada) may already have reached its peak and be on the decline.

This context indicator is a measure of the efforts by the forest industry to manage its forests on a sustainable basis, not just in terms of sustainable yield, but also including ecosystem considerations. The figures need to be interpreted with caution as, for some countries, there may be an overlap between the two categories of plantation and certified forests. Eco-certification is still in its infancy, but in the longer term an indicator measuring the share of wood production from non-ecocertified forests might prove a meaningful a context indicator (Table 2.6.3).

References

OECD (1999), *Environmental Data Compendium 1999*, OECD, Paris

OECD (2000), *Environmental Outlook in the Forestry Sector*, Background document for the OECD Environmental outlook for Chapter 10: Forestry, OECD, Paris.

OECD (2000), *Environmental Outlook: The Forestry Sector*, Background document for the OECD Environmental outlook for Chapter 10: Forestry, OECD, Paris.

OECD (2000), *Pulp and Paper Industry*, Background document for the OECD Environmental outlook for Chapter 18: Pulp and Paper Industry, OECD, Paris.

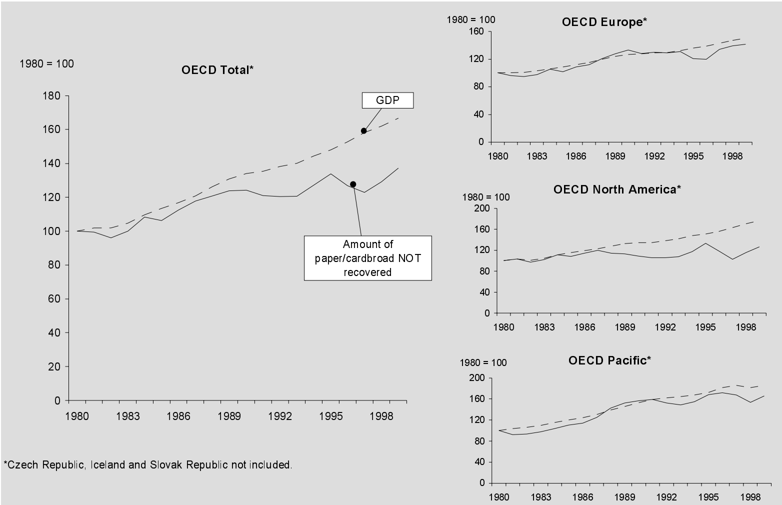
OECD (2001), *OECD Environmental Indicators: Towards Sustainable Development 2001*, OECD, Paris

Table 2.6.3 **Share of plantation and certified forests in total forest area,** 2001[a]
(1000 ha)

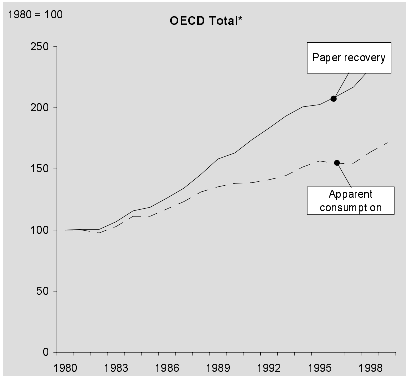
	Total forest	Forest plantations	Forest area certified[b]	Share of total forest area (%)
Australia	154539	1396	..	..
Austria	3886	-	553	14
Belgium-Luxembourg	728	-	4	1
Canada	244571	-	4360	2
Czech Republic	2632	-	10	-
Denmark	455	341	-	75
Finland	21935	0	21900	100
France	15341	961	1	6
Germany	10740	0	5294	49
Greece	3599	120	..	..
Hungary	1840	136	61	11
Iceland	31	12	-	39
Ireland	659	590	..	..
Italy	10003	133	11	1
Japan	24081	10682	3	44
Korea	6248	..	..	..
Mexico	55205	267	527	1
Netherlands	375	100	70	45
New Zealand	7946	1542	430	25
Norway	8868	300	5100	61
Poland	9047	39	2743	31
Portugal	3666	834	..	..
Slovak Republic	2177	15	..	..
Spain	14370	1904	..	..
Sweden	27134	569	10996	43
Switzerland	1199	4	101	9
Turkey	10225	1854	..	..
United Kingdom[c]	2794	1928	958	..
United States	225993	16238	3118	9
Total	877681	39965	60772	11

a) or latest year available; b) sum of areas covered by the Forest Stewardship Council (FSC) and the Pan European Forest Certification (PEFC);
c) last column has not been calculated because the figures for plantation and certified forests are not mutually exclusive.
Source: FAO, FSC, PEFC

Figure 2.6.2 **Amount of paper/cardboard NOT recovered for recycling versus GDP,** 1980-1999



For Reference



Amount of paper/cardboard NOT recovered per unit of GDP

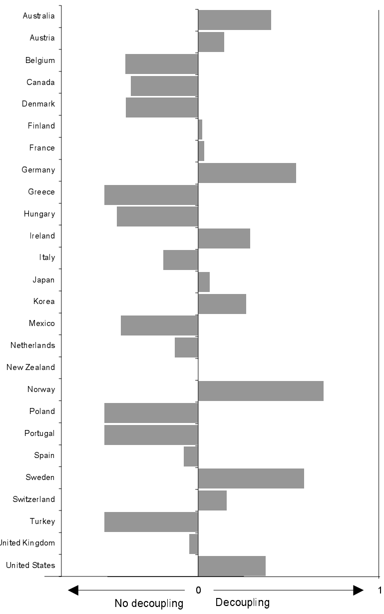
Country	Amount of paper/cardboard NOT recovered		GDP		Amount of paper/cardboard NOT recovered/GDP		Decoupling factor[a)]
	1999 10^3 tonnes	1999 (1980 = 100)	1999 10^9 USD	1999 (1980 = 100)	1999 tonnes/ 10^6 USD	1999 (1980 = 100)	
Australia	1701	115	468.1	191	3.63	60	0.40
Austria	1257	131	189.4	153	6.64	86	0.14
Belgium & Luxembourg	1707	209	261.0	149	6.54	140	-0.40
Canada	8199	225	769.8	164	10.65	137	-0.37
Denmark	934	198	132.3	142	7.06	140	-0.40
Finland	1294	156	116.8	159	11.08	98	0.02
France	6015	142	1311.6	147	4.59	97	0.03
Germany	4650	66	1850.9	142	2.51	46	0.54
Greece	930	276	151.4	141	6.14	196	-0.96
Hungary	707	172	107.6	119	6.57	145	-0.45
Ireland	357	182	92.8	255	3.85	71	0.29
Italy	7354	167	1222.0	141	6.02	119	-0.19
Japan	15695	155	2964.5	166	5.29	94	0.06
Korea	4460	281	710.0	380	6.28	74	0.26
Mexico	4878	224	758.6	158	6.43	142	-0.42
Netherlands	1976	178	377.2	158	5.24	113	-0.13
New Zealand	491	152	68.1	152	7.21	100	0.00
Norway	191	54	114.8	172	1.66	31	0.69
Poland	2200	234	334.7	137	6.57	171	-0.71
Portugal	613	278	156.5	171	3.92	163	-0.63
Spain	3432	177	689.4	165	4.98	108	-0.08
Sweden	751	58	196.0	140	3.83	42	0.58
Switzerland	660	109	191.6	129	3.44	84	0.16
Turkey	1493	360	391.6	219	3.81	164	-0.64
United Kingdom	7665	165	1215.3	157	6.31	105	-0.05
United States	47531	113	8587.7	180	5.53	63	0.37
Total	127141	137	23429.7	167	5.43	82	

* The decoupling factor is defined as 1-$(EP/DF)_{1999}/(EP/DF)_{1980}$ where EP = environmental pressure and DF = driving force. Decoupling occurs when the value of the decoupling factor is between 0 and 1.

Shaded figures indicate absolute decoupling.

Source: FAO,OECD.

Decoupling factor[a)]



2.6.3 Fisheries

The fisheries sector comprises two distinct sub-sectors, capture fisheries and aquaculture. Capture fisheries involves the hunting and gathering of fish in the wild. Aquaculture, or "fish farming," involves the raising of fish under controlled circumstances. Capture fisheries, with just under 74% of the total fisheries production of 117 million tonnes in 1998, is the dominant sub-sector. Capture fishery harvests may be approaching a natural upper limit dictated by the finite supply of nutrients to the world's oceans, and have proven to be very difficult to manage in both biological[31] and economic terms. Many capture fishery resources have suffered from overexploitation and are producing well below their potential. Although production from some developing capture fisheries may increase and some depleted fisheries may recover, future growth in fisheries production will largely be in aquaculture[32].

♦ ***<u>Capture fisheries production versus food consumption</u>***

Population growth, per capita income growth and changing consumer preferences drive the demand for fish products. At the same time, sound fishery management must respect maximum sustainable yields (as measured by biological reference points for particular fisheries) that are independent of the level of economic activity. The decoupling concept cannot easily be applied to the fisheries sector and lack of pertinent data makes it difficult to present a wholly adequate decoupling indicator for the fishery sector. The OECD Fisheries Committee is now (2002) developing economic and social sustainability indicators for fisheries.

An indicator measuring production from capture fisheries relative to total food consumption might serve as a proxy decoupling indicator[33] (Figure 2.6.3). Between 1980-99, capture fisheries production in OECD countries decreased by about 11%, whereas food consumption increased by 23%. In non-OECD countries, capture fish production increased by more than 75%, and food consumption by 58%. However, these figures do not take account of trade in fish products between the OECD and the rest of the world. Readers should also be aware of the fact that fishery capture data are difficult to verify[34] and need to be interpreted with extreme caution.

♦ ***Context indicator – fisheries sector***

In addition, it is possible to present information about selected relevant variables such as fish catch by OECD and non-OECD countries, aquaculture production, fish consumption and the state of world marine fish resources (Figure 2.6.4). Over the four decades between 1950 and 1990, with an average annual rate of 4%, world capture fisheries experienced a rapid growth. After 1990, there appears to have been some levelling off of capture fishery harvests. In fact between 1990 and 1999, the average annual rate of growth was just slightly less than 1%, while between 1994 and 1999, the growth rate was slightly negative.

In contrast, OECD country capture fisheries have been declining in absolute terms since the mid-1980s (Figure 2.6.4). In 1999, the combined catch of OECD countries amounted to about 90% to what in was in 1980. Also, the share of world capture fishery harvests accounted for by OECD countries has been declining since, at least, the 1950s. The three leading nations involved in capture fisheries are developing nations (China, Peru and Chile), as are six of the leading ten. Capture fishery production levels of OECD Member Countries (based upon the most recent five-year annual average) collectively account for 31.5% of the world total of 92.5 million tonnes. The shares of OECD North America, OECD Europe[35] and OECD Pacific are 7.6, 12.1 and 8.6 million tonnes, respectively.

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31 . Refer to the caveat made under section 1.9 regarding the lack of understanding of the functioning of complex ecosystems.

32 . Readers should keep in mind, however, that a significant part of aquaculture depends on feed fish (fishmeal) provided by capture fisheries.

33 . One would expect little growth in the volume of production from capture fisheries once sustained yields are achieved

34 . For instance, Watson and Pauly (2001) question the Chinese data on fish production. Evidence of over-reporting would suggest that world marine catches are in fact below the reported figures.

35 . Figures in this section do not include data for the Czech Republic and the Slovak Republic.

Fishery products account for approximately 20% of all animal protein consumed by human beings. In Asia, the percentage may be as high as 30%. Indeed in Japan, the leading fish producing member of the OECD, fishery products constitute the single most important source of protein for the population. In OECD countries, per capita fish consumption ranges from 5 kg in the Czech Republic to 92 kg in Iceland.

♦ *References*

OECD (2000), *Fisheries Trends*: A Background Report, Background document for the OECD Environmental Outlook for Chapter 9: Fisheries Trends, OECD, Paris.

OECD (1999), *Towards more sustainable household consumption patterns, Indicators to measure progress*, OECD Series on Environmental Indicators, OECD, Paris.

OECD (2001), *OECD Environmental Indicators: Towards Sustainable Development 2001*, OECD, Paris

Watson, R. and Pauly, D (2001), *Systematic distortions in world fisheries catch trends*, *Nature* 414.

Figure 2.6.3 **Fisheries production versus food consumption**, 1980-99

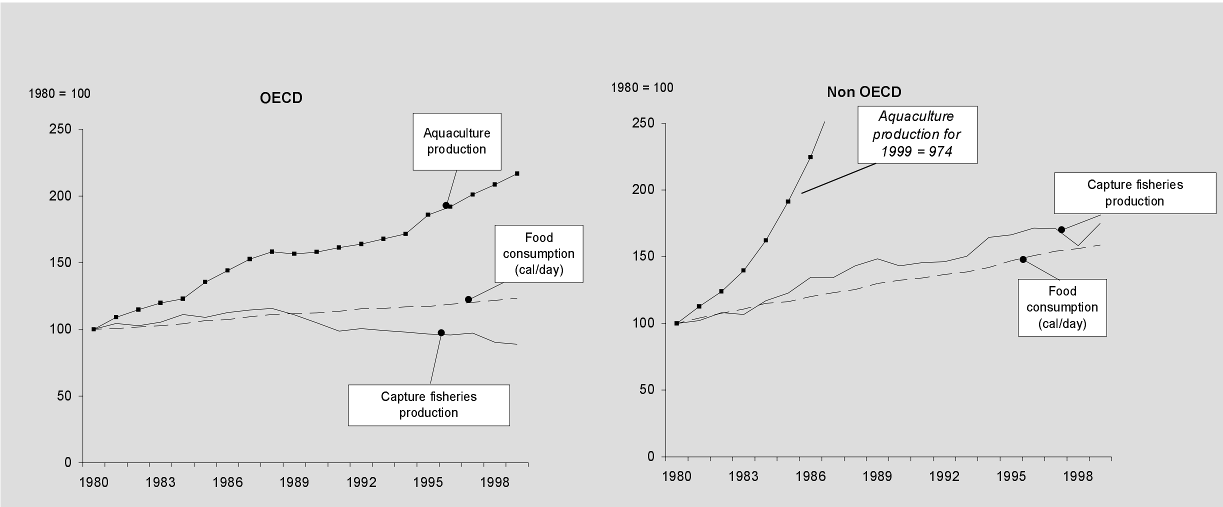
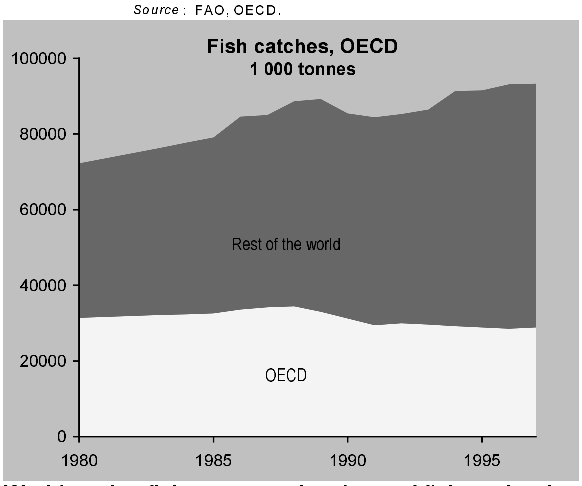


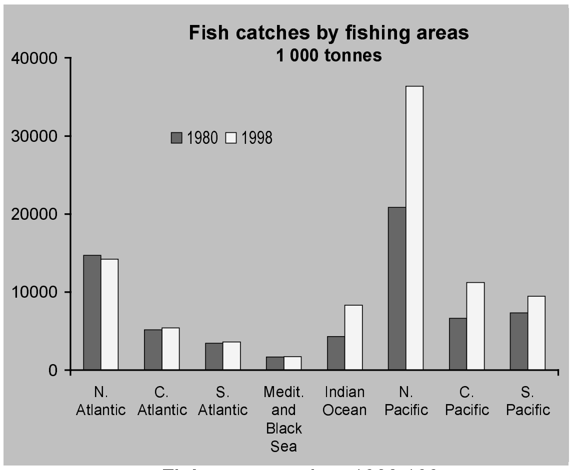
Figure 2.6.4 **Context indicator - fisheries sector**

Fisheries sector

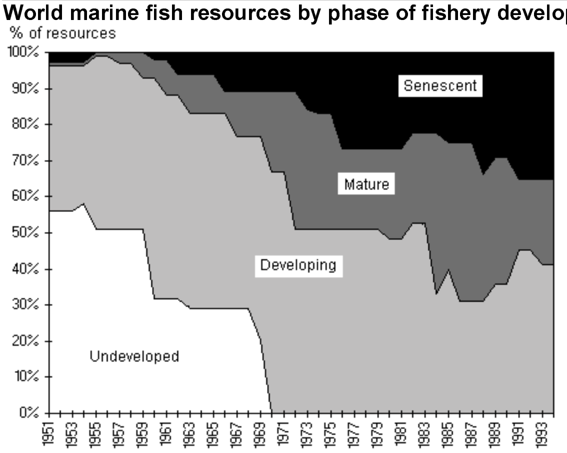
Country	Capture fisheries		Aquaculture production		GDP		Fish consumption	
	1999 10^3 tonnes	1999 (1980 = 100)	1999 10^3 tonnes	1999 (1980 = 100)	1999 10^9 USD	1999 (1980 = 100)	1999 10^3 tonnes	1999 (1980 = 100)
Australia	216	175	34	375	468.1	191	357	162
Austria	0	39	3	96	189.4	153	114	212
Belgium & Luxembourg	30	65	1	940	261.0	149	216	109
Canada	1022	76	114	3186	769.8	164	664	134
Czech Republic	4	..	19	..	129.3	110	118	..
Denmark	1405	70	43	230	132.3	142	130	91
Finland	161	96	15	314	116.8	159	184	133
France	578	100	268	129	1311.6	147	1696	125
Germany	239	46	74	190	1850.9	142	1198	117
Greece	137	129	79	4038	151.4	141	283	185
Hungary	8	67	12	53	107.6	119	47	102
Iceland	1736	115	4	9063	7.1	161	25	128
Ireland	286	198	44	778	92.8	255	58	98
Italy	294	69	246	330	1222.0	141	1352	143
Japan	5176	52	759	133	2964.5	166	8395	111
Korea	2120	117	303	106	710.0	380	2283	149
Mexico	1202	97	48	561	758.6	158	1025	145
Netherlands	515	195	109	141	377.2	158	252	178
New Zealand	594	385	92	2846	68.1	152	91	190
Norway	2620	109	466	5840	114.8	172	223	124
Poland	235	37	34	350	334.7	137	544	134
Portugal	208	77	8	1256	156.5	171	581	205
Slovak Republic	1	..	1	..	54.9	126	32	..
Spain	1167	101	318	155	689.4	165	1630	137
Sweden	351	151	6	723	196.0	140	244	97
Switzerland	2	55	1	668	191.6	129	128	183
Turkey	575	135	63	4599	391.6	219	453	140
United Kingdom	838	101	155	5422	1215.3	157	1315	142
United States	4750	134	479	284	8587.7	180	5685	160
Total[a)]	26464	89	3776	217	23436.8	189	29173	132

a) Czech Republic and Slovak Rrepublic are not included into the total.
Source : FAO, OECD.

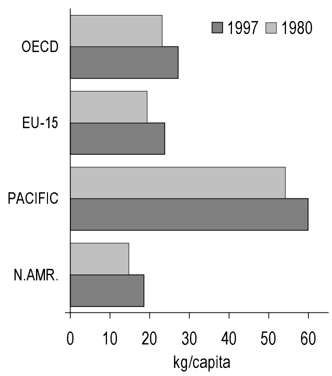




World marine fish resources by phase of fishery development



Fish consumption, 1980-1997



2.6.4 Biodiversity

The UN Convention on Biological Diversity defines "biodiversity" as "the variability among living organisms from all sources including, *inter alia* terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems."

In order to determine whether efforts to protect and enhance biodiversity are effective, it is desirable to develop yardsticks by which progress can be measured. Several such yardsticks have been proposed (e.g. WWF Living Planet Index, IUCN Well-being Index), but none of them has found widespread acceptance so far. Another measure, the Natural Capital Index (NCI) was specifically developed as an assessment tool for the Convention On Biological Diversity (CBD) and preliminary implemented in UNEP's Global Environment Outlooks.

NCI is a function of the remaining natural area and its quality. Although the NCI is a state indicator, a pressure version has also been developed. Its rationale is that the intensification of a set of pressures on the quality and quantity of natural areas over time will reduce the productivity of these ecosystems, including the biodiversity they support.

A preliminary pressure version of the NCI has been worked out for Europe based on seven pressure variables (rate of climate change, human population density in natural areas, consumption and production in natural areas, isolation/fragmentation, acidification, eutrophication, and exposure to high ozone concentration). The methodology is based on evaluating the change in natural area and its quality as a result of the 7 pressures for all 1 by 1 km grid cells of natural area in a country. The aggregate value of the quality index at the country level is the weighted average of the indices of the individual grid cells. The quantity index is then averaged with the index representing the share of natural areas in the country's total area. The pressure version of the NCI takes a value of between 0 and 100; for example, if 50% of a country still consists of natural area and the quality of this area has been degraded by 50%, then the value of the index is 25.

♦ ***Pressure version of the Natural Capital Index versus GDP***

This tentative indicator is presented as an illustration of what a biodiversity decoupling indicator might look like for Europe as a whole and for three European regions (Figure 2.6.5). The indicator is based on estimates/projections of the pressure version of the NCI and of GDP for 1990 and 2010 (as presented in some of the preparatory work for the OECD Environmental Outlook).

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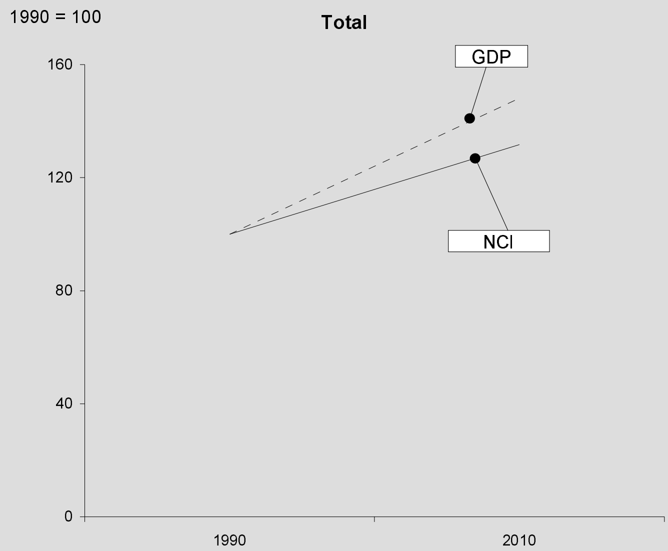
Figure 2.6.5 **Tentative biodiversity decoupling indicator: pressure version of Natural Capital Index (NCI) versus GDP**



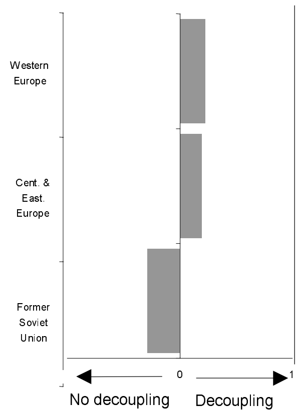
Western Europe: Austria, Belgium-Luxembourg, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.
Central & Eastern Europe: Bulgaria, Czech Republic, Hungary, Poland Romania and Slovak Republic.
Former Soviet Union: Belarus, Estonia, Latvia, Lithuania, Republic of Moldova, Russian Federation and Ukraine.

Hypothetical biodiversity decoupling indicator: pressure version of Natural Capital Index (NCI) versus GDP

Region	NCI a)		GDP		Decoupling factor b)
	2010 (%)	2010 (1990 = 100)	2010 10^9 USD	2010 (1990 = 100)	
Western Europe	34	117.80	10668	152	0.22
Central & Eastern Europe	14	155.63	1435	193	0.19
Former Soviet Union	48	148.39	2113	115	-0.29

a) The NCI pressure index was developed as an assessment tool for the Convention On Biological Diversity (CBD) by the Dutch National Institute of Public Health and the Environment RIVM and the UNEP World Conservation and Monitoring Centre. The index comprises seven variables (rate of climate change, human population density, consumption and production, isolation/fragmentation, acidification, eutrophication, exposure to high ozone concentration) and takes a value of between 0 and 100.
b) Decoupling factor is defined as 1-(EP/DF)end of period/(EP/DF)start of period where EP = environmental pressure and DF = driving force. Decoupling occurs when the value of the decoupling factor is between 0 and 1.
Source: OECD, RIVM and WCMC.

Decoupling factor b)



3. DECOUPLING INDICATORS FOR SPECIFIC SECTORS

3.1 ENERGY USE AND PRODUCTION

Energy is an essential part of modern life. The production and use of energy satisfies human needs and wants, but also gives rise to a host of adverse environmental pressures, such as greenhouse gas emissions, air pollution and the generation of nuclear waste. Energy use leads to noise, water pollution, and ecosystem degradation. Energy-related air pollution also has significant negative effects on human health. The environmental externalities from energy production and use strongly vary, depending on the source of energy (coal, oil, hydro, nuclear) considered. In this section, only energy-related emissions to the atmosphere are examined.

