

POLLUTION PREVENTION AND CONTROL
ENVIRONMENTAL CRITERIA FOR SUSTAINABLE TRANSPORT

Report on Phase 1 of the Project on Environmentally Sustainable Transport (EST)

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

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FOREWORD

In 1992, the OECD Group on Pollution Prevention and Control (PPCG) was established to further a principal goal of the OECD Environment Ministers—accelerated reduction of environmental pollution in the OECD area and beyond. The Group has focused a key part of its work on the transport sector, where current pollution and emissions of gases that contribute to climate change, and projected future trends, especially intensification of road transport and rapidly growing air transport, pose difficult challenges. The PPCG organised a Task Force on Transport to study concepts and strategies for “environmentally sustainable transport” (EST). The present report, on environmental criteria which could be used in establishing and implementing EST strategies, is the first product of the Task Force’s EST project. It is based on a survey of current efforts and “best thinking” in Member countries on EST.

The discussion of environmental criteria for EST links global, regional, and local environmental protection objectives that could otherwise be expressed by hundreds of specific environmental or pollution parameters. Two basic assumptions are reflected in this work: (a) that strategies for EST, to be successful, require both a qualitative vision of EST and a set of specific environmental goals capable of being expressed (and progress measured) in quantitative terms; and (b) that the numerical goals must be relatively few in number, capturing critical environmental trends and values.

As suggested in the subtitle, this work represents “work in progress.” Use of the criteria is being tested in the subsequent phases of the EST project. The PPCG and the Task Force hope to stimulate wide discussion on this important topic, and welcome comment on the approach, the assumptions, and the specific criteria chosen.

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ENVIRONMENTAL CRITERIA FOR SUSTAINABLE TRANSPORT

SUMMARY

This is the report on Phase 1 of a study designed to examine the concept of environmentally sustainable transport (EST), to determine the kinds of actions that might be required to achieve EST, and to develop guidelines for the achievement of EST. It is also a stand-alone study concerned with characterising EST, based on a review presented here of programmes and plans of OECD Member countries relating to transport and environment. The review indicates great interest in concepts of sustainability and concern to develop effective approaches to address transport's currently unsustainable trends.

Several introductory sections discuss the notion of sustainable development and the unsustainable elements of today's transport systems. These sections and the review of Member country plans and programmes set the stage for elaboration of a brief qualitative definition of EST and a preliminary characterisation of EST in terms of six criteria for which quantitative goals and targets can be derived for the purpose of planning and moving towards more sustainable transport systems.

The brief *qualitative* definition of EST proposed here is this: Transportation that does not endanger public health or ecosystems and meets needs for access consistent with (a) use of renewable resources at below their rates of regeneration and (b) use of non-renewable resources at below the rates of development of renewable substitutes.

Three of the six *quantitative* criteria concern air quality; they are expressed in terms of emissions of nitrogen oxides, volatile organic compounds, and particulates. The other three concern, respectively, emissions of carbon dioxide from fossil fuels, the use of land for motorised transport, and noise.

The preliminary quantitative characterisation of EST presented here will be used in the construction of several EST scenarios for evaluation by participating countries during Phases 2 and 3 of the OECD study. Refinement of the criteria may well occur during the course of the study. Readers of this report are invited to provide both comment and supporting information.

1. INTRODUCTION

1.1. Origin of this report

The Environment Directorate of the OECD has addressed pollution and other issues posed by transportation for many years with an increasing focus on what might constitute “sustainable transportation” and on how it might be achieved. A recent review of the Directorate’s work in this area lists 16 major studies on the topic published since 1990.¹ In 1994, the Pollution Prevention and Control Group, on completion of a report entitled *Motor Vehicle Pollution: Reduction Strategies beyond 2010*,² established a Task Force on Transport and gave it the task of fostering accelerated reduction of the pollution burden imposed by the transport sector.

The OECD Secretariat convened an ad hoc Expert Group in December 1994 to prepare a proposal for further work on transport and environment. It proposed a four-part study as follows:

- Phase 1: Develop a definition of environmentally sustainable transport (EST), review the plans and programmes of Member countries concerning transport and environment, and review the best thinking in Member countries concerning EST and progress towards EST.
- Phase 2: Apply appropriate methodology, including backcasting,³ in order to estimate the amount of change required to attain EST, the means available to secure the change, and the strategic points of decision that would be involved.
- Phase 3: Conduct case studies at regional and local levels to test the results of the backcasting exercise.
- Phase 4: Refine and extend the definition of EST and set out options for policies and measures consistent with the achievement of EST.

The Task Force on Transport met in February 1995 and approved work on Phase 1, which was to be conducted both as a stand-alone study and as a prelude to subsequent phases of the kind proposed by the Expert Group. The Task Force felt that elaboration of what might be meant by *environmentally sustainable transport* could be of intrinsic value to researchers and policy-makers, as could the review of Member country programmes and plans. An informal workshop of the Task Force and the Expert Group was held in July 1995 to assist with the work, and a draft of the present report on Phase 1 of the project was considered at a meeting of the Task Force in November 1995.