Energy is used by all sectors of the economy. The first decoupling indicator hence refers to emissions of a range of air-pollutants (CO_2, NO_x and SO_x) from all types of energy use, while the second indicator looks at carbon emissions from a particular type of use, e.g. space heating of residential and commercial sectors. But energy contributes to air emissions also when produced. Utilities and industrial energy-production facilities account for the predominant share of sulphur oxides emissions (23% in 1998) in the OECD area, and the second largest, after transport, of nitrogen oxides (28%). CO_2 emissions from energy production and transformation accounted for 34% of total CO_2 emissions from fossil fuel combustion in 1998.[36] A third decoupling indicator discussed in this section looks at carbon emissions from energy production in the electricity sector.

♦ ***Emissions of CO_2, SO_x and NO_x per unit of GDP***

Emissions of carbon dioxide, sulphur dioxide and nitrogen oxides are driven by the demand for energy services, which in turn are linked to economic growth. Energy-related emission intensities (emissions per unit of GDP) are therefore important indicators for measuring progress in decoupling energy-related emissions from economic activity.

Overall, emissions of all three air-pollutants considered here have been significantly decoupled from economic growth, most pronounced in the case of SO_x emissions. Since 1980, significant relative decoupling of CO_2 emissions from GDP growth occurred for the total of OECD[37] countries (emissions increased by just over 7% during 1980-98, whereas GDP increased by almost 59%, Figure 3.1.1). Over the same period, decoupling was absolute in OECD Europe. Significant relative decoupling occurred in OECD North America (minus Mexico), while less significant progress was achieved in OECD Pacific. Absolute decoupling, for the OECD as a whole, occurred for NO_x emissions (as emissions fell by almost 5% over 1980-98, as compared to a 59% increase in GDP, Figure 3.1.1). Decoupling was absolute for OECD Europe, but only relative for OECD North America and OECD Pacific. Last, a more significant absolute decoupling, for the OECD as a whole, occurred for SO_x emissions (which were almost halved in the period 1989-98, Figure 3.1.2). Absolute decoupling occurred in each of the three main regions, but was particularly pronounced in OECD Europe.[38]

♦ ***Decomposing atmospheric emissions from energy use***

Atmospheric emissions from energy use per unit of GDP depend on the emission intensity of Total Primary Energy Supply (emissions/TPES), on the energy conversion ratio (Total Primary Energy Supply needed to produce the Total Final Consumption of energy – TPES/TFC), a measure of conversion efficiency, and on the final energy intensity of the economy (TFC/GDP), as follows

36 . Some of the indicators presented in this section also feature among the "items for measurement of progress" listed under the second objective of the OECD Environmental Strategy, under the heading of energy. These include: i) Carbon and energy intensities and fuel mix (sectorally and nationally, share of renewables); ii) Energy prices and taxes (relative, trends); and iii) Energy consumption (total and per capita).

37 Figures quoted in this section do not include data for Australia, Korea, Mexico and Turkey.

38 . Reductions in SO_x emissions were especially strong in the electricity sector, reflecting a combination of flue-gas desulphurisation, greater use of low-sulphur fuels, fossil fuel switching, efficiency improvements and an increase in the share of non-fossil fuels.

Emissions/GDP	=	emissions/TPES	*	TPES/TFC	*	TFC/GDP
Emissions of CO_2, SO_x and NO_x per unit of GDP		depends on emission factors and fuel mix		depends on conversion efficiency and the fuel mix		depends on sectoral energy intensities, fuel mix, activity and structure of the economy

Emissions as a share of total primary energy supply. Since 1980, emissions of CO_2, SO_x and NO_x declined relatively to TPES (Table 3.1.1), mainly reflecting a lower share of oil and coal in TPES. This decline has been most pronounced for SO_x (a decline in emissions by as much as 49%), followed by NO_x (which decreased by almost 6%) and CO_2.(whereas emissions increased by about 6%, as compared to an increase in TPES by 21% during 1980-98). Among the three regions, OECD Europe achieved the greatest reduction in the emissions per unit of TPES for all three gases.

T*he energy conversion ratio* (TPES/TFC), or the amount of primary energy required to produce a given amount of final energy, however, increased steadily over recent decades. This increase exceeded 7% during 1980-98 for the OECD as a whole, and was in a range between just over 2% (OECD Europe) and 12% (OECD North America, (Table 3.1.1) for the three regions. This increase mainly reflected a higher share of electricity in final energy use, which outweighed efficiency improvements in the conversion from primary to final energy.

Total final energy consumption, as a share of GDP (TFC/GDP), declined by 13% in the period 1980-98, as GDP grew by 58%. The decline in the energy intensity of the economy has continued since the oil price shock in the 1970s (Table 3.1.1). In 1998 OECD economies used, on average, about 28% less energy per unit of GDP than in 1980. Most of this improvement is explained by improved energy efficiency and increased share of electricity in major end-uses (which has tended to increase the TFC/GDP ratio), as well as by shifts in economic structure and consumer behaviour.

Table 3.1.1 **Decomposing emissions intensities of energy use**, 1980-98
1998-value of ratio/1980-value

	emissions/GDP	=	emissions/TPES	*	TPES/TFC	*	TFC/GDP
CO_2 emissions							
OECD Total*	0.68	=	0.88				
OECD Europe	0.63	=	0.80				
OECD North America	0.67	=	0.95				
OECD Pacific	0.76	=	0.84				
SO_x emissions							
OECD Total	0.32	=	0.42	*	1.07	*	0.72
OECD Europe	0.21	=	0.27	*	1.02	*	0.77
OECD North America	0.47	=	0.66	*	1.12	*	0.63
OECD Pacific	0.38	=	0.42	*	1.03	*	0.88
NO_x emissions							
OECD Total	0.60	=	0.78				
OECD Europe	0.54	=	0.69				
OECD North America	0.61	=	0.86				
OECD Pacific	0.56	=	0.62				

Note: OECD Europe excludes Turkey; OECD North America excludes data for Mexico; OECD Pacific excludes data for Australia and Korea. OECD Total excludes data for all four countries.
Source: OECD/IEA

Overall, Table 3.1.1 shows that decoupling of energy emissions of CO_2, NO_x and SO_x from GDP reflected both lower emissions per unit of primary energy supply and lower energy consumption per unit of GDP. Higher energy conversion ratio (TPES/TFC), mainly due to the higher share of electricity in energy end-use, only partially offset the other two factors.

♦ ***CO_2 emissions from the residential and commercial sectors per square metre of floor area.***

CO_2 emissions from the residential and commercial sector, combined, accounted for 13% of total CO_2 emissions from fossil fuel combustion in the OECD area in 1998. Residential and commercial buildings also account for about one-third of the total final energy use, and for almost 60% of total OECD electricity demand. Most of the energy-use in residential buildings in OECD countries goes to space heating, though this depends on climate.

The decoupling indicator discussed for energy use in the residential and commercial sector measures carbon emissions per square metre of floor area (separately for both residential dwelling for the commercial/services sector). Information is however limited to only 10 countries in the first case, and to 4 countries in the second.

During 1981-98, CO_2 emissions (from fuel combustion and electricity use) from the residential sector were relatively decoupled from the total residential floor area for the group of countries[39] considered. The decoupling indicator decreased by 16% (Table 3.1.2), as CO_2 emissions increased by 16% while the total floor area increased by more than a third (Figure 3.1.3). In the commercial/services sector, emissions had grown as much floor area by the end of the period for the group of four countries[40] for which data are available. An absolute decoupling occurred in France, while Canada recorded relative decoupling.

♦ ***Decomposing the carbon emissions from the residential and commercial sectors***

The decoupling indicator for energy-related carbon emissions from the residential and commercial sectors, per square metre of floor area, can be decomposed as follows:

Emissions per square metre of floor area	=	Emissions per unit of TFC	*	TFC per square metre of floor area
		Depend on fuel mix		Depend on climate, efficiency of heating installations, insulation levels, building occupancy, appliance efficiency and ownership levels, and behaviour

In other words, the amount of energy used for space heating varies according to the fuel mix used (the carbon emissions per unit of total final consumption of energy), as well as with a range of factors related to climate, house size, indoor heating comfort, heating equipment and insulation. The two sets of variables played a different role in the evolution of the decoupling indicators considered.

CO_2-emissions per unit of TFC by the residential and commercial sectors grew by 13 and 41%, respectively over the period 1981-98 (Table 3.1.2), reflecting the growing share of electricity in the total energy use of these sectors.

Total final energy consumption by the residential and commercial sectors, per square metre of floor area, decreased by 25%, in the case of residential building, and of 29%, in the case of commercial building, for the small group of countries considered (Table 3.1.2). This reflected a combination of policies to reduce energy use in buildings, such as energy efficiency standards for new buildings, retrofitting of existing buildings, and minimum energy efficiency standards for domestic appliances (the fastest growing end-use of energy in buildings).

Table 3.1.2 **Decomposing CO_2 emissions from the residential and commercial/services sectors**, 1981-98
1998-value of ratio/1981-value

	CO_2/floor area		CO_2/TFC		TFC/floor area
Residential: total 10 countries[a]	0.84	=	1.13	*	0.75
Commercial/services: total 4 countries[b]	1.00	=	1.41	*	0.71

Note: a) Australia, Canada, Denmark, France, Italy, Japan, Norway, Sweden, United Kingdom and the United States; b) Canada, France, United Kingdom and the United States.
Source: IEA Energy efficiency indicators internal database

39 . Australia, Canada, Denmark, France, Italy, Japan, Norway, Sweden, United Kingdom and the United States.
40 . Australia, France, United Kingdom, United States.

♦ ***CO_2-emissions from electricity generation per kWh***

In the OECD as a whole[41], electricity generation constitutes almost one-third of total CO_2 emissions. Marked differences exist however between countries, with values range from almost zero in those mainly relying on hydro/nuclear energy-sources (e.g. Norway and Switzerland) to nearly half in countries where coal is the dominant fuel (e.g. Australia and Denmark). Carbon emissions from the generation of electricity are driven by electricity demand (kWh), which in turn is a function of economic growth.[42] The potential for reducing CO_2 emissions from the electricity generation may be substantial as, in contrast to SO_x and NO_x, CO_2 emissions from electricity generation are not subject to regulations in most OECD countries.

For the OECD as a whole, carbon emissions from public utilities and self-generation (including combined heat-power) increased by almost 40% during 1980-99, as compared to an increase of over 65% in electricity production (Figure 3.1.4). Relative decoupling, for the OECD area as a whole, mostly reflected developments in OECD Europe, where emissions grew by just under 2% as production expanded by 51%. Relative decoupling was least pronounced in OECD North America (where emissions grew by 55%, as compared to a 63% increase in electricity production) and OECD Pacific (where emissions grew by about 80%, with electricity production increasing by 115%).

♦ ***Decomposing CO_2-emissions from electricity generation***

The carbon intensity of the electricity sector can be decomposed as follows:

CO_2 emissions/kWh	=	CO_2 emissions/fossil fuels (FF) input	*	Fossil fuels input/kWh from fossil fuels	*	KWh from FF/total kWh
CO_2 emission or carbon intensity of the electricity sector		depends on emission factors and fuel mix		depends on generating efficiency and the fuel mix		depends on the share of renewables and nuclear

The CO_2 emission intensity of electricity generation depends, in other words, on: *i)* the carbon intensity of fossil fuels; *ii)* a term reflecting the generation efficiency of fossil fuels and the fossil fuel mix (i.e. the respective shares of coal, oil and natural gas); and *iii)* the share of fossil fuels (or its reverse, of carbon-free sources - nuclear and renewables) in electricity generation. While policy measures can influence each of these factors, they played different roles in reducing carbon intensity in electricity generation.

CO_2 emissions per unit of fossil fuel burned remained broadly constant for the OECD as a whole during the period 1980-98. This indicator fluctuated little for OECD North America, it fell by 3% in OECD Europe, whereas it increased by about 6% in OECD Pacific (Table 3.1.3).

The ratio of fossil fuel input per unit of electricity generated changed little since 1980. For the all OECD countries, this ratio declined by 3% (Table 3.1.2). While it increased by about 1% in OECD North America, a relative decoupling took place in OECD Europe (ratio declined by 7%) and OECD Pacific (11%).

The share of fossil fuels in electricity generation, for the whole of the OECD, fell by about 15% during 1980-93, but has edged up by about 2% since then (Table 3.1.3). The same pattern holds for each of the three OECD regions. In OECD Europe, the share of fossil fuel-derived electricity fell by 27% during 1980-93, but raised since. In OECD North America, the same share declined by 11% until 1996, but has since recovered to 93% of its 1980 value. In OECD Pacific, most of the 11% decline in the share of electricity from fossil fuel share took place during 1980-86, with small fluctuations since then.

Overall, trends in these "intermediate" indicators suggest that, for each of the three OECD regions, the main factor responsible for relative decoupling in the carbon intensity of electricity production, was the declining share of fossil fuels in total electricity generation (Table 3.1.3). Increased use of natural gas in efficient combined-cycle gas turbines, as well as a greater share of nuclear and renewables in the fuel mix all contributed to reducing emissions for OECD Europe in 1990-97. In OECD North America, emissions

41 . *Figures quoted in this section include all 30 OECD countries*

42 . *OECD electricity demand increased by 15% between 1990 and 1997 and is expected to rise by 25% between 1997-2010 (IEA, 2001a).*

remained broadly stable over the same period, as lower efficiency in fossil fuel generation and a small increase in the share of fossil fuel in the electricity fix offset the increased share of gas in the fossil fuel mix. In OECD Pacific, the fossil fuel share fell significantly over 1990-97, as more nuclear capacity came on-line and generation efficiency improved, but this was offset by a shift towards a more carbon intensive fuel mix (due to a shift from oil to coal).

Table 3.1.3 **Decomposing CO_2 emissions from electricity generation** 1980-99
1999-value of ratio/1980-value

	CO_2/kWh	=	CO_2/FF input	*	FF input/ kWh from FF	*	KWh from FF/ total kWh
OECD Total	0.84	=	1.00	*	0.97	*	0.87
OECD Europe	0.68	=	0.97	*	0.93	*	0.75
OECD North America	0.95	=	1.01	*	1.01	*	0.93
OECD Pacific	0.84	=	1.06	*	0.89	*	0.89

Source: OECD/IEA

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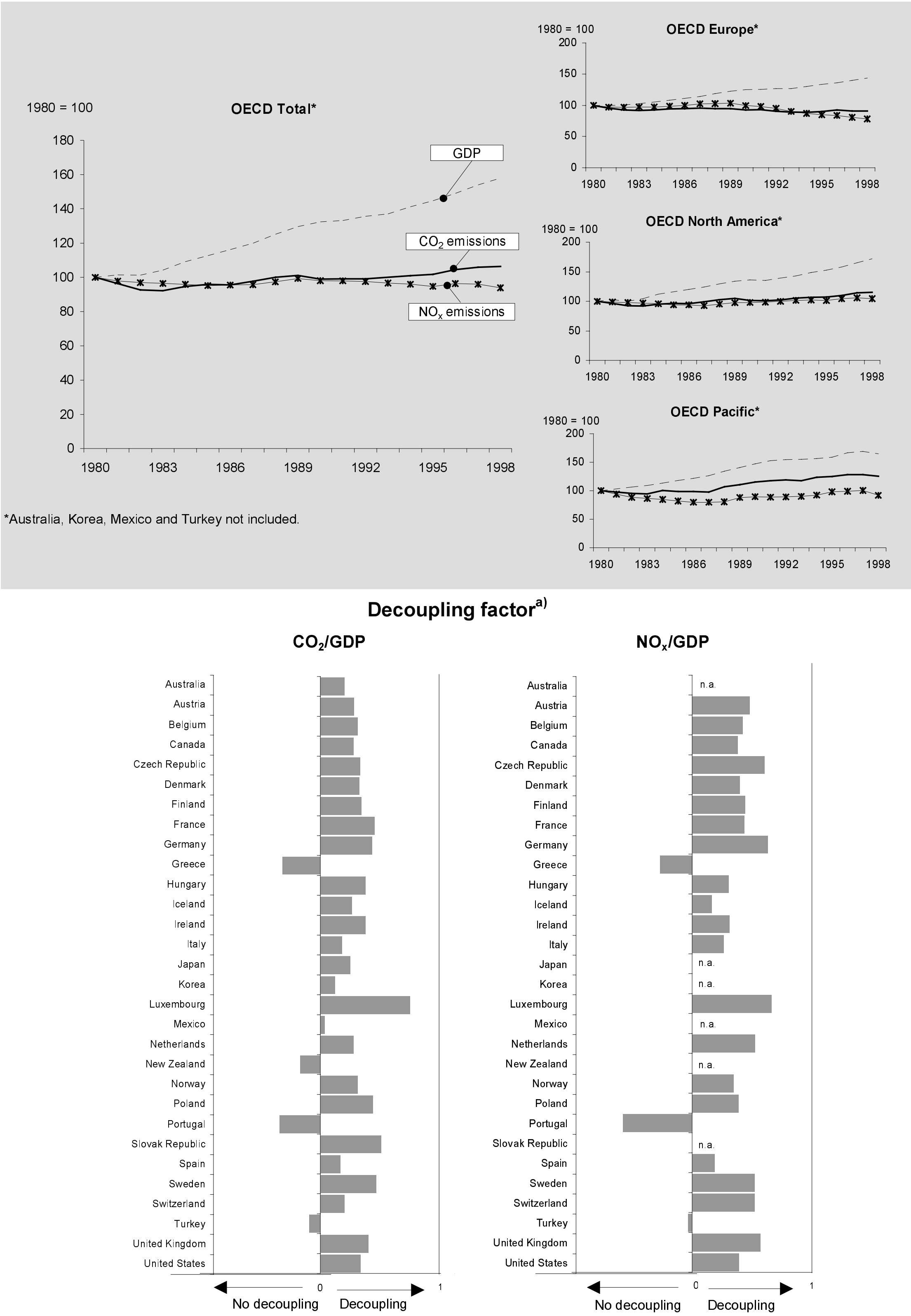
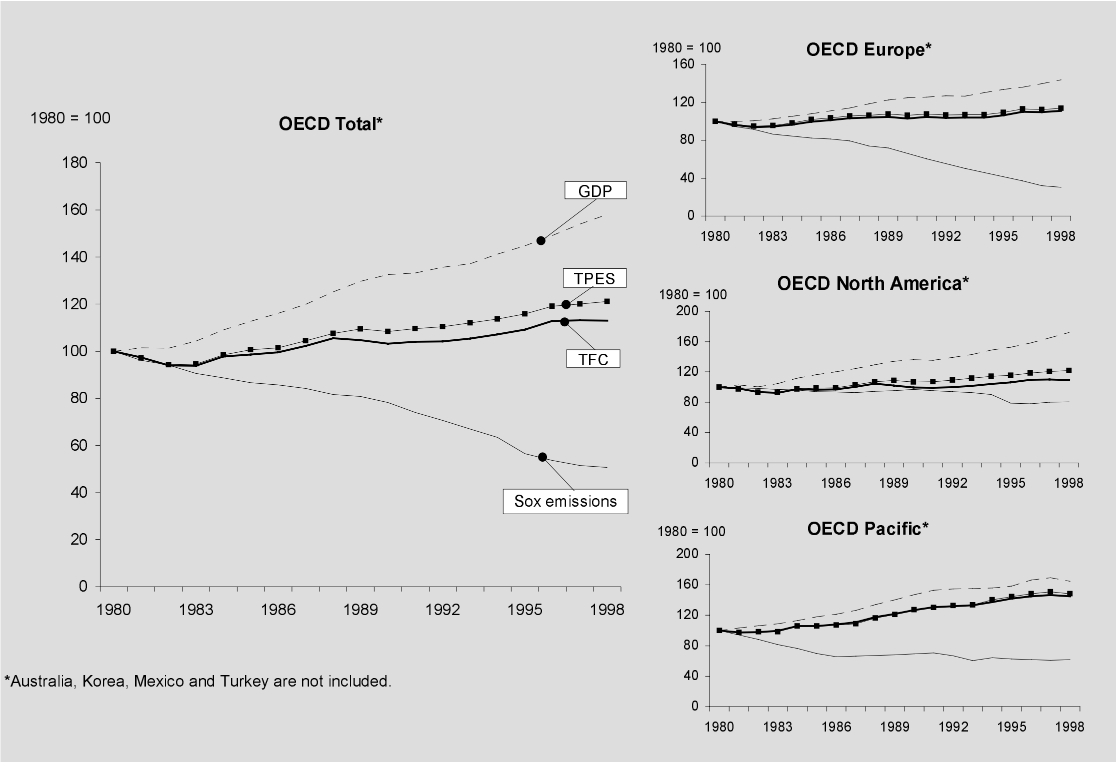
Figure 3.1.1 **CO_2 and NO_x emissions from energy use versus GDP**, 1980-1998

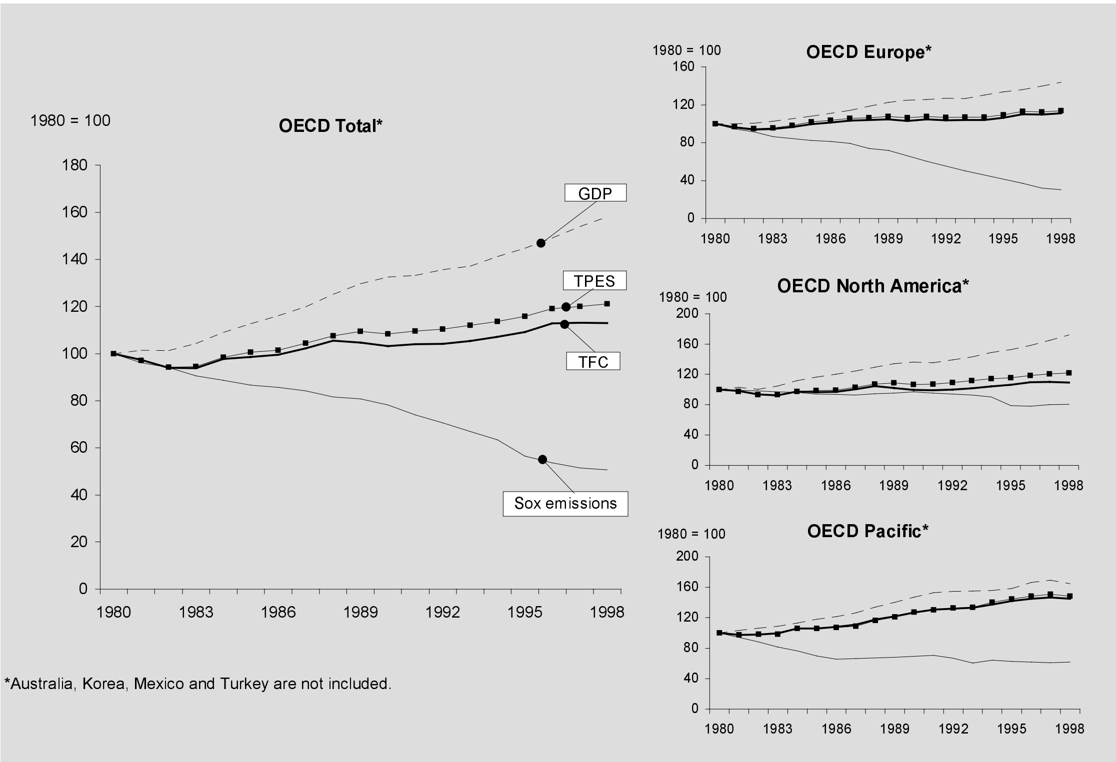


a) Decoupling factor is defined as 1- (EP/DF)end of period/(EP/DF)start of period where EP = environmental pressure and DF = driving force. Decoupling occurs when the value of the decoupling factor is between 0 and 1.
Source: OECD, IEA.

Figure 3.1.2 **SO_x emissions from energy use versus GDP,** 1980-1998



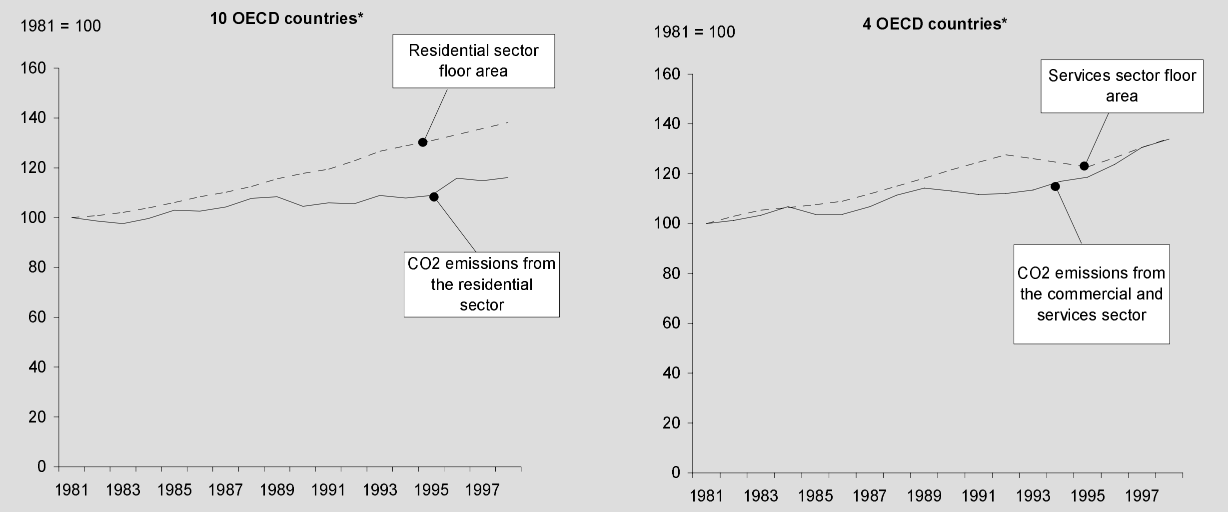
Decoupling factor[a)]



a) Decoupling factor is defined as 1-(EP/DF)end of period/(EP/DF)start of period where EP = environmental pressure and DF = driving force. Decoupling occurs when the value of the decoupling factor is between 0 and 1.
Source: OECD

Figure 3.1.3 **Energy-related emission of CO_2 from the residential and commercial sector per square metre,** 1981-1998

Residential sector | **Commercial and Services sector**



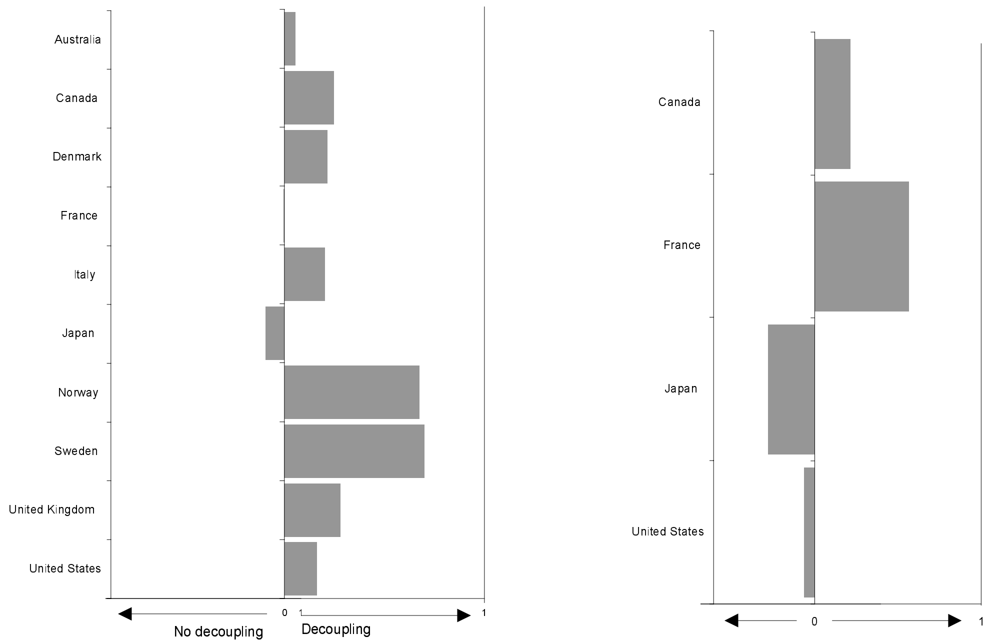
*Australia, Canada, Denmark, France, Italy, Japan, Norway, Sweden, United Kingdom and United States.

Source: IEA, Energy efficiency indicators internal database.

*Canada, France, Japan and United States.

Decoupling factor[a)]

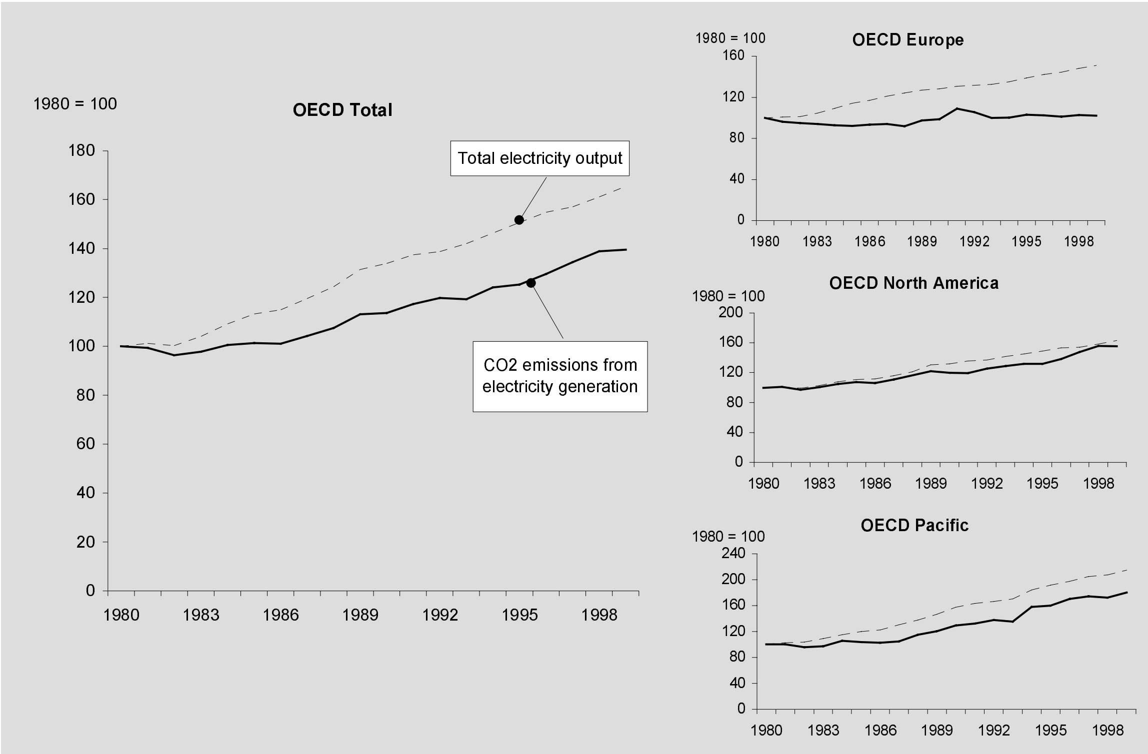
Residential sector CO_2/m^2 | **Commercial and Services sector** CO_2/m^2



a) Decoupling factor is defined as 1-(EP/DF)end of period/(EP/DF)start of period where EP = environmental pressure and DF = driving force. Decoupling occurs when the value of the decoupling factor is between 0 and 1.

Source: IEA, Energy efficiency indicators internal database.

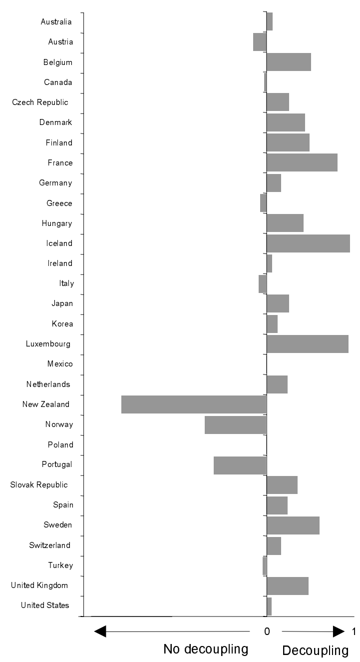
Figure 3.1.4 **CO_2 emission intensity of electricity generation,** 1980-1999



CO_2 emissions intensity of electricity generation

Country	CO_2 emissions from electricity generation		Electricity output		CO_2 emissions/electricity output		Decoupling factor[a]
	1999 10^6 tonnes of CO_2	1999 (1980 = 100)	1999 GWh	1999 (1980 = 100)	1999 g of CO_2/kWh	1999 (1980 = 100)	
Australia	172	199	203020	213	846.94	93	0.07
Austria	10	164	59151	142	165.19	116	-0.16
Belgium	22	77	83373	157	269.08	49	0.51
Canada	115	159	576969	155	199.80	103	-0.03
Czech Republic	43	90	64158	122	665.00	74	0.26
Denmark	16	81	38869	145	405.25	56	0.44
Finland	12	86	69433	170	178.32	50	0.50
France	42	39	519821	202	81.26	19	0.81
Germany	290	98	551315	118	526.22	83	0.17
Greece	42	234	49382	218	842.66	107	-0.07
Hungary	21	90	37154	156	553.82	58	0.42
Iceland	0	10	7188	226	0.43	4	0.96
Ireland	16	193	21807	206	711.12	94	0.06
Italy	129	154	259245	141	497.56	109	-0.09
Japan	396	137	1056969	185	374.51	74	0.26
Korea	146	621	264979	712	549.72	87	0.13
Luxembourg	0	2	358	39	117.45	6	0.94
Mexico	108	285	192267	287	560.51	99	0.01
Netherlands	39	102	86680	134	452.92	76	0.24
New Zealand	6	447	38102	168	168.89	266	-1.66
Norway	0	248	121723	145	2.38	171	-0.71
Poland	114	115	140001	116	815.52	99	0.01
Portugal	23	452	42930	282	541.18	160	-0.60
Slovak Republic	9	89	27501	138	311.49	64	0.36
Spain	88	143	206317	189	424.90	76	0.24
Sweden	2	64	155169	161	15.48	40	0.60
Switzerland	0	119	68528	142	6.38	83	0.17
Turkey	67	521	116440	500	576.57	104	-0.04
United Kingdom	152	67	363896	128	417.02	52	0.48
United States	2330	152	3910160	161	595.97	94	0.06
Total	4410	140	9332905	165	472.55	84	

Decoupling factor[a]



a) The decoupling factor is defined as $1-(EP/DF)_{1999}/(EP/DF)_{1980}$ where EP = environmental pressure and DF = driving force. Decoupling occurs when the value of the decoupling factor is between 0 and 1.

Shaded figures indicate absolute decoupling.

Source: IEA, CO_2 emissions database, Energy Balances database and Energy efficiency indicators internal database

3.2 TRANSPORT

Economic growth and the demand for passenger and freight transport in OECD countries have - thus far – been strongly correlated. This has been particularly true for road transport and aviation. While GDP in the OECD area grew by 46% from 1980 to 1995, the number of motor vehicles increased by 55% and vehicle-kilometres travelled by 59%. Air traffic also grew much faster than GDP, typically around 9% per annum for passenger traffic and 11 percent for air cargo. Nevertheless, economic growth is just one of the factors affecting transport demand. Other factors include increasing income levels, rising car ownership, fuel prices, transport system improvements, competition between public and private transport, land use patterns and demographic changes.

Transport activity affects human health and the environment[43]. Transport causes local air pollution and noise, and emission of greenhouse gases. Emissions of CO_2, acidifying substances (mainly SO_x and NO_x) and ozone precursors (CO, NMVOC, NO_x, methane) are among the main transport-related environmental pressures. CO_2 emissions contribute to climate change, whereas the other substances participate in the complex set of chemical transformations in the atmosphere that result in acid deposition and low-level ozone formation. Other effects on the environment include water pollution, impacts on natural ecosystems by contributing to acidification and eutrophication, and habitat-disrupting land use.

Road transport is the dominant transportation mode with a share of over 91% for passenger travel and 75% for goods transported. Over 550 million of the world's almost 700 million motor vehicles are registered in OECD countries. Three-quarters of these are passenger cars. The three primary indicators[44] presented in this section all relate to atmospheric emissions from road transport. The first one focuses on the combined emissions of private passenger and freight vehicles, while the second and third indicators separately focus on, respectively, passenger and freight transport. In order to highlight different aspects of the environmental impact of road transport, the decomposition of the primary indicator is different in the first case than for the other two.

♦ ***Road transport-related emission intensities***

Overall, there has been a decoupling from GDP of the road transport-related emissions of all three gases considered here. During the past two decades, a slight decoupling has occurred of emissions of CO_2 from passenger and freight road transport from GDP in the OECD area [45]: emissions grew by 44% during 1980-98, whereas GDP grew by almost 60% (Figure 3.2.1). However, these overall figures disguise differences among the three OECD regions and within the period considered. For the OECD as a whole, most of the decoupling took place in the early 1980s and has fluctuated since then. This decoupling was solely due to developments in OECD North America, where emissions grew by 34% and GDP by 72%. In the other two regions no decoupling took place: in OECD Europe and OECD Pacific emissions increased by 57 and 67%, respectively, while GDP grew by 46 and 67%. This relative decoupling of CO_2 emissions and GDP has been achieved thanks to improvements in the specific emissions per vehicle-km and in spite of the growth in road traffic, which itself has been stronger than that of GDP. This result has been due mainly to developments in the OECD North America region (notably the United States) and to a lesser extent to improvements in specific emissions in OECD Europe during the 1980s. During the 1990s, CO_2 emissions in OECD Europe grew faster than GDP because the relatively constant specific emissions were accompanied by strong growth in traffic. In the OECD Pacific region, CO_2 emissions kept pace with the

43 . *OECD-wide, the transport sector accounted for most of the growth in final energy consumption between 1980 and 1999, increasing by an average of 2.1% per year. Growth in consumption was high in both the air and road sub-sectors. Most of all, road transport accounts for the major share of total transport final energy consumption (80% in 1998) and grew at an average of 2.2% per year over the period. CO_2 emissions from the transport sector accounted for 27% of total CO_2 emissions from fossil fuel combustion in the OECD area in 1998.*

44 . *Some of the indicators presented in this section are a first step towards implementing the "items for measurement of progress" listed under the second objective of the OECD Environmental Strategy, under the heading of transport: These include: i) Total distances travelled (passenger km and ton km by transport mode); ii) Fuel use efficiency by mode of transport; iii) Emissions from different modes of transport; iv) Frequency of exceeding air quality standards for major transport-related air pollutants and hazardous trace pollutants; v) Proportion of population exposed to noise at levels harmful to human health; and vi) Habitat loss and fragmentation resulting from transport infrastructure.*

45 . *Figures quoted in this section relating to CO_2 emissions do not include data for Korea, Mexico and the Slovak Republic.*

growth of both traffic and GDP, as specific emissions remained constant. The above changes should be interpreted against the background of the absolute values of emission intensities in the three regions, which amounted to 0.16, 0.08 and 0.09 kg/USD for, respectively, OECD North America, Europe and Pacific in 1998.

Road transport-related emissions of NO_x have been decoupled from GDP in the OECD area[46] since 1980: emissions stayed about constant for the whole of the period 1980-98 and GDP grew by 60% (Figure 3.2.1). In OECD North America (excluding Mexico), decoupling was absolute during 1980-90, but has been relative since then. In OECD Europe, NO_x emissions from road transport have declined sharply in the 1990s as a result of the introduction of catalytic converters on passenger cars and decoupling has thus been absolute.

Road transport-related emissions of VOCs have been absolutely decoupled from GDP for the OECD as a whole[47] and for all its regions individually since 1990 (Figure 3.2.2). OECD-wide, emissions reduced by 26% while GDP increased by almost 20%. As with NO_x emissions, most of the decline can be attributed to the introduction of catalytic converters for passenger cars. In OECD Europe, growing VOCs emissions from trucks partly neutralised this trend until the mid-90s, but emissions from this source have since decreased as well. In a few OECD Member Countries, however, VOC emissions do not appear to have decreased significantly.

Table 3.2.1 **Decomposing atmospheric emissions from road transport**, 1980-98

	emissions/GDP	=	emissions/veh-km	*	Veh-km/GDP[a]
CO_2 emissions[b]: 1998-value of ratio/1980-value					
OECD Total	0.92	=	0.75	*	1.09
OECD Europe	1.08	=	0.87	*	1.23
OECD North America	0.80	=	0.81	*	0.99
OECD Pacific	1.07	=	1.01	*	1.07
NO_x emissions[c]: 1998-value of ratio/1980-value					
OECD Total	0.62	=	0.56	*	1.09
OECD Europe	0.67	=	0.54	*	1.23
OECD North America	0.58	=	0.59	*	0.98
OECD Pacific	0.56	=	0.51	*	1.09
VOCs emissions[d]: 1998-value of ratio/1990-value					
OECD Total	0.62	=	0.60	*	1.03
OECD Europe	0.56	=	0.58	*	1.09
OECD North America	0.65	=	0.67	*	0.97
OECD Pacific	0.69	=	0.66	*	1.05

Note: a) Figures vary slightly for different gases due to differences in the number of countries and the time periods considered; b) excluding Slovak Republic; c) excluding Mexico, Korea and Slovak Republic; d) excluding Korea, Mexico, Slovak Republic and Turkey.
Source: OECD/IEA

♦ *Decomposing atmospheric emissions from road transport*

Road transport-related emissions of CO_2, NO_x and VOCs from both passenger cars and freight vehicles can be decomposed as follows:

Road transport-related emissions of CO_2, NO_x and VOCs per unit of GDP	=	emissions/vehicle-km	*	veh.-km/GDP
Road transport-related emissions intensity		Specific emissions (depend on fleet composition, fuel quality and fuel efficiency)		Road traffic intensity

46 . *Figures quoted in this section relating to NO_x emissions do not include data for Korea, Mexico and the Slovak Republic*
47 *Figures quoted in this section relating to VOCs emissions do not include data for Korea, Mexico, the Slovak Republic and Turkey*

Specific emissions per vehicle-kilometre have been significantly reduced for all three gases considered here (Table 3.2.1). Specific emissions depend on control technology, fuel quality, fuel efficiency, average occupancy rate and fleet composition (type, size, age and state of the vehicle fleet). Better fuel quality has contributed significantly to the improvement in specific emissions and this trend will continue as a result of the agreements with the global car manufacturing industry. Fuel efficiency of passenger cars improved markedly in the decade 1975-85, but these gains have been eroded since then by increases in car size and performance. Further improvements can be made by way of better vehicle maintenance and phasing out old vehicles.

Road traffic (the number of road vehicle-kilometres) per unit of GDP has increased more strongly than GDP since the mid-1980s for the OECD as a whole, although the trend has been less pronounced in the latter part of the period (Table 3.2.1). However, the various OECD regions show different trends. In the OECD North America region (excluding Mexico), traffic growth appears to show a beginning of decoupling from GDP since the early 1990s, but in OECD Europe in particular, traffic is still growing faster than the economy. Further rises in total annual vehicle-km are expected for each type of vehicle category over the next 20 years, with the largest absolute increase for passenger cars, but the greatest percentage increase for trucks.

♦ ***Private passenger car-related emissions of NO_x and VOCs per unit of GDP***

In addition to examining the emission intensities of total road transport, it is possible to consider the respective contributions of passenger and freight transport separately. This is done in the following two sections, using data for the OECD Europe region. The demand for passenger transport, i.e. the need for personal mobility, is closely related to income levels, location, the distance from home to employment, location of educational services, shopping opportunities available, and recreational needs.

In the 1990s, a significant absolute decoupling of private passenger transport-related emissions of ozone precursors NO_x and VOCs from GDP took place in OECD Europe[48] (Figure 3.2.3). NO_x and VOCs emissions from cars decreased by, respectively, about 35 and 40% during 1990-98, whereas GDP grew by almost 16% over the same period. These reductions in emissions intensity in OECD Europe are due to the decrease in specific emissions, which has overshadowed the effects of the increasing share of the private car in total passenger transport and the increasing number of total passenger-kilometres travelled per unit of GDP (Table 3.2.2).

♦ ***Decomposing emissions from private passenger car transport***

The passenger car-related intensity of NO_x and VOCs emissions of the economy can be decomposed in terms of the emissions per (private car) passenger-kilometre, the share of private cars in total passenger transport, and the mobility demand intensity.

Emissions from passenger cars/GDP	=	emissions/car pass-km	*	Car pass-km/ total pass-km	*	Total pass-km/GDP
Private passenger car-related emissions intensity		Specific emissions (depend on fleet composition, occupancy rate, driving conditions, fuel quality and fuel efficiency)		Modal share of private passenger transport in total passenger transport		Mobility intensity (passenger transport demand per unit of GDP)

Values for the specific emissions from passenger cars per passenger-kilometre, calculated for the group of EU-15 countries as part of the European Union's Transport and Environment Database System (TRENDS), have been applied to OECD Europe. Emissions intensity per passenger-kilometre depends on fuel quality, vehicle fuel efficiency, car occupancy rates, and fleet composition. Specific emissions have

[48] *Figures quoted in this section do not include data for Iceland, Ireland, Luxembourg and the Slovak Republic*

declined gradually throughout the 1990s, mainly as a result of the continued penetration of catalytic converters in petrol vehicles. Specific NO_x emissions are projected to continue to decline as many European countries are tightening emission standards. For instance, in the EU, such reductions are expected to amount to 66% for cars over the period 2000-10.

Table 3.2.2 **Decomposing NO_x and VOCs emissions from passenger transport in OECD Europe[a] countries**, 1990-98
1998-value of ratio/1990-value

	Emissions from passenger cars/ GDP	=	Emissions/ pass-km	*	Car pass-km/ tot. pass-km	*	Tot. pass-km/ GDP
NO_x	0.56	=	0.49	*	1.03	*	1.07
VOCs	0.58	=	0.53				

Note: a) Data not available for Iceland, Ireland, Luxembourg and the Slovak Republic.
Source: OECD/ETC, AE 2000, Eurostat 2001

Figures for the *share of private passenger transport in total passenger transport* need to be interpreted cautiously, for what constitutes the most environment-friendly transport mode in any particular case depends on a range of circumstances (e.g. technology, occupancy rates, location). The share of passenger transport by private car in total land passenger transport (private car, bus, coach and rail) has continued to increase since 1990 and that of public transport is declining. The total number of passenger-kilometres increased by about 23% over 1990-98, while total passenger land transport by just 19% (Table 3.2.2). In 1998, private car transport constituted 97% of the total passenger land transport by private car, bus, coach and rail. This share of passenger transport by private car is highly correlated to car ownership and increasing fastest in countries that still have a relatively low rate of car ownership. The trend towards the private car can also be seen in OECD Pacific, whereas in the U.S. and Canada there has been little change since 1990.

The *mobility demand intensity (passenger-km/GDP)* can be viewed from different perspectives: increased mobility can mean improved economic welfare, but it also points to increased external costs. In the 1970s and 1980s, total private and public travel measured as person-km grew faster than GDP in many OECD countries. In OECD Europe this trend continued in the 1990s: during 1990-98 total passenger-kilometres increased by 19%, whereas GDP grew by almost 16% (Table 3.2.2).

♦ ***Road freight-related emissions of NO_x and VOCs per unit of GDP***

The demand for freight transport is closely linked to economic growth and the development of the various economic sectors. It is also linked to international trade driven by increased globalisation of markets. Freight transport has been growing faster than passenger transport, although total vehicle-kilometres travelled is greater for passenger transport.

Road freight transport-related emissions of ozone precursors NO_x and VOCs in OECD Europe[49] increased at a faster rate than GDP until 1996, but in 1997 and 1998 there was an absolute decoupling for both gases (Figure 3.2.3). NO_x and VOCs emissions increased by 18 and 17%, respectively during 1990-96 and GDP by 9%. In 1997 and 1998, however, emissions dropped significantly while GDP continued to rise. As with emissions from passenger vehicles, the reduction of specific emissions was counteracted by the increased share of road transport in total freight transport and of total freight transport per unit of GDP (Table 3.2.3).

♦ ***Decomposing emissions from road freight transport***

The freight vehicle-related emission intensity of the economy can be decomposed in terms of the emissions per tonne-kilometre, the share of road freight in total freight transport, and the freight transport demand intensity.

[49] *Figures quoted in this section do not include data for Iceland, Ireland, Luxembourg and the Slovak Republic*

Emissions from freight vehicles/GDP	=	Emissions/tonne-km	*	Road tonne-km/ total tonne-km	*	tonne-km/GDP
Road freight emission intensities for CO_2, etc.		Specific emissions (depend on fleet composition, load factor, fuel quality and fuel efficiency)		Share of road freight transport in total freight transport		Freight intensity (demand per unit of GDP)

Values for the *specific emissions from freight vehicles per tonne-kilometre*, calculated for the group of EU-15 countries as part of the European Union's Transport and Environment Database System (TRENDS), have been applied to OECD Europe. Specific emissions depend on fuel quality, fuel efficiency, load factor and fleet composition (type, size, age and state of the vehicle fleet). The EU study shows that that specific emissions of both gases from heavy and light-duty trucks fell by about 20% between 1990 and 1998. Specific NO_x emissions are projected to continue to decline as many European countries are tightening emission standards. For instance, in the EU, such reductions are expected to amount to 55% for trucks over the period 2000-10. It is not clear to what extent changes in load factor (i.e., the number of tonne-km divided by the number of freight vehicle-km) have contributed to the reduction of specific emissions per tonne-kilometre. Changes in load factor can be due to several factors. For example, an apparent increase in load factor can be explained by a higher loading rate of freight vehicles, a decrease in empty haulage or an increase in the weight of goods of a given volume. The varying use of "just-in-time" deliveries may also explain differences.

Table 3.2.3 **Decomposing NO_x and VOCs emissions from freight transport in OECD Europe[a] countries**, 1990-98

1998-value of ratio/1990-value

	Emissions/ GDP	=	Emissions/ tonne-km	*	Road tonne-km/to. tonne-km	*	Total tonne-km/GDP
NO_x	0.98	=	0.80				
VOCs	0.98	=	0.80	*	1.11	*	1.10

Note: a) Data not available for Iceland, Ireland, Luxembourg and the Slovak Republic.
Source: OECD/ETC, AE 2000, Eurostat 2001

The *share of road freight transport of total freight transport* in OECD Europe increased by about 10% during the period 1990-98 (Table 3.2.3). As with passenger transport, the optimum mix of freight transport modes will vary from to country. In the European Union, for example, the average distance over which a tonne of goods is transported is 110 km. This is a distance for which rail and inland waterways are less efficient, as transport kilometres by road to and from the points of loading and unloading may be a high proportion of the total distance covered.

The *total amount of freight transported per unit of GDP* in OECD Europe grew by almost 7.5% over the period 1990-98, despite a fall in freight transport in the early 1990s due to a slowing economy (Table 3.2.3). Freight transport demand grew by 24% between 1980 and 1999, outstripping a GDP growth of almost 16%. No significant change to the relationship of GDP and freight transport demand is expected until at least the end of the current decade. Readers should also bear in mind that the environmental impact of transport is caused by a range of factors, of which overall demand for transport services is only one.

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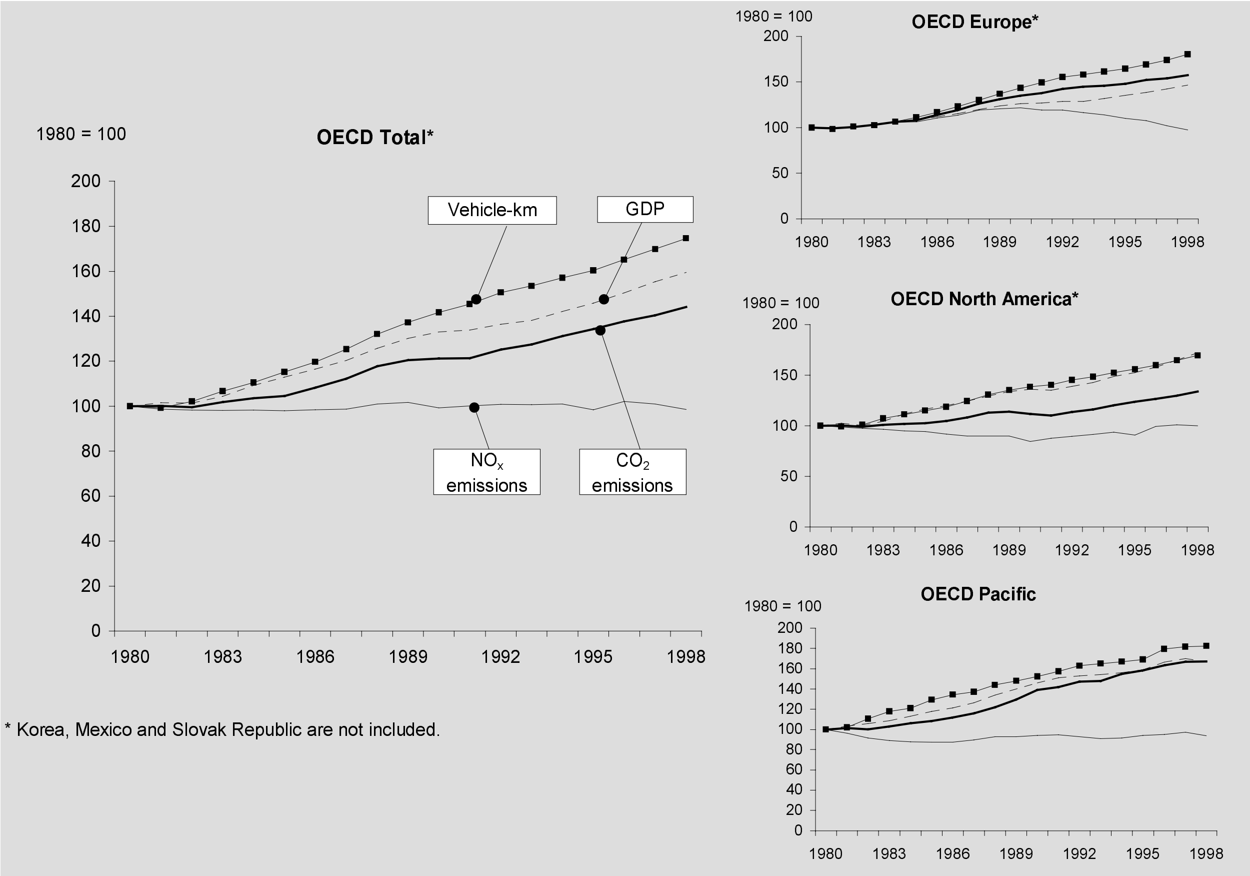
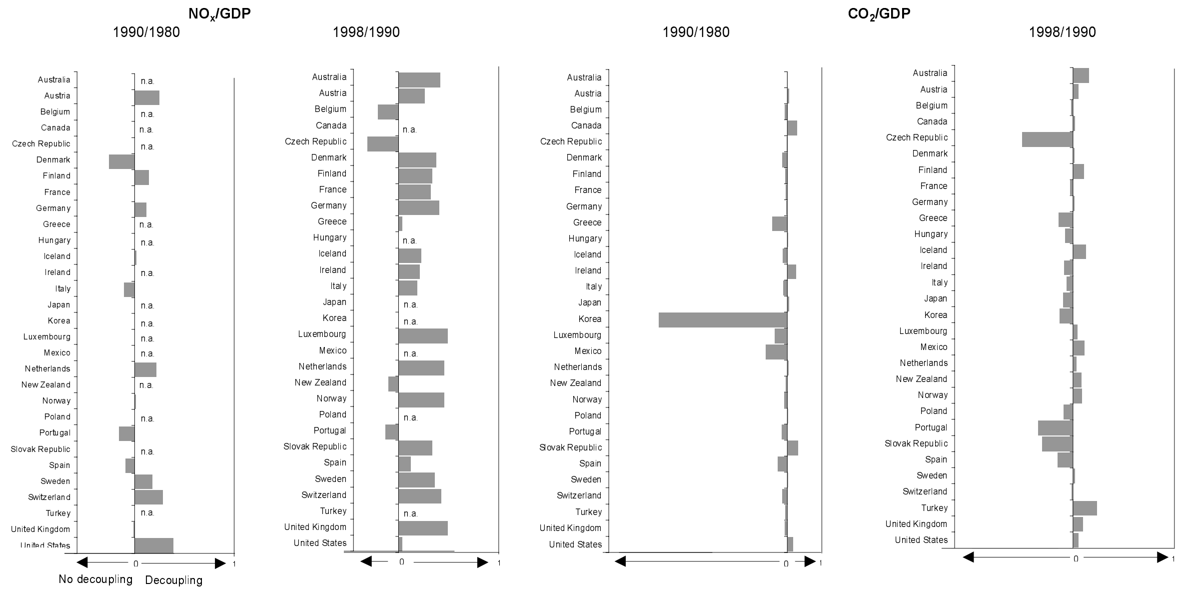
Figure 3.2.1 **Emissions of CO_2 and NO_x from private passenger and freight vehicles versus GDP**, 1980-1998

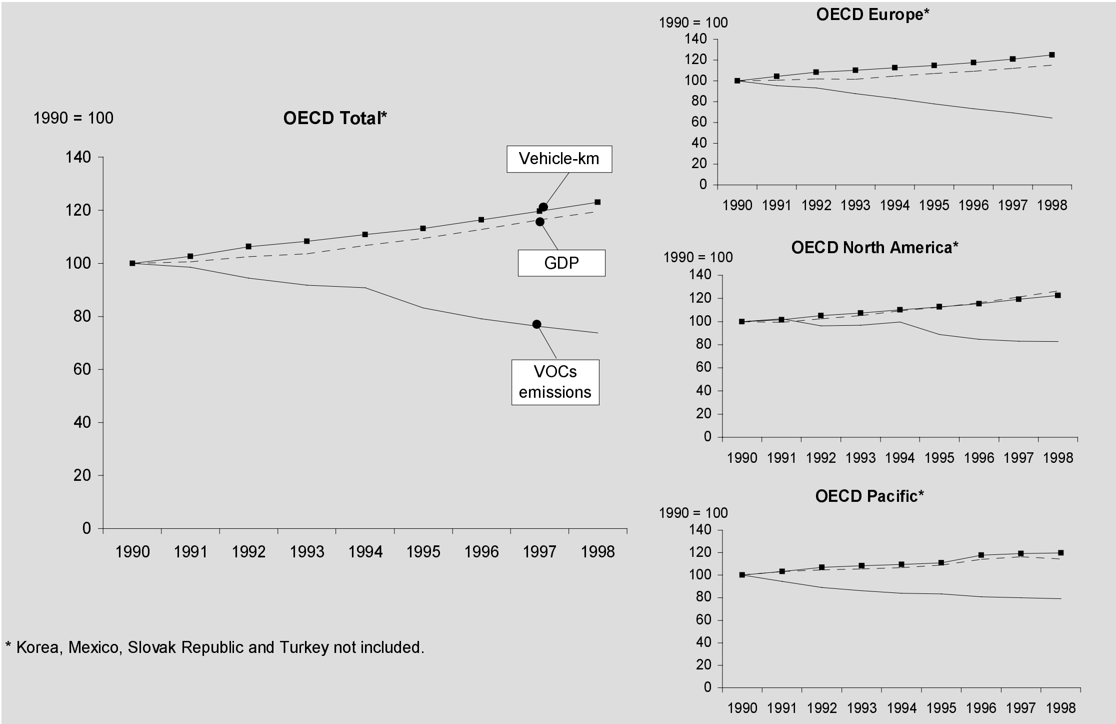


Decoupling factor[a)]

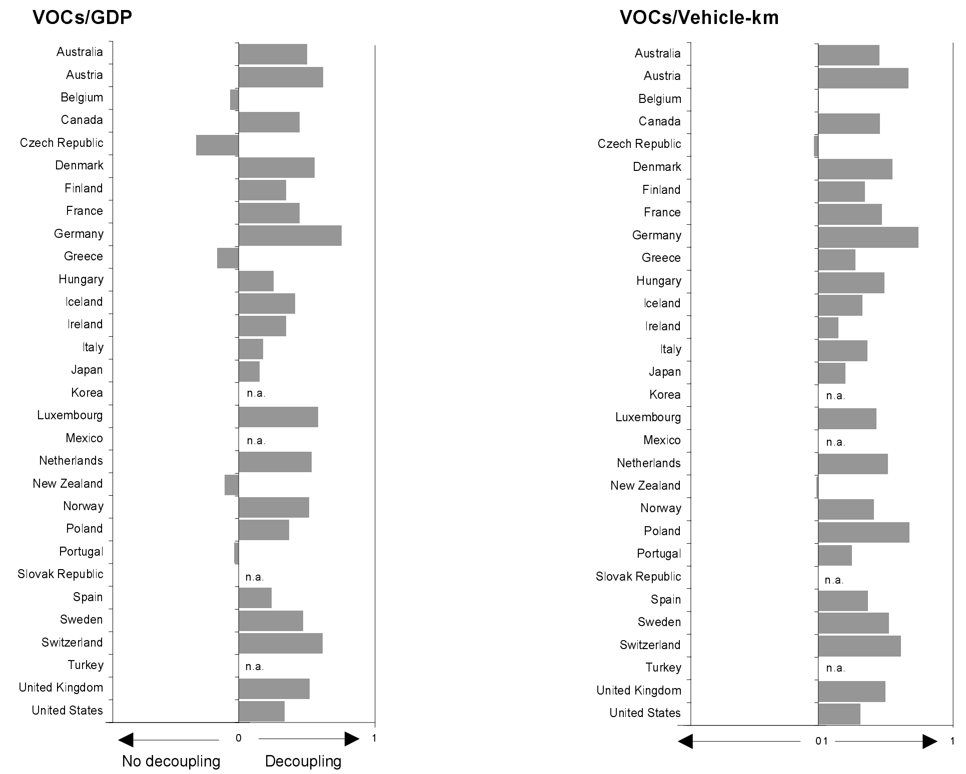


a) Decoupling factor is defined as 1-(EP/DF)end of period/(EP/DF)start of period where EP = environmental pressure and DF = driving force. Decoupling occurs when the value of the decoupling factor is between 0 and 1.
Source: OECD, IEA.

Figure 3.2.2 **Emissions of VOCs from private passenger cars and freight vehicles versus GDP,** 1990-1998



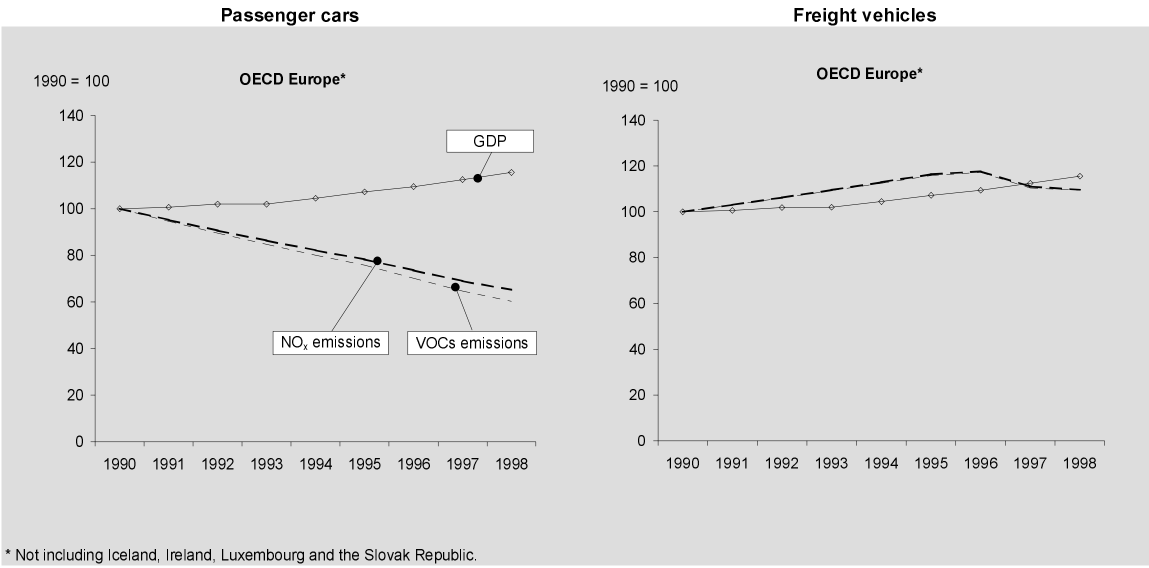
Decoupling factor[a)]



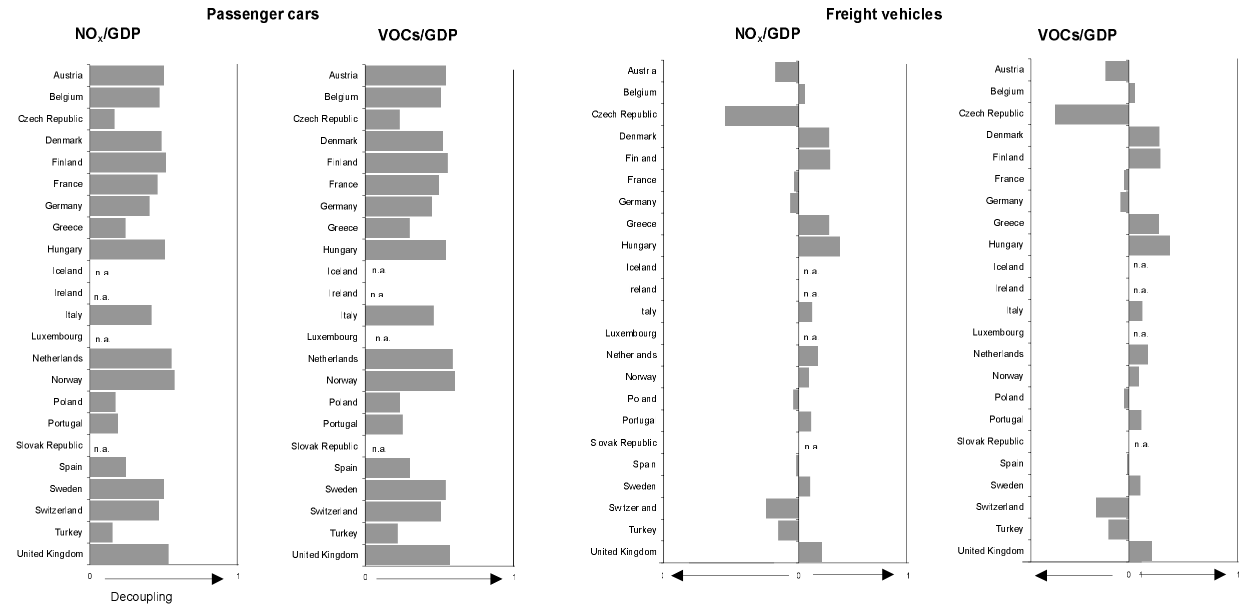
a) Decoupling factor is defined as 1-(EP/DF)end of period/(EP/DF)start of period where EP = environmental pressure and DF = driving force. Decoupling occurs when the value of the decoupling factor is between 0 and 1.

Source: OECD.

Figure 3.2.3 **Road transport related emissions of NO_x and VOCs**, in OECD Europe, 1990-1998



Decoupling factor[a)]



a) Decoupling factor is defined as 1-(EP/DF)end of period/(EP/DF)start of period where EP = environmental pressure and DF = driving force. Decoupling occurs when the value of the decoupling factor is between 0 and 1.
Source: OECD.

3.3 AGRICULTURE

The impact of agriculture on the environment is of major public concern. The indicators presented in this section show some decoupling of environmental pressures from agricultural production, but at the same time agricultural production is becoming more specialised and, with cheap and fast transport, concentrated in areas with the lowest production costs. This is leading to an increasing intensification on the most productive land and in key production areas near important markets. The need for agricultural production to keep pace with the ever-growing world population – and also better meet the needs of the millions of undernourished people on earth –is also likely to make agriculture more intensive. Environmental conditions and farming systems vary within and across OECD countries and, consequently, best farm management practices vary from one region to another. Farm management decisions are influenced by environmental regulations, agricultural support measures, investments in research, education and extension services and site-specific environmental conditions.

Agricultural activity imposes multiple pressures on the environment through, for instance, off-site impact from sediment flows, pollution of water bodies (phosphates and nitrates), habitat alteration, deforestation, loss of biodiversity, and the emission of ammonia and greenhouse gases. Some of these pressures also degrade the productive potential of the agricultural resource base itself, for example through soil erosion, wasteful use and resulting shortages of water (especially groundwater), the build-up of pest resistance and the loss of diversity of genetic resources. Although agriculture can also provide environmental benefits, such as the capacity to provide a sink for greenhouse gases, help control flooding, protect landscapes and provide certain habitats important to biodiversity, it is important to further decouple environmental pressures from agricultural output.

♦ ***Soil surface nitrogen balance versus agricultural output***[50]

The OECD soil surface nitrogen balance is the physical difference between nitrogen inputs into, and outputs from an agricultural system, per hectare of agricultural land. The magnitude of the nitrogen balance, if positive or in surplus, can be seen as a measure of the risk of air and water pollution or, if negative, of nutrient depletion of the soil. The input of nitrogen includes the quantity of inorganic or chemical fertiliser, net livestock manure nitrogen production (i.e. production + imports – exports), biological nitrogen fixation, atmospheric deposition, nitrogen from recycled organic material (sewage sludge) and nitrogen contained in seeds and planting materials. The quantity of output includes the nitrogen uptake in the harvested crop and fodder production as well as the uptake by grass from pasture.

This decoupling indicator[51] takes a country's national nitrogen balance and divides it by the value of that country's agricultural output, so that the indicator takes the dimension of kg N/USD. National level statistics for this indicator need to be interpreted carefully because they can be distorted by the presence of regions with highly intensive agricultural activity, such as areas with a concentration of animal husbandry enterprises. It would therefore be helpful if national scale information could be complemented by an evaluation of the indicator for specific regions with a significant agricultural production.

Of the 20 OECD countries[52] considered for this indicator, fourteen show a downward trend of nitrogen surpluses, but in the six others there has been some increase in the nitrogen surplus (Figure 3.3.1). In OECD America and OECD Pacific, no clear trend of decoupling nitrogen surpluses from agricultural output is discernible. In OECD Europe, some decoupling occurred in the late 1980s/early 1990s, but this trend did

50 . *Agricultural output is taken here as final agricultural output minus farm origin intermediate consumption, as provided by the OECD Economic Accounts for Agriculture.*

51 . *Some of the indicators presented here are a first step towards implementing the "items for measurement of progress" listed under the second objective of the OECD Environmental Strategy, under the heading of agriculture: i) Use of pesticides with lower environmental risk, intensity of pesticide and fertiliser use, and dispersion of nutrient surpluses across agricultural areas; ii) Share of agricultural area farmed or number of farmers using environmentally sustainable management practices addressing input use and integrated farm management, including organic agriculture; iii) Area of agricultural land at high or moderate risk from soil erosion and degradation; and iv) Trends in agri-environmental expenditures as a share of support to agriculture.*

52 . *Figures in this section do not include data for the Czech Republic, Hungary, Iceland, Korea, Luxembourg, Mexico, New Zealand, Poland, Portugal and the Slovak Republic (because data for agricultural output, the agricultural output deflator or the PPP 1995 were not available).*

not persist beyond that. Some of the countries showing no decoupling (e.g. Canada) have a national nitrogen surplus per hectare well below those of some countries that have managed a certain decoupling.

♦ ***Context indicator: nitrogen efficiency***

Nitrogen efficiency is defined as the ratio of total nitrogen uptake (output) to the total nitrogen available (input) in an agricultural system. This intermediate indicator provides a physical measure of the nitrogen use efficiency in agriculture.

Table 3.3.1 **Nitrogen efficiency in agriculture: output/input**
%

	1985	1990	1995	1997
Australia	0.64	0.61	0.66	0.59
Austria	0.72	0.64	0.74	0.74
Belgium	0.44	0.39	0.44	0.45
Canada	0.79	0.90	0.73	0.71
Czech Republic	0.49	0.52	0.60	0.59
Denmark	0.41	0.47	0.48	0.49
Finland	0.45	0.43	0.46	0.52
France	0.64	0.59	0.63	0.67
Germany	0.66	0.63	0.68	0.72
Greece	0.56	0.53	0.71	0.75
Iceland	0.62	0.63	0.61	1.00
Ireland	0.59	0.56	0.54	0.56
Italy	0.64	0.69	0.73	0.76
Japan	0.48	0.47	0.46	0.48
Korea	0.43	0.33	0.32	0.34
Mexico	0.51	0.51	0.56	0.52
Netherlands	0.43	0.48	0.44	0.49
New Zealand	0.98	1.00	0.97	0.98
Norway	0.67	0.75	0.68	0.62
Poland	0.65	0.63	0.71	0.71
Portugal	0.42	0.29	0.32	0.32
Spain	0.47	0.42	0.37	0.41
Sweden	0.59	0.73	0.71	0.70
Switzerland	0.57	0.58	0.63	0.59
Turkey	0.75	0.75	0.82	0.82
United Kingdom	0.42	0.44	0.48	0.48
United States	0.62	0.59	0.53	0.59
OECD*	0.62	0.60	0.58	0.61
OECD Europe*	0.59	0.58	0.61	0.63
OECD North America	0.64	0.62	0.55	0.61
OECD Pacific	0.62	0.59	0.63	0.58

* Hungary, Luxembourg and the Slovak Republic are not included.
Source: OECD, Soil Surface Nitrogen Balances database

Greater efficiency in the use of chemical fertilisers and livestock manure in agricultural production is essential for reducing pollution of water bodies from agricultural run-off. On average, it is expected that 30% of the nitrogen content of manure fertiliser applied to agricultural lands is lost through leaching, though this figure can range from 10-80%. Methods to better calibrate nitrogen applications to plant utilisation requirements include soil testing (to determine soil requirements), nutrient accounting, and setting realistic yield targets. Several OECD countries have policies to promote the more efficient management of livestock manure and reduced use of nitrogen fertilisers, including taxes on fertilisers, subsidies for the use of low-input systems, further research and development, and information provision and awareness raising amongst farmers.

The efficiency of nitrogen use reveals marked differences across OECD countries. On average, OECD countries[53] use 60% of the annual nitrogen available (input) in the agricultural system (Table 3.3.1). For the OECD as a whole, no consistent trend towards greater efficiency is discernible. However, OECD Europe appears to have improved nitrogen efficiency, whereas the performance of the other two regions seems to have slipped somewhat. Considering the decoupling and context indicator together, it is worth noting that countries with similar nitrogen efficiency can have very different nitrogen surplus per hectare levels.

- ***Methane and nitrous oxide emissions from agriculture versus agricultural output***[54]

Methane emissions originate mainly from rice cultivation and ruminant livestock. Nitrous oxide emissions originate mainly from chemical fertiliser and manure applications and in the waste deposited by grazing animals. OECD-wide, agriculture contributed 8% of total OECD national anthropogenic sources of GHGs in 1995-97. However, this share is 20% or higher for Australia, Denmark, Ireland and New Zealand. Agriculture also emits carbon dioxide, mainly through biomass burning and oxidisation of soil organic matter.

This indicator measures gross total agricultural emissions of the two main greenhouse gases (GHG) from agriculture, methane (CH_4) and nitrous oxide (N_2O) expressed in CO_2 equivalents of global warming potential. Caution is required in interpreting this indicator because considerable uncertainty still exists with estimating emissions of methane and nitrous oxide from agriculture. Also, the available time series is still rather short for assessing the trend of the indicator. In the longer term, it would be desirable to have reliable estimates of the total net GHG emissions due to agriculture and agriculture's role as a sink for GHGs.

Some decoupling appears to have occurred during 1990-97 between GHG emissions from agriculture and agricultural output (Figure 3.3.2). In the group of 19 OECD countries[55] considered here, methane emissions fell by less than 1% and those of nitrous oxide increased almost 6%, while agricultural output rose by almost 10%. OECD Europe recorded a small, but absolute decoupling for both gases, probably due mainly to reductions in livestock numbers, especially of pigs and cattle, and changes in manure management. This performance was less pronounced in the other two OECD regions.

- ***Agricultural water use per unit of agricultural agricultural output***[56]

In the OECD as a whole, agriculture is responsible for over 40% of total water abstractions and in some countries irrigation is still showing growth. Increasing competition for scarce water resources reinforces the need to allocate water to highest-value uses. This need is greatest in arid and semi-arid regions, but even where competition for offstream uses is less strong, growing demand for various instream uses (e.g. for recreation and to preserve wetlands and other ecosystems) will encourage a greater efficiency of water use. This will particularly affect agriculture, as it is the main water using sector in many countries. Thus, the solution to many water management problems, in terms of quantity as well as quality, is strongly linked to the use of water in agriculture.

Total agricultural water use for the group of 9 OECD countries[57] considered for this indicator, showed relative decoupling from agricultural value added during 1980-95: water use increased by 3%, whereas value added increased by 15% (Figure 3.3.3). For six countries, no decoupling took place during the period considered.

The results presented here should not be generalised to the whole of the OECD, as some of the major irrigation countries are not included in the figures. Neither do these figures include some of the Member countries where irrigation has expanded strongly over the time period considered. Furthermore, it would

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53 . Figures in this section do not include data for Luxembourg and the Slovak Republic.

54 . Agricultural output is taken here as final agricultural output minus farm origin intermediate consumption, as provided by the OECD Economic Accounts for Agriculture. Output figures do not take account of positive or negative externalities.

55 . Figures in this section do not include data for the Czech Republic, Hungary, Iceland, Korea, Luxembourg, Mexico, New Zealand, Poland, Portugal, Slovak Republic and Turkey.

56 . Agricultural output is taken here as final agricultural output minus farm origin intermediate consumption, as provided by the OECD Economic Accounts for Agriculture.

57 . Austria, Canada, Denmark, Finland, Greece, Japan, Spain, Sweden and the United Kingdom.

improve the interpretation of the indicator if subnational water use could be evaluated for specific agricultural regions. Finally, the accuracy of water use data could be improved in many countries.

Over the past 20 years, considerable improvements have been made in the efficiency of irrigation systems of many OECD countries. These have generally been realised either through more efficient water conveyance systems (e.g. reducing leakage) or advanced and better calibrated irrigation application systems (e.g. drip irrigation, etc.). This trend is still continuing and it is expected irrigation water usage may stabilise of even decline in many OECD countries over the next two decades. However, future trends in agricultural water use will partly depend on the extent of reforms to agricultural water charges and support for the construction and maintenance of irrigation infrastructure. At present, agricultural water charges are subsidised in most countries.

- ***Apparent consumption of commercial fertiliser (NPK) versus final crop output***

The intention of this indicator is to focus on the input efficiency of agriculture, whereas the indicator on the nitrogen balance focused on pollution aspects. The indicator presents the apparent consumption (sales) of N-P-K fertilisers, per unit of final crop output. Mineral fertilisers are usually not spread on pasture, except in a few Member countries. Some caution is required in attributing all changes in the value of this indicator to efficiency gains in fertiliser use, as changes in market prices and support policies also affect fertiliser use and crop production.

For the group of 20 OECD countries[58] included in this indicator, there has been a clear and absolute decoupling of the apparent consumption of mineral fertilisers and crop production between 1985 and 1997: fertiliser use decreased by almost 4% while crop production grew by 19% (Figure 3.3.4). The decoupling was most pronounced in OECD Europe. In OECD North America, decoupling appears to have started in the early 1990s.

- ***Apparent consumption of pesticide versus final crop output***

Agricultural pesticides contribute to agricultural productivity, but the environmental pressures associated with the use of pesticides include the contamination of ground and surface water used for drinking by both humans and livestock; and adverse impacts on terrestrial and aquatic habitats (e.g., risks to non-targeted organisms and wildlife). In addition, there are several occupational and consumer health issues to consider.

This indicator should be interpreted with caution. For example, the composition of crops produced, and the pesticide products used, varies over time. Moreover, while the major share of the pesticides included in these statistics is used for agricultural crop production in most countries, a varying proportion is used on pasture and in forestry, but the data do not permit this adjustment. Ideally, a pesticide decoupling indicator should also relate the hazards associated with pesticide use to crop output. Hazards will vary depending on the inherent toxicity and persistence of the pesticide and the crop in question, and the medium (water, soil) considered. Until such an indicator is available, the (numerator of the) present indicator remains the only one for which data are available for a range of Member Countries.

In the group of 14 OECD countries[59] considered here, a significant, absolute decoupling occurred between the apparent consumption of pesticides and final crop output during 1985-97: the use of pesticides fell by more than 4% while final crop output increased by over 19% (Figure 3.3.5). The decoupling was absolute for ten countries and relative for a further two. For Greece and Ireland no decoupling can be shown as yet.

Some OECD countries have set targets to reduce the total quantity of agricultural pesticides used over a given time period. The sale and use of pesticides in OECD countries is typically subject to prior safety assessment and approval by the regulatory authorities, as well as to maximum permissible residue levels both for individual pesticides and for total pesticide substances in food and drinking water. Denmark, the

58 . *Figures in this section do not include data for the Czech Republic, Hungary, Iceland, Korea, Luxembourg, Mexico, New Zealand, Poland, Portugal, Slovak Republic.*

59 . *Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Netherlands, Norway, Spain, Sweden, Switzerland and the United Kingdom.*

Netherlands and Sweden, for example, have introduced programmes to substantially reduce pesticide use. Pesticide use is taxed in some countries (e.g. Denmark, Norway, Sweden), though still subsidised in some others (e.g. Mexico and Turkey). Usually, farmers pay the market price for pesticides, but their use is also influenced by market prices and support for crop production.

♦ ***Context indicator: Share of the total agricultural area under organic farming***

Organic farming generally produces lower yields than conventional farming, although this gap is closing, but can lead to lower pressures on the environment because no synthetic pesticides or fertilisers are used. Organic farming may also help enhance biodiversity, but nevertheless generates some of the same environmental pressures as conventional agriculture (e.g. water use, nutrient loads). Whereas this share remains relatively small, in addition a larger area of land is farmed under various types of environmentally-friendly farming practices, such as integrated pest management, “land care” schemes, or “irrigation raisonnée.”

This indicator shows the share of total agricultural land under organic farming (Table 3.3.4). A dramatic growth occurred during the 1990s in all 20 countries for which figures are available, even if for 14 countries the area of land under organic farming is still below 1% of total agricultural land. In Austria, the share of organically farmed land now amounts to 10%. The most recent figures available from some countries suggest that the rapid extension of organically-farmed land is continuing.

Table 3.3.4 **Share of the total agricultural land under organic farming**

	Total agricultural land, 1997	Share of organically farmed land %	
	Km^2	Early 1990s	Late 1990s
Austria	34220	0.62	10.03
Belgium	14180	0.09	0.37
Czech Republic	42790	0.08	0.47
Denmark	26880	0.30	0.77
Finland	25580	0.26	3.95
France	308330	0.21	0.32
Germany	173270	0.24	2.25
Greece	91320	0.00	0.09
Hungary	64950	..	0.37
Iceland	19010	..	0.04
Ireland	44320	0.08	0.22
Italy	154850	0.54	4.15
Korea	20140	..	0.03
Netherlands	20120	0.37	0.66
Portugal	39000	..	0.78
Spain	298510	0.03	0.46
Sweden	33750	1.14	9.00
Switzerland	15810	1.20	7.00
United Kingdom	174330	0.12	0.28
United States	4182500	0.09	0.15

Source: OECD, Environmental Indicators for Agriculture and FAO

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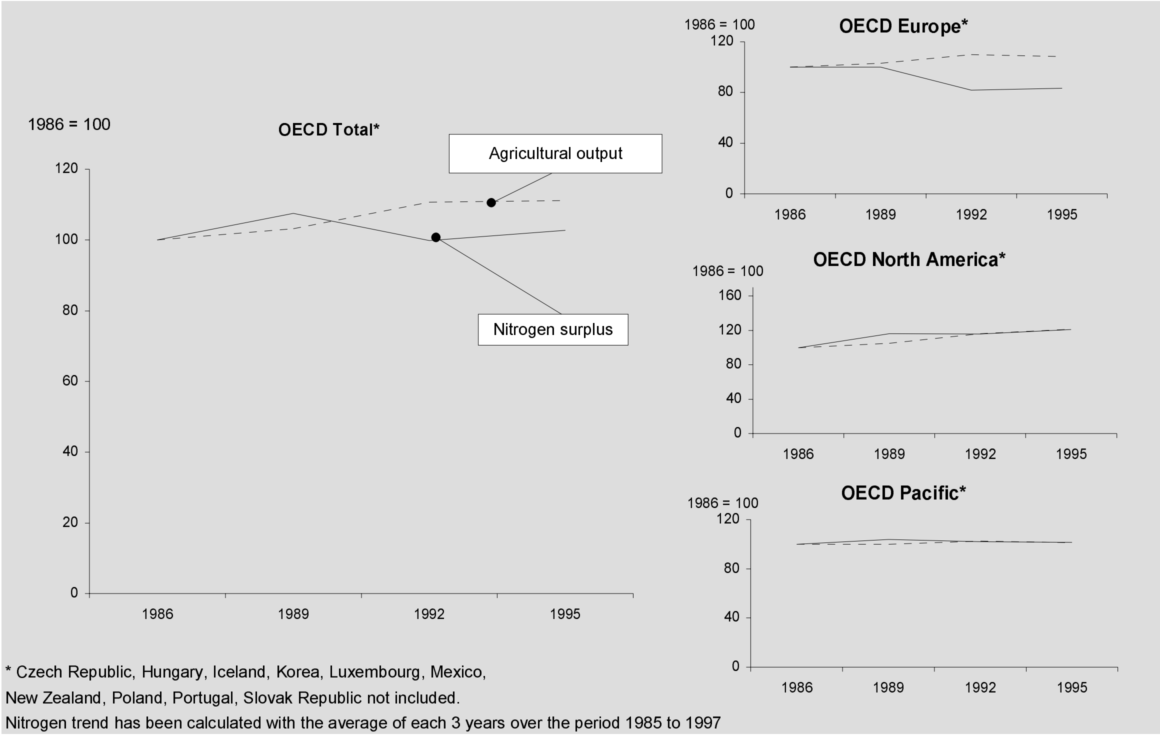
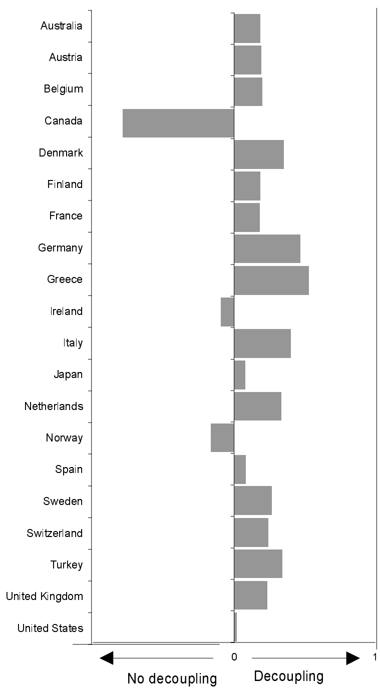
Figure 3.3.1 **Soil surface nitrogen balance versus agricultural output,** 1986-1995



* Czech Republic, Hungary, Iceland, Korea, Luxembourg, Mexico, New Zealand, Poland, Portugal, Slovak Republic not included.
Nitrogen trend has been calculated with the average of each 3 years over the period 1985 to 1997

Decoupling factor[b)]
Nitrogen balance/Agricultural output

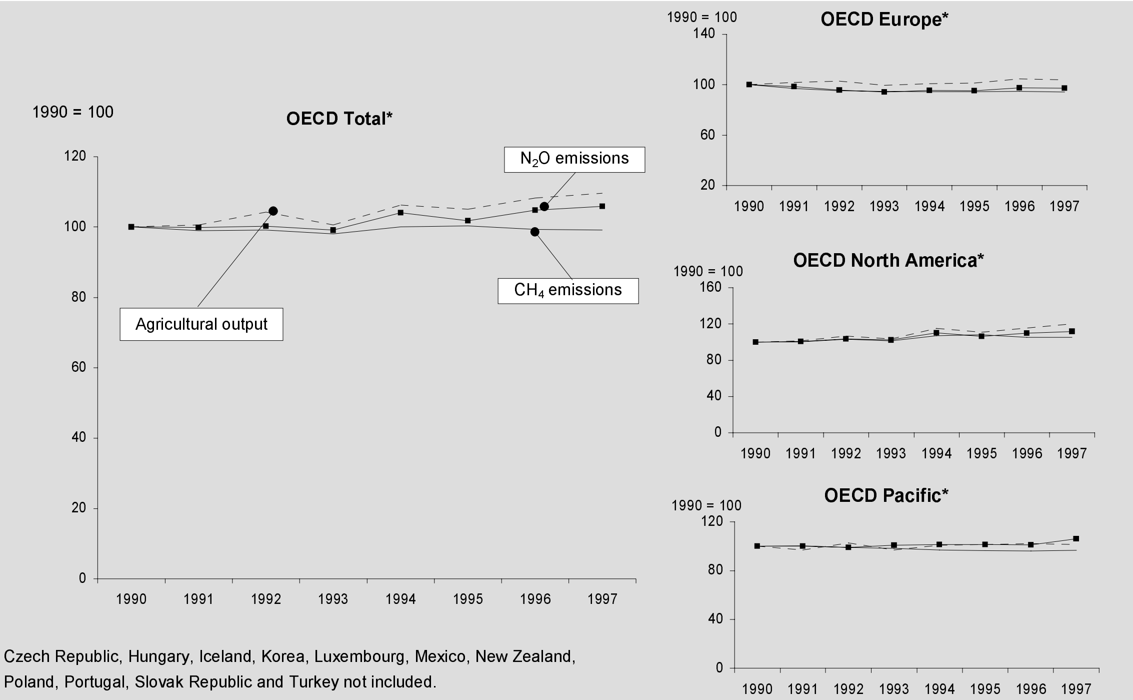


Soil surface nitrogen balance per unit of agricultural output[a)]

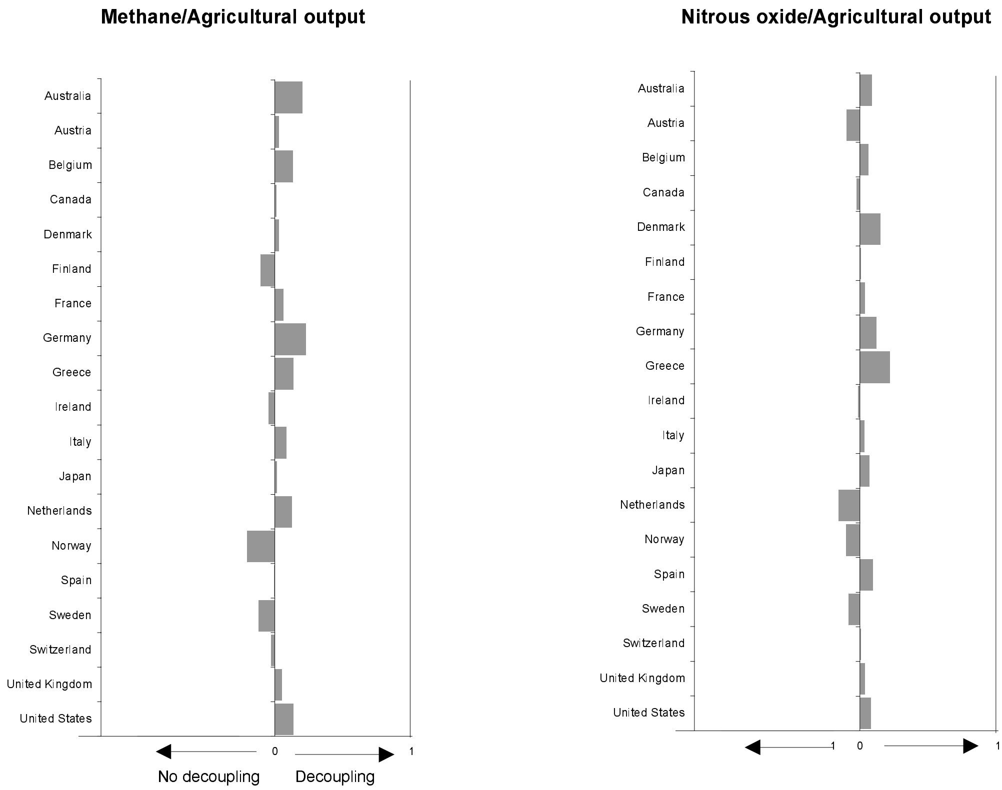
Country	Nitrogen surplus		Agricultural output		Decoupling factor[b)]
	Average 1995-97 tonnes	1995-97 (1985-87 = 100)	Average 1995-97 10^6 USD	1995-97 (1985-87 = 100)	
Australia	3305428	106	21647	131	0.19
Austria	94856	77	3078	95	0.19
Belgium	246892	94	4494	117	0.20
Canada	1038753	224	19674	125	-0.79
Denmark	315411	74	4444	114	0.35
Finland	138110	73	1777	90	0.19
France	1620116	88	37196	107	0.18
Germany	1057564	68	25428	127	0.47
Greece	170801	51	11596	109	0.53
Ireland	399038	128	4562	117	-0.09
Italy	496729	64	36793	107	0.40
Japan	673792	87	58949	94	0.08
Netherlands	512824	82	12670	123	0.33
Norway	75341	109	1735	93	-0.16
Spain	1310275	106	27340	116	0.08
Sweden	105094	67	2350	91	0.26
Switzerland	96089	76	3413	100	0.24
Turkey	499657	75	66170	114	0.34
United Kingdom	1477941	81	18619	107	0.24
United States	13200750	121	167943	124	0.02

a) Agricultural output is taken here as final agricultural output minus farm origin intermediate consumption, as provided by the OECD Economic Accounts for Agriculture.
b) The decoupling factor is defined as 1-(EP/DF)end of period/(EP/DF)start of period where EP = environmental pressure and DF = driving force. Decoupling occurs when the value of the decoupling factor is between 0 and 1.
While these calculations have been derived from using an internationally harmonised methodology, nitrogen conversion coefficients can differ between countries, which may be due to a variety of reasons.
Shaded figures indicate absolute decoupling.
Source: OECD, Environmental Indicators for Agriculture, Economic Accounts for Agriculture database, Environmental Data Compendium.

Figure 3.3.2 **CH_4 and N_2O emissions from agriculture versus agricultural output[a)]**, 1990-1997



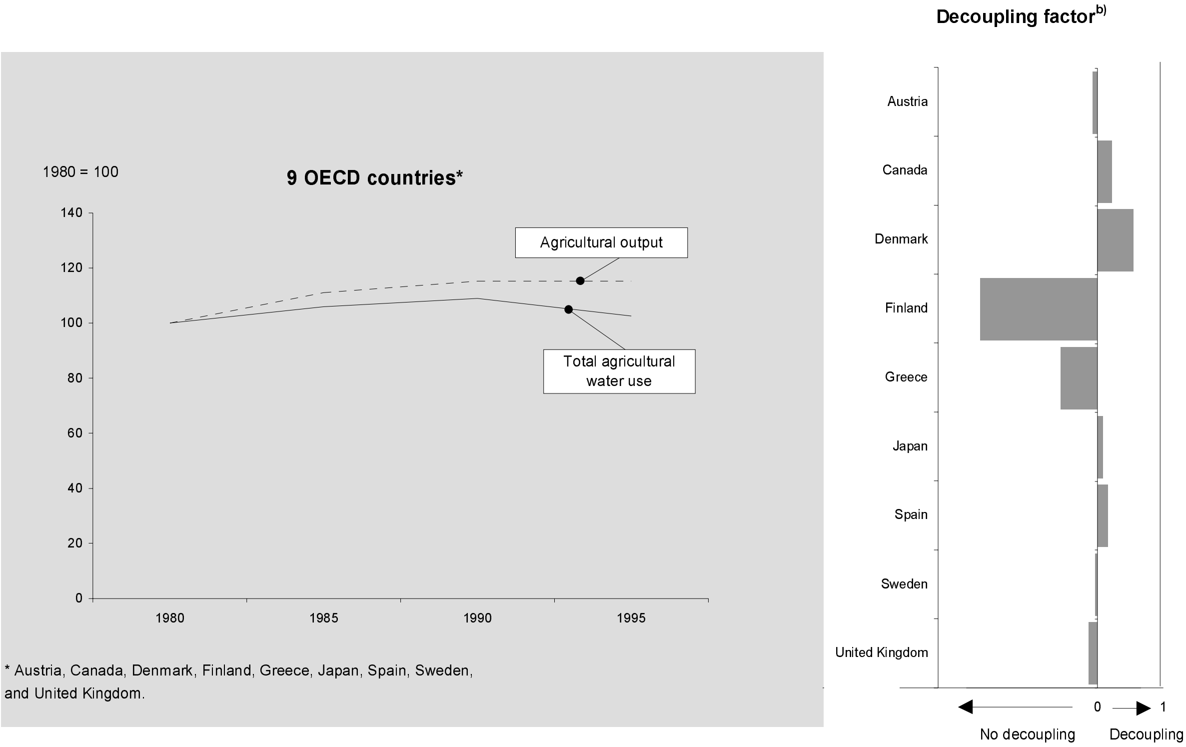
Decoupling factor[b)]



a) Agricultural output is taken here as final agricultural output minus farm origin intermediate consumption, as provided by the OECD Economic Accounts for Agriculture.
b) Decoupling factor is defined as 1-(EP/DF)end of period/(EP/DF)start of period where EP = environmental pressure and DF = driving force. Decoupling occurs when the value of the decoupling factor is between 0 and 1

Source: OECD, UNFCCC.

Figure 3.3.3 **Agricultural water use versus agricultural output**, 1980-1995



Water intensity

Country	Agricultural water use		Agricultural output[a)]		Water use/Agricultural output		Decoupling factor[b)]
	1995 10^6 m^3	1995 (1980 = 100)	1995 10^6 USD	1995 (1980 = 100)	1995 m^3 /USD	1995 (1980 = 100)	
Austria	100	111	3113	103	0.03	108	-0.29
Canada	3991	115	19030	147	0.21	78	0.08
Denmark	295	64	4474	142	0.07	45	0.55
Finland	50	250	1759	90	0.03	279	-3.15
Greece	7600	183	11879	117	0.64	156	-0.66
Japan	58600	101	59988	110	0.98	92	0.08
Spain	24116	92	24567	109	0.98	85	0.08
Sweden	137	98	2333	94	0.06	104	-0.35
United Kingdom	225	137	18726	120	0.01	114	-0.23
Total	95114	103	145868	115	0.73	89	

a) Agricultural output is taken here as final agricultural output minus farm origin intermediate consumption, as provided by the OECD Economic Accounts for Agriculture.

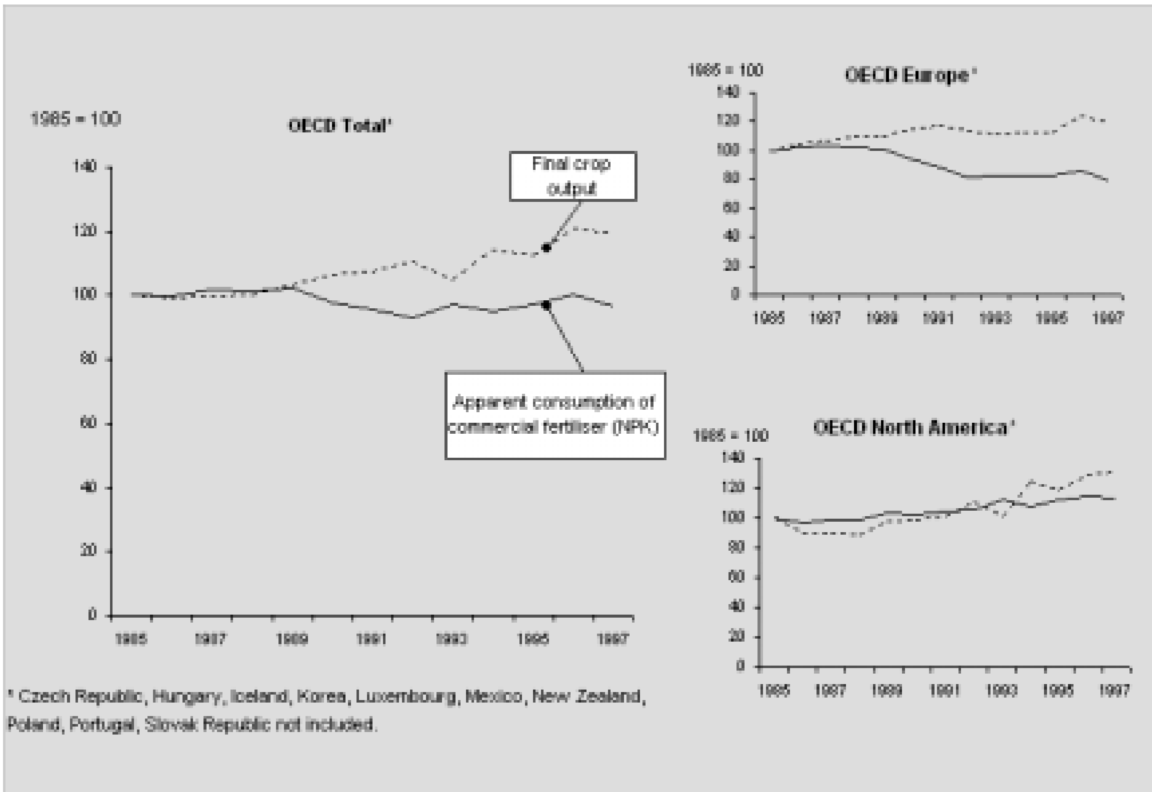
b) The decoupling factor is defined as 1-(EP/DF)end of period/(EP/DF)start of period where EP = environmental pressure and DF = driving force. Decoupling occurs when the value of the decoupling factor is between 0 and 1.

Shaded figures indicate absolute decoupling.

Source : OECD, Economic Accounts for Agriculture Database, Environmental Data Compendium.

Source: OECD, Economic Accounts for Agriculture Database, Environmental Data Compendium

Figure 3.3.4 **Apparent consumption of commercial fertiliser (NPK) versus final crop output,** 1985-1997



Apparent consumption of commercial fertilser (NPK) versus final crop output*

Country	Apparent consumption of commercial fertiliser (NPK)		Final crop output		NPK/Crop output		Decoupling factor[a)]
	1997 10^3 tonnes	1997 (1985 = 100)	1997 10^6 USD	1997 (1985 = 100)	1997 tonnes /10^3USD	1997 (1985 = 100)	
Australia	2184	189	13104	153	0.17	124	-0.24
Austria	254	65	1226	109	0.21	60	0.40
Belgium	307	73	2428	130	0.13	56	0.44
Canada	2726	117	11367	152	0.24	77	0.23
Denmark	436	69	1657	100	0.26	69	0.31
Finland	314	62	705	99	0.45	62	0.38
France	4989	88	24985	117	0.20	75	0.25
Germany	2857	59	12526	152	0.23	39	0.61
Greece	504	74	8916	109	0.06	68	0.32
Ireland	659	106	709	123	0.93	86	0.14
Italy	1769	84	25784	108	0.07	78	0.22
Japan	1509	74	49237	93	0.03	80	0.20
Netherlands	502	72	8214	162	0.06	44	0.56
Norway	205	86	621	97	0.33	89	0.11
Spain	2110	122	20503	116	0.10	104	-0.04
Sweden	309	74	988	85	0.31	87	0.13
Switzerland	121	67	1268	110	0.10	61	0.39
Turkey	1826	128	49932	127	0.04	101	-0.01
United Kingdom	1043	41	8570	98	0.12	42	0.58
United States	20165	113	106364	129	0.19	88	0.12
Total	44788	96	349104	119	0.13	81	

* This indicator will over-estimate fertiliser consumption in countries where commercial fertiliser is also spread on pasture.

a) Decoupling factor is defined as 1-$(EP/DF)_{1997}/(EP/DF)_{1985}$ where EP = environmental pressure and DF = driving force. Decoupling occurs when the value of the decoupling factor is between 0 and 1.

Shaded figures indicate absolute decoupling.

Source: OECD, Economics Accounts for Agriculture Database, FAO.

Decoupling factor[a)]

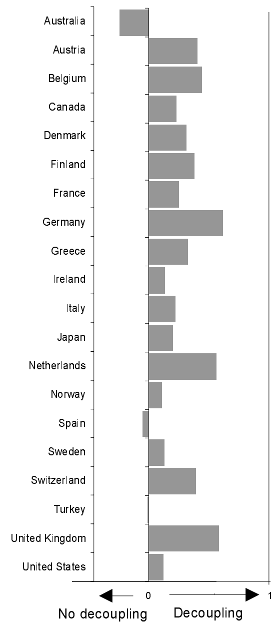
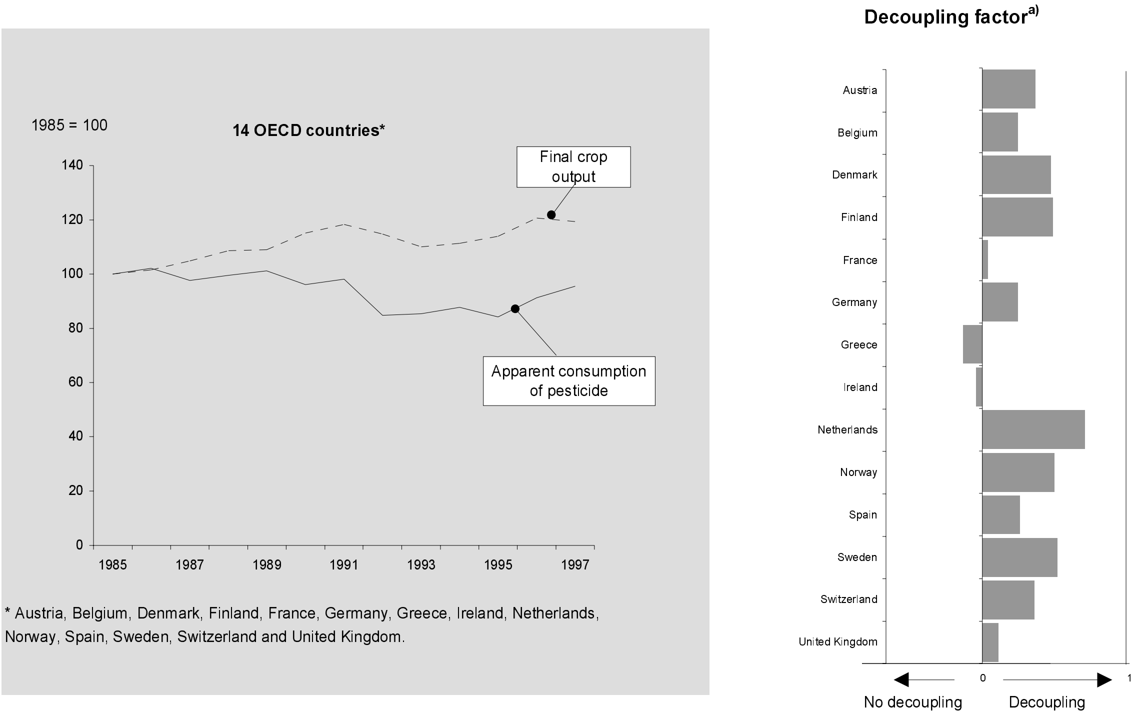


Figure 3.3.5 **Apparent consumption of pesticide versus final crop output,** 1985-1997



Apparent consumption of pesticide versus final crop output*

Country	Apparent consumption of pesticide (active ingredient)		Final crop output		Pesticide/Crop output		Decoupling factor[a)]
	1997 tonnes	1997 (1985 = 100)	1997 10^6 USD	1997 (1985 = 100)	1997 tonnes /10^6USD	1997 (1985 = 100)	
Austria	3690	70	1226	109	3.01	64	0.36
Belgium	8619	99	2428	130	3.55	76	0.24
Denmark	3675	54	1657	100	2.22	53	0.47
Finland	1016	52	705	99	1.44	52	0.48
France	109792	112	24985	117	4.39	96	0.04
Germany	34648	115	12526	152	2.77	76	0.24
Greece	9034	123	8916	109	1.01	113	-0.13
Ireland	2325	128	709	123	3.28	104	-0.04
Netherlands	10397	50	8214	162	1.27	30	0.70
Norway	754	49	621	97	1.21	51	0.49
Spain	34023	87	20503	116	1.66	75	0.25
Sweden	1527	42	988	85	1.55	49	0.51
Switzerland	1747	71	1268	110	1.38	65	0.35
United Kingdom	35432	87	8570	98	4.13	89	0.11
Total	256679	96	93316	119	2.75	80	

a) Decoupling factor is defined as $1-(EP/DF)_{1997}/(EP/DF)_{1985}$ where EP = environmental pressure and DF = driving force. Decoupling occurs when the value of the decoupling factor is between 0 and 1.

* This indicator will over-estimate pesticide consumption on crops to the extent that consumption figures include use of pesticides in forestry and on pasture.

Shaded figures indicate absolute decoupling.

Source: OECD, Economics Accounts for Agriculture Database, FAO.

3.4 MANUFACTURING INDUSTRY

The manufacturing industry sector covers a broad spectrum of manufacturing and processing activities producing a wide range of products such as clothing, computers, cars or furniture. The term is used here to comprise Tabulation Category D, groups 15-37 of the International Standard Industrial Classification of all economic activities (ISIC). "Energy-intensive industries" are a subset of the manufacturing sector and comprise the five following groups within the same category D: food & beverages(15), pulp & paper (21), chemical (24), non-metallic minerals (26), and basic metals [iron & steel & non-ferrous metals] (27).

The manufacturing sector puts pressures on the environment by way of the emission of pollutants (e.g., NO_x) and the use of natural resources. Pollutant emissions have for long been subject to regulation. More recently, industry has started paying greater attention to increasing the efficiency of resource use (eco-efficiency). The sector is also beginning to assume responsibility for material re-use and recovery of its products (e.g. for cars and office equipment). A new stage in the development of the manufacturing sector, which in future is likely to fundamentally affect its modus operandi and environmental impact, is the move from selling products (e.g. pesticides and solvents) to providing a service (e.g. plant protection and degreasing services).

Four decoupling indicators are presented here. Three of these concern pollution issues: the generation of industrial waste and emissions of nitrogen oxides and of carbon dioxides (the latter one specifically in relation to energy-intensive industries). The fourth indicator relates to the use of water by the manufacturing industry. In all cases the relevant value added figure is selected as the denominator[60].

♦ ***NO_x emissions from manufacturing industry versus manufacturing value-added***

NO_x emissions from the manufacturing industry were absolutely decoupled from manufacturing value added during 1991-98 for the group of 19 Member Countries[61] considered here: emissions fell by almost 3% whereas value added increased by over 10% (Figure 3.4.1). Decoupling was most pronounced in OECD Europe, where the ratio emissions per unit of value added fell by 24% over the period concerned. In OECD North America the corresponding figure was 11% and decoupling remained relative.

NO_x emissions from manufacturing are dominated by those emanating from fossil fuel combustion, with industrial processes only contributing about one-fifth. Energy use relative to total manufacturing output (measured by value-added) has fallen more or less continuously in most Member Countries since the 1950s. The improvement has been due both to structural shifts away from energy-intensive products and by changes in individual energy intensities in each manufacturing sub-sector. The latter have been showing steady improvement since the 1970s. The attention given by industry in recent years to achieving greater eco-efficiency can be expected to result in further decoupling of NO_x emissions from manufacturing value added.

♦ ***Waste generated by manufacturing industry versus manufacturing value-added***

The amount of non-hazardous waste generated by the manufacturing industry in the OECD area was estimated at roughly 990 million tonnes in 1997, an increase of about 40% since 1980. Of this amount, OECD North America, Europe and Pacific accounted for 35%, 44% and 21%, respectively. Trends in manufacturing output and industrial waste generation suggest that, for the whole of the OECD, decoupling has not yet occurred. During the period 1990-97, both the generation of manufacturing waste and industrial production increased by about 15%.

This indicator might be interpreted as a partial measure of the resource use efficiency of the manufacturing industry. Differences in manufacturing waste intensity among Member Countries may be due to differences in industrial structure or to greater or lesser progress with implementing cleaner production processes

60. Gross manufacturing output (minus intra-sectoral transactions), which includes all inputs, would have been a preferred denominator, but it is at this stage not feasible to present time series for such a variable.

61. Figures in this section do no include data for Australia, Hungary, Japan, Korea, Luxembourg, Mexico, Poland, Slovak Republic, Sweden, Switzerland and Turkey.

(including internal recycling). Manufacturing waste statistics need to be interpreted with caution, however, as their quality is still far from satisfactory.

The most recent information available for a limited number of Member Countries[62] suggests that a slight decoupling has taken place in the second half of the 1990s of the generation of manufacturing waste from manufacturing value added. For the total of the 11 countries considered, manufacturing waste decreased by almost 2% and value added grew by just over 2% during 1995-98 (Figure 3.4.2). Four (Hungary, Japan, Korea and Portugal) of the eleven countries show an absolute decoupling, while six show no decoupling at all (Figure 3.4.2). These different trends are superposed on underlying waste intensities (manufacturing waste per unit of value added) that range very widely around the (11-country) average of 190 tonnes per million USD of value added.

♦ ***CO_2 emissions of energy-intensive industries versus value added***

The sub-sectors of the manufacturing industry with the highest energy intensity are pulp & paper, chemicals, non-metallic minerals, iron & steel, non-ferrous metals, and food & beverages. For the group of G7 countries[63], a slight absolute decoupling occurred between 1995 and 1999: CO_2 emissions from energy-intensive industries fell by almost 5%, whereas the value added (VA) of the same industries increased by 2% (Figure 3.4.3).

♦ ***Decomposing CO2 emissions from energy intensive-industries***

The CO_2 emissions per unit of VA from this group of energy-intensive industries can be decomposed as follows:

$$\frac{CO_2 \text{ emissions/}}{\text{value added}} = \frac{CO_2 \text{ emissions/}}{\text{energy consumption}} * \frac{\text{Energy consumption/}}{\text{value added}}$$

CO_2 emissions from energy intensive industries per unit of energy consumption by the same industries fell by 4% for the group of G7 countries as a whole during 1995-99 and therefore contributed to the above decoupling of CO_2 emissions from the VA of energy-intensive industries (Table 3.4.1).

Table 1. Table 3.4.1 **Decomposing CO_2 emissions of energy-intensive industries in G7 countries versus value added of the same industries**, 1995-99
1999-value of ratio/1995-value

Country	*CO_2 emissions/VA*	=	*emissions/energy consumption*	*	*Energy consumption/VA*[a]
Canada[a]	1.00	=	0.97	*	1.03
France	0.95	=	0.97	*	0.98
Germany	0.95	=	0.94	*	1.01
Italy	0.95	=	0.97	*	0.97
Japan[b]	1.02	=	1.00	*	1.02
United Kingdom	0.93	=	0.89	*	1.05
United States	0.88	=	0.94	*	0.93
Total G7 countries	0.93	=	0.96	*	0.98

Note: a) *1997* is last year; b) 1998 is last year
Source: Eurostat, Wuppertal Institute, OECD/IEA

The *energy intensity of energy-intensive industries per unit of value added* fell by as much as 7% in the United States during 1995-99, but changed much less in the other six countries (Table 3.4.1). Without further analysis, it is difficult to say whether any of these changes are due to structural developments in the industry or the result of energy efficiency improvements.

62. *Denmark, Finland, Hungary, Iceland, Ireland, Italy, Japan, Korea, Netherlands, Norway, Portugal.*
63 . *Canada, France, Germany, Italy, Japan, United Kingdom, United States*

♦ ***Freshwater abstraction by manufacturing industry versus manufacturing value-added***

Average industrial water use in OECD countries makes up an estimated 45% of total water abstractions. More than three-quarters of this volume are supplied by direct abstraction from surface or groundwater, with the remaining quarter being sourced from public water supply systems.

Much progress has been made in recent years in making manufacturing less water intensive. Efficiency improvements have been achieved through the adoption of water saving technologies or the greater re-use of partially treated "grey" water. The reductions in industrial water use also reflect changes in industrial structure with large water-intensive industries (e.g. mining, steel) closing down. In general, efforts to reduce industrial water use have been driven by the desire to reduce the cost of production input water.

Information about the use of water by the manufacturing industry in 7 OECD Europe countries[64] show an absolute decoupling from manufacturing value added during 1993-98 (Figure 3.4.4). For the group of 7 countries, manufacturing water use fell by almost 6% and manufacturing value added increased by 11% over the same period (Figure 3.4.4). The amounts of water used per unit of value added vary widely from country to country and comparisons are difficult as national statistics sometimes include the use of cooling water for power generation.

References

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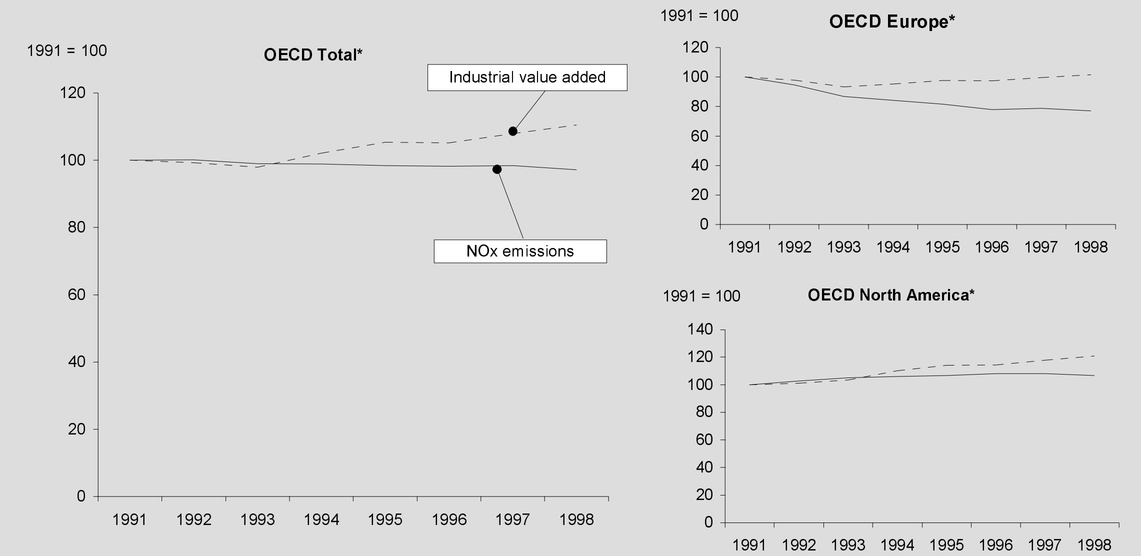
64. Austria, Czech Republic, France, Iceland, Poland, Slovak Republic and United Kingdom.

Figure 3.4.1 **NO_x emissions from manufacturing industry versus manufacturing value added,** 1991-1998



* Australia, Hungary, Japan, Korea, Luxembourg, Mexico, Poland
Slovak Republic, Sweden, Switzerland and Turkey are not included.

NOx emissions in the manufacturing industry per unit of value added

Country	NOx emissions from industrial processes and energy combustion in industry		Manufacturing VA		NOx emissions/VA		Decoupling factor[a)]
	1998 10^3 tonnes	1998 (1991 = 100)	1998 10^9 USD	1998 (1991 = 100)	1998 t/10^6USD	1998 (1991 = 100)	
Austria	32	93	35.02	106	0.91	87	0.13
Belgium	80	101	43.17	106	1.85	95	0.05
Canada	508	119	119.13	137	4.26	87	0.13
Czech Republic	54	34	33.36	106	1.62	32	0.68
Denmark	16	131	19.55	116	0.81	113	-0.13
Finland	41	98	24.90	152	1.66	65	0.35
France	159	85	216.07	102	0.74	83	0.17
Germany	235	68	383.60	90	0.61	76	0.24
Greece	56	112	15.89	88	3.52	127	-0.27
Iceland	1	156	0.95	115	0.77	136	-0.36
Ireland	10	87	23.47	184	0.41	47	0.53
Italy	203	61	237.86	101	0.85	61	0.39
Netherlands	61	65	57.09	109	1.07	59	0.41
New Zealand	41	122	10.73	115	3.78	106	-0.06
Norway	26	116	12.30	126	2.15	93	0.07
Portugal	43	120	26.62	115	1.63	104	-0.04
Spain	207	96	118.74	99	1.74	97	0.03
United Kingdom	226	86	212.48	112	1.06	77	0.23
United States	3535	105	1364.67	120	2.59	88	0.12
Total[b)]	5534	97	2955.61	110	1.87	88	

a) The decoupling factor is defined as $1-(EP/DF)_{1998}/(EP/DF)_{1991}$ where EP = environmental pressure and DF = driving force. Decoupling occurs when the value of the decoupling factor is between 0 and 1.

Manufacturing industry comprises all industries in the International Standard Industrial Classification (ISIC) Tabulation Category D, groups 15-37.

b) Total trends calculate using some OECD Secretariat estimates.

Shaded figures indicate absolute decoupling.

Source : OECD

Decoupling factor[a)]

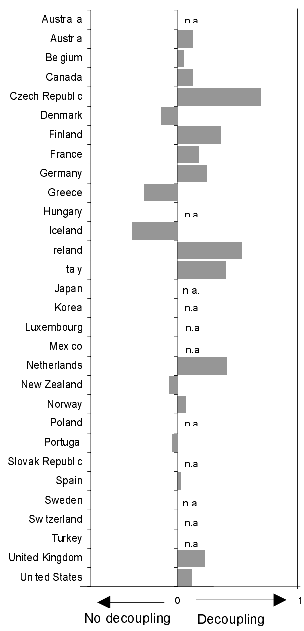
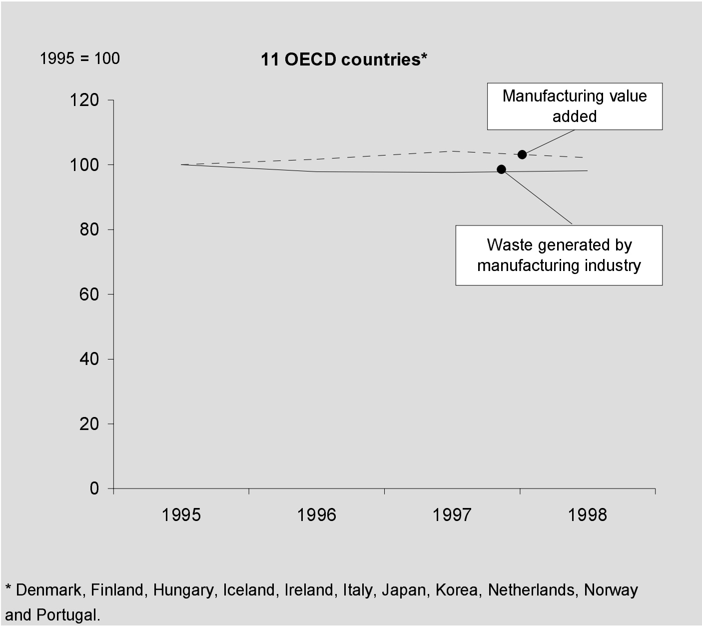
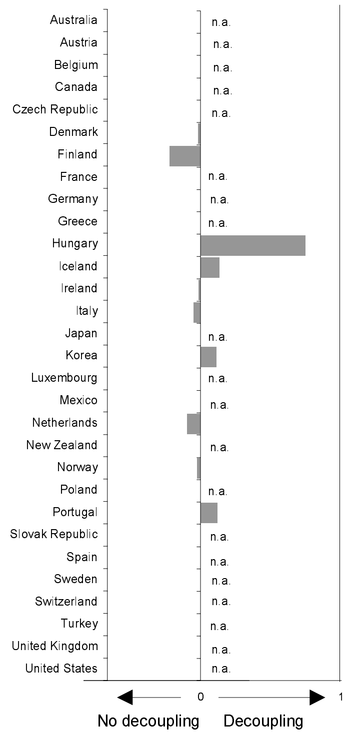


Figure 3.4.2 **Waste generated by manufacturing industry versus manufacturing value added,** 1995-1998



Decoupling factor[a)]



Generation of manufacturing waste per unit of value added

Country	Generation of manufacturing waste		Manufacturing VA		Manufacturing Waste/VA		Decoupling factor[a)]
	1998 10^3 tonnes	1998 (1995 = 100)	1998 10^6 USD	1998 (1995 = 100)	1998 tonnes/ 10^3USD	1998 (1995 = 100)	
Denmark	2783	109	19553	107	0.14	102	-0.02
Finland	15910	140	24901	115	0.64	122	-0.22
Hungary	2028	30	21809	119	0.09	25	0.75
Iceland	10	100	954	115	0.01	87	0.13
Ireland	5113	135	23471	133	0.22	101	-0.01
Italy	22993	104	237859	99	0.10	105	-0.05
Japan	125045	95	671195	99	0.19	95	..
Korea	35762	98	166716	110	0.21	89	0.11
Netherlands	9779	114	57092	104	0.17	110	-0.10
Norway	3403	103	12297	101	0.28	102	-0.02
Portugal	12804	96	26624	109	0.48	88	0.12
Total	235630	98	1262470	102	0.19	96	

a) Decoupling factor is defined as $1-(EP/DF)_{1998}/(EP/DF)_{1995}$ where EP = environmental pressure and DF = driving force. Decoupling occurs when the decoupling factor is positive.

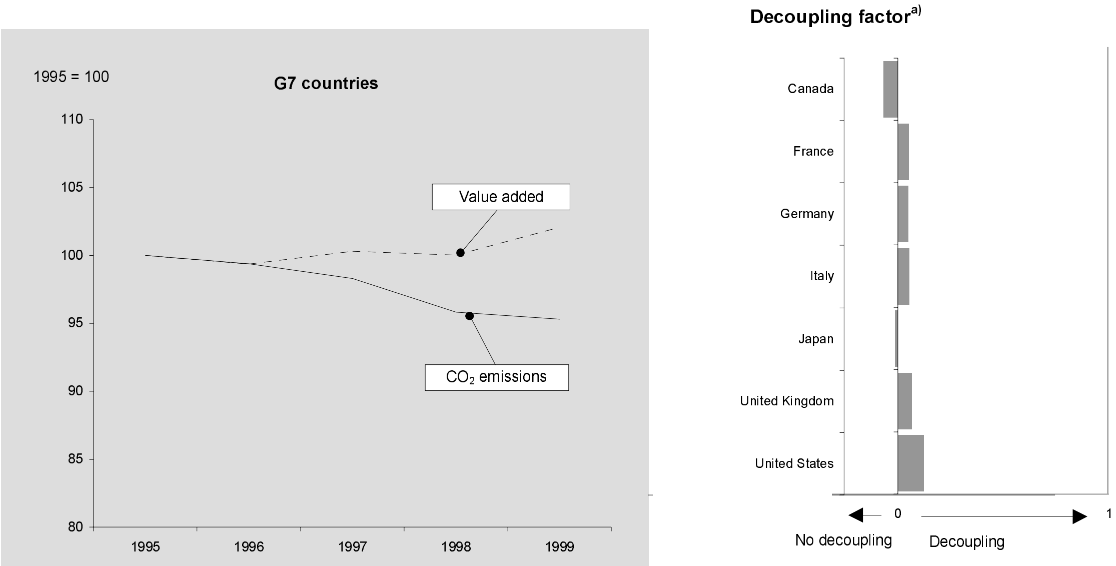
VA = value added

Manufacturing industry comprises all industries in the International Standard Industrial Classification (ISIC) Tabulation Category D, groups 15-37.

Shaded figures indicate absolute decoupling.

Source : OECD

Figure 3.4.3 **CO_2 emissions from energy-intensive industries versus value added,** 1995-1998



CO_2 emissions of energy-intensive industries per unit of value added

Country	CO_2 emissions of energy intensive industries		Value added 1999		Decoupling factor[a)]
	1999 Mt of CO_2	1999 (1995 = 100)	1999 10^6 USD	1999 (1995 = 100)	
Canada	54.38	103	51375	96	-0.07
France	61.51	100	93376	105	0.05
Germany	102.91	93	132098	98	0.05
Italy	60.42	94	83619	99	0.05
Japan	179.05	101	263508	98	-0.01
United Kingdom	48.12	88	88357	94	0.07
United States	424.47	93	542583	106	0.12

a) Decoupling factor is defined as $1-(EP/DF)_{1999}/(EP/DF)_{1995}$ where EP = environmental pressure and DF = driving force. Decoupling occurs when the value of the decoupling factor is between 0 and 1.

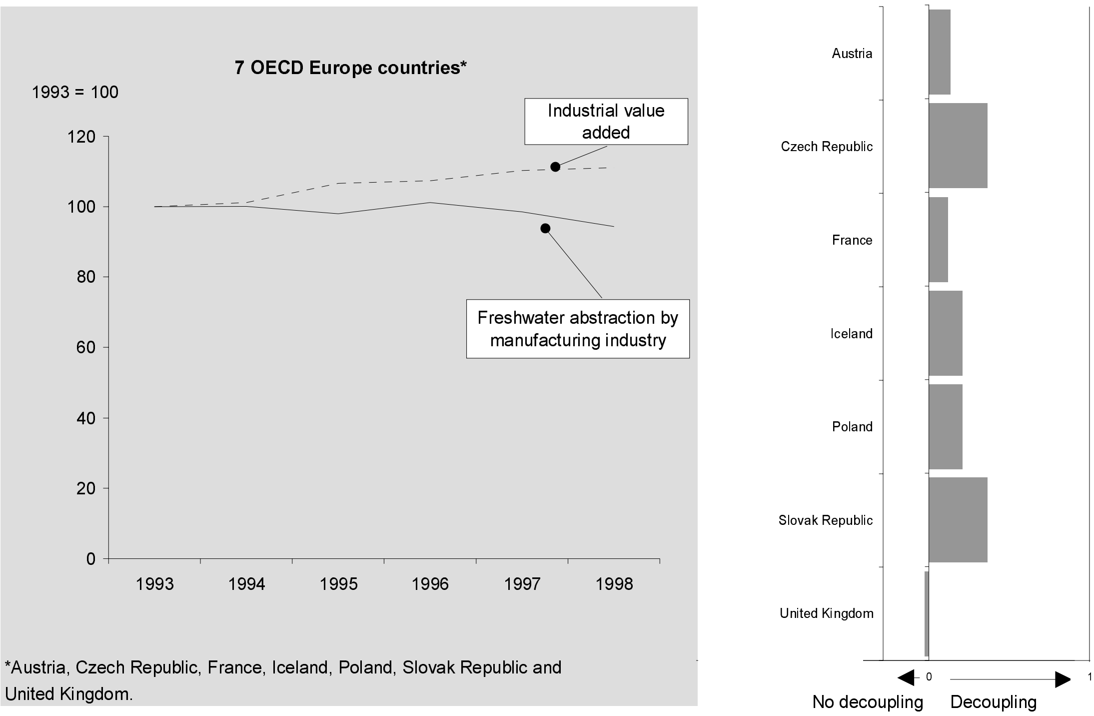
Shaded figures indicate absolute decoupling.

Energy-intensive industries include food and beverages (ISIC 15), Pulp & paper (ISIC 21), Chemical (ISIC 24), Non-metallic minerals (ISIC 26) and Basic metals (ISIC 27).

Source : OECD STI Directorate: STAN database and IEA.

Figure 3.4.4 **Freshwater abstraction by manufacturing industry versus manufacturing value added,** 1993-1998

Decoupling factor[a)]



Freshwater abstraction in the manufacturing industry per unit of value added

Country	Freshwater abstraction		Manufacturing VA		Abstraction/VA		Decoupling factor[a)]
	1998 10^6 m^3	1998 (1993 = 100)	1998 10^9 USD	1998 (1993 = 100)	1998 $m^3/10^3$USD	1998 (1993 = 100)	
Austria	1300	100	35.02	115	37.12	86	0.14
Czech Republic	505	79	33.36	125	15.14	64	0.36
France	3890	97	216.07	110	18.00	88	0.12
Iceland	10	100	0.95	126	10.48	79	0.21
Poland	913	79	60.49	100	15.10	79	0.21
Slovak Republic	685	88	11.51	138	59.51	63	0.37
United Kingdom	907	115	212.48	112	4.27	103	-0.03
Total	8210	94	569.89	111	14.41	85	

* Decoupling factor is defined as $1-(EP/DF)_{1998}/(EP/DF)_{1993}$ where EP = environmental pressure and DF = driving force. Decoupling occurs when the value of the decoupling factor is between 0 and 1.

VA = value added.

Manufacturing industry comprises all industries in the International Standard Industrial Classification (ISIC) Tabulation Category D, groups 15-37.

Shaded figures indicate absolute decoupling.

Source: OECD

APPENDIX 1 DECOUPLING INDICATORS AND OTHER INDICATOR SETS[65]

	OECD		UN	EU	
	Core set of env. indicators[a]	Sets of sectoral env. indicators[b]	UNCSD Sustainable Development indicators[c]	EU Env. Pressure indicators[d]	EEA Environmental Themes/Signals[e]
ECONOMY-WIDE DECOUPLING INDICATORS					
CLIMATE CHANGE					
Total greenhouse gas (GHG) emissions per unit of GDP and per capita	✓		✓	✓	✓
Total CO_2 emissions per unit of GDP and per capita	✓			✓	✓
AIR POLLUTION					
Total NO_x emissions per unit of GDP	✓	✓	✓	✓	✓
Total SO_x emissions per unit of GDP	✓	✓	✓	✓	✓
Total emissions of fine particulate matter per unit of GDP				✓	✓
Total VOC emissions per unit of GDP				✓	✓
WATER QUALITY					
Population NOT connected to sewage treatment plants versus total population	✓	✓		✓	✓
Discharges of nutrients from households into the environment versus total population	✓			✓	✓
WASTE MANAGEMENT					
Municipal waste going to final disposal versus private final consumption (PFC)		✓		✓	
– *Municipal waste going to final disposal per unit of municipal waste generated*	✓	✓		✓	
– *Municipal waste generation versus PFC and population*	✓	✓		✓	✓
Amount of glass NOT collected for recycling versus PFC	✓	✓	✓	✓	
MATERIAL USE					
Direct Materials Input (DMI) per unit of GDP	✓				✓
Ecological Footprint (minus energy component) per unit of GDP.					
NATURAL RESOURCES					
Water resources					
Total freshwater abstraction per unit of GDP	✓	✓	✓	✓	✓
– *Freshwater abstraction as a share of available resources*	✓	✓	✓		
Forests and forest products					
Amount of paper/cardboard NOT recycled versus GDP	✓			✓	
– *Intensity of use (harvest/annual growth)*	✓	✓		✓	
– *Share of plantation & sustainably managed forests in total forest area*	✓				
Fisheries					
– *Context information, fisheries sector*	✓	✓		✓	
Biodiversity					
Pressure version of the Natural Capital Index per unit of GDP					

65. *Note*: Intermediate and context indicators are in italic font / ✓: indicators that are based on identical or similar variables
a) OECD Core set of environmental indicators; b) OECD sets of sectoral environmental indicators (transport, energy, agriculture, household consumption); c) UN-CSD List of indicators of sustainable development; d) European Commission/Eurostat Environmental pressure indicators for the European Union (2001); e) European Environment Agency Themes for indicators and Environmental Signals (2000 and 2001 edition)

	OECD		UN	EU	
	Core set of env. indicators[a]	Sets of sectoral env. indicators[b]	UNCSD Sustainable Development indicators[c]	EU Env. Pressure indicators[d]	EEA Environmental Themes/Signals[e]
DECOUPLING INDICATORS FOR SPECIFIC SECTORS					
ENERGY					
CO_2, SO_x, and NO_x emissions from energy use per unit of GDP		✓			✓
– *Emissions versus total primary energy supply (TPES)*		✓			✓
– *TPES versus total final consumption (TFC)*			✓	✓	✓
– *TFC versus GDP*		✓	✓	✓	✓
Energy-related CO_2 emissions from the residential and commercial sectors per square metre of floor area					
– *Emissions per unit of TFC by the residential and commercial sectors*					
– *TFC by the residential and commercial sectors per square metre of floor area*					
CO_2 emissions from electricity generation					✓
– *CO_2 emissions per unit of fossil fuels (FF) input*					
– *FF input per unit of electricity generated from FF*			✓	✓	
– *Share of fossil fuels in electricity generation*					
TRANSPORT					
Emissions of CO_2, NO_x, VOCs from passenger cars and freight vehicles (combined) per unit of GDP				✓	✓
– *Emissions per vehicle-kilometre*		✓			✓
– *Vehicle-kilometres per unit of GDP*		✓			✓
Passenger car-related emissions of NO_x and VOCs per unit of GDP					
– *Emissions from passenger cars per private passenger-kilometre*					✓
– *Share of private passenger transport in total passenger-kilometres*					✓
– *Total passenger-kilometres per unit of GDP*		✓			✓
Freight road transport-related emissions of NO_x and VOCs per unit of GDP					✓
– *Emissions from freight vehicles per road tonne-km*					✓
– *Share of road freight transport in total freight transport*		✓			✓
– *Total tonne-kilometres per unit of GDP*		✓			✓
AGRICULTURE					
Soil surface nitrogen surplus versus agricultural output	✓	✓			✓
– *Nitrogen efficiency: share of uptake to input*		✓			
Methane and nitrous oxide emissions from agriculture versus agricultural output		✓			✓
Water intensity: total agricultural water use versus agricultural output				✓	✓
Fertiliser intensity: apparent consumption of commercial fertiliser (NPK) versus final crop output	✓	✓	✓	✓	✓
Pesticide intensity: apparent consumption of pesticide versus final crop output	✓	✓	✓	✓	✓
– *Share of the total agricultural area under organic farming*		✓			✓
MANUFACTURING					
NO_x emissions from manufacturing industry versus manufacturing value-added				✓	✓
Waste generated by manufacturing industry versus manufacturing value-added	✓				
CO_2 emissions from energy-intensive industries versus value-added					
– *CO_2 emissions versus energy consumption*					
– *Energy consumption of energy-intensive industry versus value-added*					
Freshwater abstraction by manufacturing industry versus manufacturing value-added				✓	

TECHNICAL ANNEX

GENERAL INFORMATION

- **Country region codes used are as follows:**

CAN:	Canada	FIN:	Finland	POL:	Poland
MEX:	Mexico	FRA:	France	PRT:	Portugal
USA:	United States	DEU:	Germany	SLO:	Slovak Republic
JPN:	Japan	GRC:	Greece	ESP:	Spain
KOR:	Korea	HUN:	Hungary	SWE:	Sweden
AUS:	Australia	ISL:	Iceland	CHE:	Switzerland
NZL:	New Zealand	IRL:	Ireland	TUR:	Turkey
AUT:	Austria	ITA:	Italy	UKD:	United Kingdom
BEL:	Belgium	LUX:	Luxembourg		
CZE:	Czech Republic	NLD:	Netherlands		
DNK:	Denmark	NOR:	Norway		

- **Country aggregates**

OECD: All OECD Member countries, which include the OECD Europe — i.e. countries of the European Union (EU) plus Czech Republic, Hungary, Iceland, Norway, Poland, Slovak Republic, Switzerland and Turkey — plus Canada, Mexico, the United States, Japan, Korea, Australia and New Zealand.

- **Signs**

..; n.a.	not available	.	decimal point	USD	US dollar
-	nil or negligible	n. app.	not applicable		

- **Abbreviations**

CFC	- chlorofluorocarbon	Mtoe	- million tonnes of oil equivalent	Pop	- population
CO	- carbon monoxide	N	- nitrogen	PPP	- purchasing power parities
CO_2	- carbon dioxide	N_2O	- nitrous oxide	SO_x	- sulphur oxides
CH_4	- methane	NO_x	- nitrogen oxides	t	- tonne
GDP	- gross domestic product	NMVOC	- non-methane volatile organic compounds	veh-km	- vehicle-kilometre
GHG	- greenhouse gas				
HCFC	- hydrochlorofluorocarbon	PFC	- private final consumption		

- **Units**

g	- gram (1 g = 0.0353 ounces)	kWh	- kilowatt hour (1 kWh = 103 Wh = 0.8598 kilocalories)	m^3	- cubic metre (1 m^3 = 1.3079 cubic yards)
µg	- microgram (1 µg = 10^{-6} g)	litre	- (1 l = 1 dm^3 = 0.001 m^3)	Toe	- tonne of oil equivalent (1 Toe = 10^7 kcal = 41.868*10^9 joules)
mg	- milligram (1 mg = 10^{-3} g)	km	- kilometre (1 km = 1 000 m. = 0.6214 miles)	tonne	- metric ton (1 t = 1 000 kg = 0.9842 long ton = 1.1023 short ton)
ha	- hectare (1 ha = 0.01 km^2)	km^2	- square kilometre (1 km^2 = 0.3861 square miles)		
kg	- kilogram (1 kg = 1 000 g = 2.2046 pounds)				

- **Per capita values and population data**

All per capita information uses OECD population data: all nationals present in or temporarily absent from a country, and aliens permanently settled in the country.

- **GDP data**

The information on GDP, Private Final Consumption (PFC), agricultural output and manufacturing value added (VA) used in this document is based, where available, on OECD National Accounts data at 1995 prices and 1995 purchasing power parities (PPPs). GDP figures for the Czech Republic and Poland prior to 1990, Hungary prior to 1991, and the Slovak Republic prior to 1992 are IEA estimates based on GDP growth rates from the World Bank.

The use of PPPs appears preferable to the use of exchange rates in conjunction with environmental questions, as the objective of comparing measures of economic activity such as GDP is to reflect underlying volumes and physical processes as closely as possible. PPPs are defined as the ratio between the amount of national currency and the amount of a reference currency needed to buy the same bundle of consumption goods in the two countries. In this publication, the reference currency is USD. Typically, PPPs differ from exchange rates as the latter reflect not only relative prices of consumer goods but also a host of other factors, including international capital movements, interest rate differentials and government intervention. As a consequence, exchange rates exhibit much greater variations over time than PPPs.

- **Data inclusion/exclusion policy**

The graphs and tables in this paper generally include all countries for which data are available. Estimates were made in some cases for the sake of including as many countries as possible. Gaps in time series were filled by interpolation. When for any country data were not available for the first or last year of the time period considered, figures for the nearest available year were taken instead, as long as in the Secretariat's view the resulting error remained acceptable. Readers wishing to know where such estimates were made, should consult the Technical Notes for individual indicators.

CLIMATE CHANGE

- A number of gases have direct effects on climate change and are considered responsible for a major part of global warming: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N2O), chlorofluorocarbons (CFCs), hydrofluorocarbons (HCFCs), methyl bromide (CH_3Br) and sulphur hexa fluoride (SF_6). Other air pollutants, such as NMVOC, NO_x and CO, have indirect effects on climate change as their reactions in the atmosphere result in the production of tropospheric ozone which effectively a GHG. Sulphur-containing trace gases also play a role. A major part of these emissions stems from combustion of fossil fuels and biomass. Other sources are industrial processes, agriculture and changes in land use

CO_2 EMISSION INTENSITIES

Data sources: United Nations Framework Convention on Climate Change (UNFCCC) (FCCC/SBI/2001/13, Table B4).

- Data refer to emissions from all: Fuel combustion, Fugitive emissions from fuels, Industrial processes, Solvent and other product use, Agriculture, Waste, and Other.
- No data for Mexico, Korea and Turkey.
- Luxembourg: some data are missing.
- Belgium, Czech Republic, Luxembourg and Poland: The trend shown may not be fully consistent, since data for the entire period were not provided in the latest submission and different sources of data may have been used.
- Hungary, and Poland: In accordance with decision 9/CP.2, some Parties with economies in transition use base year other than 1990. For Hungary base year is in lieu of 1990 the average of 1985-1987 and for Poland base year is 1988.

GREENHOUSE GAS EMISSIONS

Data sources: United Nations Framework Convention on Climate Change (UNFCCC) (FCCC/SBI/2001/13, Table B1).

- Data refer to emissions from all sources, except land use change and forestry.
- No data for Mexico, Korea and Turkey.
- Luxembourg: some data are missing.
- Belgium, Czech Republic, Luxembourg and Poland: The trend shown may not be fully consistent, since data for the entire period were not provided in the latest submission and different sources of data may have been used.
- Hungary, and Poland: In accordance with decision 9/CP.2, some Parties with economies in transition use base year other than 1990. For Hungary base year is in lieu of 1990 the average of 1985-1987 and for Poland base year is 1988.

AIR QUALITY

SO_X NO_X VOC_S PARTICULATES EMISSIONS

Data sources: OECD, UN/ECE

- Data refer to man-made emissions only. SOx and NOx data are given as quantities of SO_2 and NO_2 respectively.
- Emissions from international transport (aviation and marine) are excluded.
- Data may include provisional figures and Secretariat estimates.
- For further details, please refer to *OECD Environmental Data — Compendium 1999.*
- National objectives: current reduction targets as submitted by the Parties to the Convention on Long-Range Transboundary Air Pollution.

CAN ➢ SO_x: SO_2 only. Data for 1998 refers to 1997. VOCs: Data for 1998 refers to 1997. Particulates: Data refer to particulate>75 microns.Data for 1998 refer to 1996.
USA ➢ SO_x: SO_2 only. NO_x: Source: Environmental Protection Agency. VOCs: Forest wildfires are excluded. Particulates: Data refer to PM10. Emissions from natural sources, agriculture and forestry, fugitive dust, prescribed burning and other fires are excluded.
JPN ➢ Data are UNFCCC format..
KOR ➢ SO_x: SO_2 only, excluding industrial processes. Data from 1980 to 1983 are Secretariat estimates. NO_x: NO_2 only. Break in time series in 1990 due to a change in the emission coefficient of industrial fuel combustion. Data from 1980 to 1983 are Secretariat estimates.
AUS ➢ Data source: Australia's National GHG Inventory. NO_x: excl. land use changes and forestry. Incl. large amounts of emissions from prescribed savannah burning.
NZL ➢ SO_x: SO_2 only. Data refer to emissions from energy sources only. Data for 1980 is Secretariat estimate. NO_x:: Data for 1980 is Secretariat estimate. Particulates: Data refer to PM10
AUT ➢ Data source: Umweltbundesamt, UNFCCC 2000 (IPCC 1996 guidelines).SO_x: SO_2 only.
CZE ➢ SO_x: SO_2 only.
DNK ➢ Data based on CORINAIR inventories and UNECE format. Fluctuations in emissions are due to import/export of electricity.
FIN ➢ Change in estimation methodology in 1992. VOCs: 1990-1999 data are UNFCCC format (EEA inventory).
FRA ➢ Data refer to UNECE format; emissions from nature included. SOx: SO2 only. Particulates: Total emissions exclude mobile sources other than road transport. Data for 1998 refers to 1994.
DEU ➢ 1990-1999 data are from "Daten zur Umwelt in Deutschland 2000", Umweltbundesamt. SO_x SO_2 only.
HUN ➢ SO_x: SO_2 only.
ISL ➢ IPCC 1995 methodology. SO_x: SO_2 only.
IRL ➢ 1989, 1991-1992 and 1994-1997 data are from UNECE. Estimation methodology changed in 1990.Emissions from industrial processes are excluded.
ITA ➢ Data are from ANPA. Emissions from volcanoes, forest and grasland conversion are excluded.
LUX ➢ Data are from UNECE.
NLD ➢ Change in estimation methodology in 1990. Particulates: Data refer to PM10. Data for 1998 refers to 1997.
NOR ➢ Particulates: Data refer to PM10.
POL ➢ SO_x.: SO_2 only.
PRT ➢ Break in time series in 1990. Since 1990 data include Madeira and Azores Islands. SO_x: Pre-1990 data refer to SO_2 only.
ESP ➢ SO_x.: SO_2 only. Data for 1998 refers to 1996. NO_x and VOCs: Data 1990-1999 are from UNFCCC (EEA inventory).
SWE ➢ Data for 1990-1999 are UNFCCC format. SO_x: SO_2 only.
CHE ➢ SO_x.: SO_2 only. Particulates: Data refer to PM10.
UKD ➢ SO_x: SO_2 only. VOCs: Emissions from forests are excluded. Particulates: Data refer to PM10.
OECD ➢ Secretariat estimates.

WATER QUALITY

WASTE WATER TREATMENT

Data sources: OECD

- Total served: national population connected to public sewage treatment plants. Includes: primary treatment - physical and mechanical processes which result in decanted effluents and separate sludge (sedimentation, flotation, etc.); secondary treatment - biological treatment technologies, i.e. processes which employ anaerobic or aerobic micro-organisms; tertiary treatment - advanced treatment technologies, i.e. chemical processes.
- Sewerage connection rates: refers to population connected to public sewage network with or without treatment.
- Population not connected: refers to the difference between total population and population connected to public sewage treatment plants.

CAN ➢ 1990, 1995 and 1998 data refer to 1991, 1994 and 1996. Secondary usually includes private treatment & waste stabilisation ponds. Tertiary: secondary with phosphorus removal.
JPN ➢ Total connected: 1998 data refers to 1999.
KOR ➢ 1975 data refers to 1980.
NZL ➢ 1985 data refers to 1990.
AUT ➢ 1990 data refers to 1992.
DNK ➢ 1980 data refers to 1983.
DEU ➢ 1985, 1990 and 1998 data refer to 1987, 1991 and 1994.
PRT ➢ 1995 and 1998 data refer to 1994 and 1999
ESP ➢ 1995 and 1998 data refer to 1992 and 1995
UKD ➢ 1975 and 1980 data refer to 1985. Data refer to England and Wales and to financial year (April to March).

EMISSIONS OF NUTRIENTS TO WATER

Data sources: EUROSTAT

- The indicator is defined as the average annual load of nitrogen (N) and phosphorus (P) from households discharged into aquatic ecosystems. The indicator is expressed in tonnes per year, reported separately for N and P. The load from households is estimated by means of data on population connected to treatment plants, emission factor (kg N/inhabitant, kg P/inhabitant) and the theoretical efficiency of the treatment plants. The following average annual emission factors have been used for our purposes:

	1970	1980	1985	1990	1991	1992	1993	1994	1995	1996
N emissions coefficient	4.4									
P emissions coefficient	1.4	1.4	1.4	1.2	1.1	1.0	1.0	1.0	1.0	1.0

- Data on actual treatment efficiency are scarce, therefore the decoupling indicator has been calculated using a theoretical treatment efficiency included in the table below:

	Type of treatment		
	Primary	Secondary	Tertiary
Nitrogen removal	0%	20%	80%
Phosphorus removal	5%	25%	80%

Data on actual treatment efficiency are scarce, therefore, the data reflect the level of treatment, the average load and the technical efficiency rate. Data do not aim to describe the actual situation, but the emissions of a scenario with some of the features of the existing waste water treatment system.

WASTE

PRIVATE FINAL CONSUMPTION EXPENDITURE

Data sources: OECD

- Private final consumption expenditure: the sum of (i) the outlays of resident households on new durable and non-durable goods and services less their net sales of second-hand goods, scraps and wastes; (ii) the value of goods and services produced by private non-profit institutions for own use on current account; expressed at 1995 price levels and purchasing power parities.

MUNICIPAL WASTE GOING TO FINAL DISPOSAL

Data sources: OECD

- Disposal is defined as any waste management operation serving or carrying out the final treatment and disposal of waste. It covers the following main operations: final treatment (incineration without energy recovery, biological, physical, chemical treatment resulting in products or residues that are discarded, i.e. going to final disposal) and final disposal (deposit into or onto land (e.g. landfill), including specially engineered landfill, deep injection, surface impoundment, release into water bodies and permanent storage). Data should include amounts directly treated and/or disposed of as well as amounts treated and/or disposed of after sorting.

MEX ➢ Landfill: includes open landfill and illegal dumping. 1999 data refers to 1998.
USA ➢ Landfill: after recovery and incineration.
KOR ➢ 1999 data refers to 1998.
AUT ➢ Landfill: excludes residues from other operations.
BEL ➢ 1999 figure is an estimatie based on the total of municipal waste collected for 1999.
DEU ➢ 1999 data refers to 1998 and 1995 figure is Secretariat estimates.
NLD ➢ 1995 data is Secretariat estimates.
SWE ➢ 1999 data refers to 1998 and 1995 figure is Secretariat estimates.
CHE ➢ 1999 data refers to 1998 and 1995 figure is Secretariat estimates
TUR ➢ 1999 data refers to 1997.
UKD ➢ 1996, 1997 data refer to England and Wales only.

MUNICIPAL WASTE

Data sources: OECD

- Municipal waste is waste collected by or on the order of municipalities. It includes waste originating from households, commercial activities, office buildings, institutions such as schools and government buildings, and small businesses that dispose of waste at the same facilities used for municipally collected waste.

CAN ➢ All waste disposed of, except construction and demolition waste, even if not collected by municipalities; includes flows diverted for recycling or composting. Includes some industrial waste; 1990 figure refers to 1988.
JPN ➢ Exclude waste from institutions such as schools and hospitals.
AUT ➢ Excludes construction site waste, which is included in national definition.
DNK ➢ Municipal w. data come from a new survey done in treatment plants (excl. about 9 000 t of w. from hospitals).
DEU ➢ Includes separate collection for recycling purpose conducted outside the public sector; this particularly concerns packaging material (paper, glass, metals, plastics) collected by the Duale System Deutschland.
GRC ➢ Traditional waste collection only. 1998 data refers to 1997.
ISL ➢ 1990 data refers to 1992.
LUX ➢ Includes separate collection.
NLD ➢ Includes separate collection for recycling purposes, solid waste from sewerage and small amount of mixed building and construction waste.
NZL ➢ Data refer to household waste only.
POL ➢ Includes liquid waste from cesspool and other containers.
CHE ➢ Includes separately collected waste.
TUR ➢ 1990 data refers to 1989 and 1998 data refers to 1997.
UKD ➢ Estimates based on data for England and Wales

WASTE RECYCLING

Data sources: OECD, Fédération Européenne du Verre d'Emballage (Brussels), Confederation of European Paper Industries (Brussels), FAO

- Recycling is defined as reuse of material in a production process that diverts it from the waste stream, except for recycling within industrial plants and the reuse of material as fuel.
- The recycling rate is the ratio of the quantity collected for recycling to the apparent consumption (domestic production + imports -exports).

USA ➢ Source: "Municipal solid waste in the United States: 1999 fact and figures", "Characterization of Municipal Solid Waste in the United States, 1996" +1997 update, EPA, Municipal and Industrial Solid Waste Division. Recycle data corresponds to purchases of postconsumer recovered material plus net exports (if any) of the material.
NLD ➢ Source data "Milieucompendium 1999", Het milieu in cijfers, page 199, from Centraal Bureau voor de Statistiek.

DIRECT MATERIAL INPUT (DMI)

Data sources: EUROSTAT and Wuppertal Institute.

- The DMI measures the direct input of materials for use into the economy, i.e. all materials of economic value that are used in production and consumption activities. DMI equals domestic (used) extraction plus imports.
- Data are partly based on national material flow accounts and partly estimated from international data sources (Eurostat, FAO, US BOM, etc.). Therefore, reliability of the resulting estimates is variable across countries.
- Luxembourg is shown with Belgium as there were not enough data to estimate Luxembourg separately

WATER RESOURCES

INTENSITY OF USE OF WATER RESOURCES

Data sources: OECD, FAO, World Resources Institute (WRI)

- <u>Abstractions:</u> accounts for total water withdrawal without deducting water that is reintroduced into the natural environment after use.
- <u>Abstractions as % of available resources:</u> data refer to total abstraction divided by total renewable resources, except for total, where the internal resource estimates were used to avoid double counting.
- <u>Renewable water resources:</u> net result of precipitation minus evapotranspiration (internal) plus inflow (total). This definition ignores differences in storage capacity, and represents the maximum quantity of fresh water available on average.

CAN ➢ 1980, 1985, 1990, 1995 and 1998 figures refer to 1981, 1986, 1991, 1995 and 1995.
USA ➢ 1998 data refer to 1995.
JPN ➢ 1995 and 1998 data refer to 1994 and 1997.
KOR ➢ 1995 and 1998 data refer to 1994 and 1997.
DNK ➢ 1985 and 1990 data refer to 1988 and 1991.
FIN ➢ Partial totals. 1998 data refer to 1999.
FRA ➢ 1980 and 1998 data refer to 1981 and 1997.
DEU ➢ 1990 data refer to 1989.
ISL ➢ Fish farming is a major user of abstracted water. 1990 data refers to 1992.
NLD ➢ Partial totals excluding all agricultural uses. 1990 and 1995 data refer to 1991 and 1996.
POL ➢ Totals include abstractions for agriculture, which include aquaculture (areas over 10 ha) and irrigation (arable land and forest areas greater than 20 ha); animal production and domestic needs of rural inhabitants are not covered.
ESP ➢ Excluding agricultural uses other than irrigation. Groundwater: excluding industry. 1998 data refer to 1997.
SWE ➢ 1998 data refer to 1995.
TUR ➢ 1980: partial totals; excluding agricultural uses other than irrigation and electrical cooling. 1990 data refers to 1991.

FOREST RESOURCES

INTENSITY OF USE OF FOREST RESOURCES

Data sources: OECD, FAO, national statistical yearbooks

- Annual growth: gross increment.

CAN ➢ For depletion and gross increment: 1995 data refer to 1994.
USA ➢ For depletion and gross increment: 1995 data refer to 1992.
JPN ➢ 1995 data: Basic Plan for Forest Resources.
AUS ➢ For depletion and gross increment: 1995 data refer to 1994 (TBFRA 2000 data reference year: 1994).
NZL ➢ Data refer to planted production forests only. Growth of natural forests is considered to be near zero with a growth rate equal to mortality. Harvest from natural forests is less than 3 % of harvest.
AUT ➢ For depletion and gross increment: 1995 data refer to 1992.
BEL ➢ For gross increment: 1995 data refer to 1992.
DNK ➢ 1980 data are Secretariat estimates. For depletion: 1990 data refer to 1989.
GRC ➢ For gross increment: 1995 data refer to 1992.
LUX ➢ For gross increment: 1995 data refer to 1992.
NLD ➢ Data refer to total exploitable forest. 1995: break in time series (TBFRA 2000 data).
POL ➢ Data refer to TBFRA 2000 definitions. Data refer to the 1st January. Harvest: decrease in 1990 was a result of decreased demand for wood in the economic transition period.
PRT ➢ 1995: TBFRA 2000 data; break in time series due to a change in definitions; data refer to Portugal Continental, Açores and Madeira Islands.
ESP ➢ Growth and intensity of use 1980: Secretariat estimate. For depletion: 1990 data refer to 1989.
SWE ➢ Data refer to total forest including other wooded land and trees outside the forests. For gross increment: 1995 data refer to 1993.
TUR ➢ Data are provisional.

PAPER/CARDBOARD NOT RECOVERED

Data sources: FAO

- Recovered paper: used paper and paperboard or residues from paper conversion that are collected for reuse as a raw material for the manufacture of paper, paperboard or other products.
- Paper/cardboard NOT recovered has been defined as follows:
  Paper NOT recovered = Paper and paperboard production + Net imports of paper and paperboard + Net imports of recovered paper – Recovered paper production.

PLANTATION AND SUSTAINABLY MANAGED FORESTS

Data sources: FAO, "State of the World's forests, 2001", Table 2 and 4 and the Forest Stewardship Council (FSC) and the Pan European Forest Certification (PEFC).

- Total forest is the sum of natural forest plus plantations and losses and gains in the area of natural forests.
- Forest plantation: a forest established by planting and/or seeding in the process of afforestation or reforestation. It consists of introduced species or, in some cases, indigenous species.
- Sustainable forest management: the stewardship and use of forest land in a way and at a rate, that maintains their biodiversity, productivity, regeneration capacity, vitality and their potential to fulfil now and in the future, relevant ecological, economic and social functions, at local, national and global levels and does not cause damage to other ecosystems.
- Forest certification: is the process of inspecting particular forests or woodland to see if they are being managed according to an agreed set of standards.

FISH RESOURCES

FISH CATCHES AND CONSUMPTION

Data sources: FAO

- Total catches: data refer to capture fisheries in inland and marine waters, including freshwater fish, diadromous fish, marine fish, crustaceans, molluscs and miscellaneous aquatic animals; excludes aquaculture.
- Aquaculture: defined as the farming of aquatic organisms, that is some form of intervention is implied in the rearing process to enhance production, (such as regular stocking, feeding, protection from predators), plus individual or corporate ownership of the stock is implied.
- Production: Production statistics refer to the quantities of preserved and processed fishery commodities, produced both ashore and on-board vessels utilising catches from commercial fisheries and aquaculture production. Products from imported raw materials are also included.
- Fish consumption: Total food supply = production - non-food use + imports - exports + stock variations.

BEL ➢ Data include Luxembourg.
DNK ➢ Excludes Greenland and Faroe Islands.

BIODIVERSITY

NATURAL CAPITAL INDEX (NCI)

Data sources: OECD (2001), "Biodiversity, background document for the OECD Environmental Outlook, for chapter 11: Biodiversity". RIVM for share of surface areas of Russian Federation and Ukraine taken into account in calculations.

- The NCI pressure index was developed as an assessment tool for the Convention On Biological Diversity (CBD) by the Dutch National Institute of Public Health and the Environment RIVM and the UNEP World Conservation and Monitoring Centre. The index comprises seven parameters (rate of climate change, human population density, consumption and production, isolation/fragmentation, acidification, eutrophication, exposure to high ozone concentration) and takes a value of between 0 and 100.

- The NCI framework aims at providing a quantitative and meaningful picture of the state of and trends in biodiversity due to human interventions, to support policy makers in a similar way as socio-economic figures support policy makers. The NCI can be applied on all scales –national, regional and global- and for all ecosystems, from forest and marine to agriculture. It deals with wild-living species.
- The NCI framework considers biodiversity as a natural resource containing all species with their specific abundance, distribution and natural fluctuations. The loss of biodiversity due both to loss of habitat and to pressures on the remaining habitat are called the loss of *ecosystem quantity* and *ecosystem quality*, respectively. Given these two factors the NCI framework has defined the natural capital as the product of the size of the remaining area (ecosystem quantity) and its quality. Ecosystem quantity is defined as the size of the ecosystem (% area of country or region) and ecosystem quality is defined as the ratio between the current and a baseline state (% of baseline). An NCI of 0% means that the entire ecosystem has deteriorated either because there is no area left, or because the quality is 0% or both. An NCI of 100% means that the entire country consists of natural area of 100% quality.
- The NCI for the three regions of countries has been obtained by averaging the values for individual countries, weighted by total land area.

ENERGY

CO_2 EMISSIONS

Data sources: IEA-OECD

- Data refer to gross direct emissions; CO_2 removal by sinks, indirect emissions from land use changes and indirect effects through interactions in the atmosphere are not taken into account.
- Data refer to CO_2 emissions from fossil fuel combustion. anthropogenic emissions by other sources (industrial processes, biomass burning) are not included.
- Data are estimates based on the default methods and emission factors from the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories* and on the IEA-OECD data for total primary energy supply.
- Oil and gas for non-energy purposes such as feedstocks in the chemical and petrochemical industries are excluded.
- Oil held in international marine and aviation bunkers is excluded at national level; world emissions include marine and aviation bunkers, amounting to 398 million tonnes and 322 million tonnes in 1998.
- Further details on calculation methods and conversion factors can be found in *IEA-OECD (2001), CO_2 Emissions from Fuel Combustion, 1971-1999*.

NO_X EMISSIONS

Data sources: OECD

- Data refer to emissions from all man-made sources minus emissions from industrial processes and miscellaneous.

JPN ➢ Emissions from industrial processes are included.
FIN ➢ Industrial fuel combustion includes fuel combustion in industrial power plants and processes.
ITA ➢ Industrial processes include petroleum refining and solid fuel transformation.
UKD ➢ Industrial processes include petroleum refining plants.

SO_X EMISSIONS

Data sources: OECD

- Data refer to emissions from all man-made sources minus emissions from industrial processes and miscellaneous.

IRL ➢ Emissions from industrial processes are not included.
UKD ➢ Industrial processes include petroleum refining plants.

RESIDENTIAL AND COMMERCIAL SECTORS FLOOR AREA

Data sources: IEA, Energy Efficiency Indicators.

ENERGY SUPPLY

Data sources: IEA-OECD

- Total primary energy supply: indigenous production + imports - exports - international marine bunkers and ± stock changes. Primary energy comprises hard coal, lignite and other solid fuels, crude oil and natural gas liquids, natural gas, and nuclear, hydro, geothermal and solar electricity. Electricity trade is also included.
- Total final consumption: the sum of consumption by the different end-use sectors: industry sector, transport sector (excludes international marine bunkers) and other sectors (agriculture, residential commercial and public services).
- Electricity output: electricity generated by thermal power plants as well as production by nuclear and hydro (excluding pumped storage production), geothermal, etc.
- Electricity output from fossil fuels: electricity generated by thermal power plants separated into electricity and CHP plants.
- Fossils fuels input: IEA Secretariat estimates.
- see IEA (1998-99) *Energy Balances of OECD Countries* for conversion factors from original units to Toe for the various energy sources and for definitions.
- Residential and commercial sector floor areas come from IEA Energy Efficiency Indicators, internal database.

TRANSPORT

CO_2 EMISSIONS

Data source: IEA

NO_X EMISSIONS

Data source: OECD

- Data refer to emissions from road motor vehicles.

JPN ➢ Data for total transport.
KOR ➢ Data for total transport.

VOC EMISSIONS

Data source: OECD

- Data refer to emissions from road motor vehicles.

UKD ➢ Road transport includes evaporative and combustion emissions.

ROAD TRAFFIC

Data sources: OECD, International Road Federation (IRF), national yearbooks

- Traffic volumes are expressed in billions of kilometres travelled by road vehicle; they are usually estimates and represent the average annual distance covered by vehicles, in kilometres, multiplied by the number of vehicles in operation. In principle, the data refer to the whole distance travelled on the whole network inside the national boundaries by national vehicles, with exception of two- and three-wheeled vehicles, caravans, and trailers.
- Data include Secretariat estimates.

USA ➢ Traffic by local and urban buses is excluded.
JPN ➢ Traffic by light vehicles is excluded.
BEL ➢ Including motor vehicles with 2 or 3 wheels (about 1%)
CZE ➢ Excludes buses.
DEU ➢ Except for military vehicles, traffic by special vehicles is included.
GRC ➢ Data refer to inter-city traffic only.
ISL ➢ Traffic by local and urban buses is excluded.
ITA ➢ Traffic by three-wheeled goods vehicles is included.
NLD ➢ Traffic by trams and subways is included.
ESP ➢ Data refer only to traffic on motorways and national roads.
SWE ➢ Data include traffic by Swedish passenger cars abroad. Traffic by goods vehicles with a load capacity under 2 tonnes is excluded. Up to 1988, only the public network is included; after 1989, the total network is taken into account.

PASSENGER CAR AND TON KM RELATED EMISSIONS OF NO_X AND VOC_S

Data sources: European Environment Agency, ETC/AE, 2000 and EUROSTAT 2001.

- EUROSTAT and DG Transport are jointly developing a database system (TRENDS) that links transport and other data with methodologies for estimating emissions and other environmental pressures. An important aim is to produce a consistent set of estimates to be used for EU policy purposes including TERM (Transport and Environment reporting Mechanism).
- Emission of air pollutants per transport unit: distinguishing by type (freight or passenger), mode and vehicle category.
- Occupancy rate (average number of passengers in a vehicle) for cars and load factor (ratio of the average load to total vehicle freight capacity) for trucks play an important role with respect to specific emissions.
- The average age of the vehicle fleet is of great importance for specific emissions of the whole vehicle fleet, as it reflects the technology level.

	Specific emissions for cars (EU-15) (g/passenger-km)		Specific emissions for trucks (EU-15) (g/ton-km)	
	VOC	NOx	VOC	NOx
1990	0.859	0.991	0.657	2.047
1995	0.571	0.680	0.606	1.897
1996	0.517	0.626	0.595	1.863
1997	0.467	0.574	0.561	1.757
1998	0.420	0.524	0.525	1.639

AGRICULTURE

APPARENT CONSUMPTION OF NPK FERTILISERS

Data sources: OECD, FAO, International Fertilizer Industry Association, national statistical yearbooks, UN/ECE, UNEP

- Apparent consumption of NPK fertilisers: data refer to the nitrogen (N) and phosphoric acid (P2O5) content of nitrogenous and phosphate fertilisers and to the K2O content of commercial potash, muriate, nitrate and sulphate of potash, manure salts, kainit and nitrate of soda potash. Data relate to apparent consumption during the fertiliser year (generally 1 July to 30 June)
- Data includes estimates.
- Phosphate fert.: includes ground rock phosphates.

USA ➢ Includes data for Puerto Rico.
BEL ➢ Data for Belgium include Luxembourg. Phosphate fert.: excludes other citrate soluble phosphates.

DNK ➢ Fertiliser year: August-July.
FRA ➢ Phosphate fert.: fertiliser year: May-April.
GRC ➢ Fertiliser year: calendar year.
ESP ➢ Fertiliser year: calendar year.
SWE ➢ Fertiliser year: June-May. Nitrogen fert.: data include forest fertilisation.
TUR ➢ Fertiliser year: calendar year.
UKD ➢ Fertiliser year: June-May.

NITROGEN BALANCES

Data sources: OECD

- Nitrogen balance: the annual total quantity of inputs includes mainly livestock manure and chemical fertilisers. The annual total quantity of outputs includes mainly crops and forage. The indicator provides information on the potential loss of nitrogen to the soil, the air, and to surface or groundwater. However, nitrogen loss through the volatilisation of ammonia to the atmosphere from livestock housing and stored manure is excluded from the calculation.
- Nitrogen efficiency: in agriculture, measures the physical nitrogen input/output ratio.

LUX ➢ No data.
SVK ➢ No data
For more details on each country or on definitions, refer to the OECD web site: www.oecd.org/agr/env/indicators.htm

ECONOMIC ACCOUNTS FOR AGRICULTURE

Data source: OECD

- Final crop output: include cereals, rice, pulses, root crops, industrial crops, fresh vegetables, fresh fruit, citrus fruit, grapes, wine, table olive, olive oil, other crops and crop products and other. Expressed at 1995 price levels and purchasing power parities.

CAN ➢ Crop output 1998 data refers to 1997.
JPN ➢ Crop output 1998 data refers to 1997.

- Final agricultural output: include final crop output, final animal output and miscellaneous. Output of goods to be recorded when the production process is completed. Final output is equal the gross production less waste (usable production) plus initial stocks (resources) less intra-branch consumption +/- change in stocks depending on final stocks. The final output, thus, measures the value of agricultural products available for export/consumption free of intra-branch consumption. Expressed at 1995 price levels and purchasing power parities.
- Agricultural value added: final agricultural output (which include final crop output, final animal output and miscellaneous) minus intermediate consumption (which include all goods and services consumed in the production process). This is the standard measure for assessing productivity. Expressed at 1995 price levels and purchasing power parities.

CAN ➢ Agricultural value added 1998 data refers to 1997.
JPN ➢ Agricultural value added 1998 data refers to 1997.

CH_4 AND N_2O EMISSIONS FROM AGRICULTURE

Data source: UNFCCC.

- No data for Mexico, Korea and Turkey.
- Luxembourg: some data are missing.
- Belgium, Czech Republic, Luxembourg and Poland: the trend shown may not be fully consistent, since data for the entire period were not provided in the latest submission and different sources of data may have been used.
- Hungary, and Poland: In accordance with decision 9/CP.2, some Parties with economies in transition use base year other than 1990. For Hungary base year is in lieu of 1990 the average of 1985-1987 and for Poland base year is 1988.

INTENSITY OF USE OF PESTICIDES

Data sources: OECD, FAO, national statistical yearbooks, European Crop Protection Association

- Unless otherwise specified, data refer to active ingredients.
- Unless otherwise specified, data refer to total consumption of pesticides, which include: insecticides (acaricides, molluscicides, nematocides and mineral oils), fungicides (bactericides and seed treatments), herbicides (defoliants and desiccants), and other pesticides (plant growth regulators and rodenticides).

BEL ➢ Data include Luxembourg.
DNK ➢ Sales for use in plant production in open agriculture.
FIN ➢ Data include forest pesticides and refer to sales.
FRA ➢ Data refer to quantities sold to agriculture.
DEU ➢ Data refer to sales.
GRC ➢ Data refer to sales.
NLD ➢ Data refer to sales of chemical pesticides. Data include soil disinfectants, which correspond to about the half of the total consumption.
NOR ➢ Data refer to sales.
ESP ➢ Data refer to sales.
SWE ➢ A special sales tax has been applied to pesticides since 1987. Another tax was applied in 1995. Data refer to sales.
CHE ➢ Data refer to sales and have been estimated to represent 95 per cent of the total market volume; Liechtenstein included.
UKD ➢ Great Britain only. Data include sulphuric acid, which represents approx. 40% (1995) of the total.

AGRICULTURAL WATER USE

Data source: OECD

CAN ➢ Data for 1980, 1985, 1990 and 1995 refer to 1981, 1986, 1989 and 1991.
JPN ➢ Data for 1995 refers to 1994.
AUT ➢ Data for 1995 refers to 1993.
DNK ➢ Data for 1985 and 1990 refer to 1988 and 1991. Includes water use in fish farming.

FIN ➢ Data for 1980 and 1995 refer to 1985 and 1994.
FRA ➢ Data for 1995 refers to 1994. Includes all agriculture uses.
GRC ➢ Data refers to irrigation only.
ESP ➢ Data for 1990 refers to 1989. Data refers to irrigation only.
UKD ➢ England and Wales only.

MANUFACTURING

MANUFACTURING VALUE ADDED

- Manufacturing value added: calculated as the difference between production and intermediate inputs. Manufacturing industry includes all industries in the International Standard Industrial Classification (ISIC Rev. 3), Category D, groups 15-37; expressed at 1995 price levels and purchasing power parities.

NO_X EMISSIONS FROM MANUFACTURING INDUSTRY

Data sources: OECD

- NO_x Emissions from Industrial processes and industrial fuel combustion.

CAN ➢ Data for 1997 and 1998 are OECD Secretariat estimates.
NZ ➢ Industrial fuel combustion includes emission from power stations.
ITA ➢ Industrial processes include petroleum refining and solid fuel transformation.
ESP ➢ Industrial fuel combustion includes emissions from off-road machinery.
UKD ➢ Industrial processes include petroleum refining plants.

CO_2 EMISSIONS FROM ENERGY INTENSIVE INDUSTRIES

Data sources: IEA

- Energy intensive industries include food and beverages (ISIC 15), Pulp & paper (ISIC 21), Chemical (ISIC 24), Non metallic minerals (ISIC 26) and Basic metal (ISIC 27)

GENERATION OF MANUFACTURING WASTE

Data source: OECD

- Waste produce by the manufacturing industry, which comprises all industries in the International Standard Industrial Classification (ISIC Rev. 3), category D, groups 15-37.

JPN ➢ Data for 1995 and 1996 are OECD estimates.
KOR ➢ Data include ISIC 01-02, 10-14, 40 and 41.
FIN ➢ Data for 1998 refers to 1997.
HUN ➢ Data exclude hazardous waste; waste from privatised enterprises may not be fully covered. 1995 data refer to 1996.
ISL ➢ Mostly waste from slaughterhouses.
PRT ➢ Include only hazardous waste.
ITA ➢ Data for 1998 refers to 1997.
NLD ➢ Data for 1995 is an OECD estimate.
NOR ➢ Data for 1998 is an OECD estimate.

FRESHWATER ABSTRACTION BY MANUFACTURING INDUSTRY

Data source: OECD

FRA ➢ 1998 data refers to 1997.
UKD ➢ England and Wales only.