¹ The superscript numbers point to 232 end notes that can be found on the last pages of the document. These end notes for the most part link the text to the 148 sources listed in Appendix 4. The sources comprise the 110 items of documentation submitted by governments and experts in the Member countries whose plans and programmes are reviewed in Section 4 —listed by country in Appendix 4—and 38 other items consulted during the course of this work.

At its November 1995 meeting, the Task Force also restructured Phases 2 and 3 of the study. Phase 2, being conducted during 1996, now comprises separate pilot studies conducted under the auspices of interested national governments. Each pilot study is to comprise two main phases: (i) development of three scenarios consistent with the characterisation of EST developed during Phase 1, as well as a business-as-usual scenario; and (ii) determination of the respective sets of instruments that might be required to achieve each scenario.

The three EST scenarios are to be (a) a technology-based scenario for which the criteria for EST would be met chiefly through advances in transport technology; (b) a capacity-constraint scenario for which the EST criteria would be met chiefly through reductions in the movement of people and goods; and (c) a combination scenario that meets the EST criteria through an optimum mix of technology and capacity constraint.

The three scenarios are to be developed for heuristic purposes only and are not necessarily to be considered as recommended or desirable. The extreme scenarios are to be considered on their own merits as well as to help identify issues of concern and facilitate development of the optimum combination. The determination of instruments is to be an iterative process of adjusting measures in the light of their impacts, which may involve formal modelling. Eight countries are involved in Phase 2: Austria, Canada, France, Germany, Netherlands, Norway, Sweden, and Switzerland.

1.2. Scope and purposes of the report

The present document is the report on Phase 1 of the study. The chief aims of the report are (i) to provide a very preliminary characterisation of EST for use during subsequent phases of the study, and (ii) to review the plans and programmes of contributing OECD Member countries relating to transport and the environment. We believe this is the first report to assemble such a range of “best thinking” about this important subject.

Sections 2 and 3 of the report provide a context for the review of the plans and programmes of 13 Member countries and the European Union that appears in Section 4, and for the development and elaboration of the brief definition of EST and the preliminary quantitative characterisation of EST in Sections 5 and 6. Some implications of the findings of Phase 1 are set out in Section 7.

The preliminary characterisation of EST is *not* an attempt to recommend goals, objectives, targets or standards to which Member or other countries should adhere. Rather, it is a first attempt to give some precision, through the use of criteria that have environmental significance and can be quantified, to a term—*environmentally sustainable transport*—that is used often in policy discourse but rarely defined. The characterisation seeks to demonstrate what an environmental framework for strategies to achieve EST might look like, and encompasses environmental issues that manifest their effects at very different geographic scales (global, regional, and local). This is an attempt to establish a basis upon which a wide and diverse range of policy-makers and economic actors can communicate and a framework within which goals, objectives, targets or standards could be set by governments and actions taken. Some goals may take a long time to achieve and the framework would accommodate interim standards and targets to guide the transition towards EST.

In its discussions of EST, the present report mostly does *not* take into account the technical or economic feasibility of attainment of any particular feature of what might be EST or the time frame for meeting specific goals. Such considerations would of course be important for establishing targets and

standards within any framework, and will be included in later phases of the project, but they are beyond the scope of the present report.

A basic assumption in initiating this work is that transportation as presently practised using current technologies is environmentally unsustainable. A brief account of trends that point to this unsustainability appears in Section 3. (If transportation were currently thought to be sustainable, there would be little need to address questions of sustainability.) What is not elaborated here are the social and economic benefits of transportation. The balancing of the benefits of transportation against its various costs is an important consideration in all countries; it is a premise of this work that better quantitative definitions of the environmental criteria to be met (or sought) will facilitate practical, meaningful analysis of the relative benefits, costs, and trade-offs associated with transportation.

Finally, this report focuses on the transportation of people and goods by road, which in 1990 was responsible for 82 per cent of final energy consumption for transportation in OECD countries (87 per cent in Japan; 83 per cent in Europe; 81 per cent in North America). Some attention is given to air transport, including a comparison of greenhouse gas emissions that appears in Appendix 2, but perhaps not enough to correspond to this mode's proportion of final energy for transportation in OECD countries: 13 per cent in 1990 and growing at a higher rate than for other modes.⁴ The characterisations of EST developed in Section 6 apply mainly to road transportation.

2. SUSTAINABLE DEVELOPMENT

2.1. Conceptual issues

Sustainable has become a fashionable word in the 1990s, a legacy of concern about the environment expressed during the 1970s and 1980s. As well as *sustainable development*—the term that made the word fashionable—our daily newspapers refer to sustainable architecture, sustainable diets, sustainable fisheries, sustainable food production, sustainable futures, sustainable communities, sustainable economic development, sustainable economic growth, sustainable policies, and even sustainable debt. *Sustainable* has come to mean *good*.

Part of the problem with *sustainable* is that it literally does mean *good*, at least in political discourse. One of the synonyms of *sustainable* is *supportable*, i.e., *arguable for without penalty*. But the originators of the term *sustainable development* had another meaning of *sustainable* in mind; it is *capable of being continued*. Thus *sustainable development* is *politically supportable development*, on the one hand, or *development that is capable of being continued*, on the other hand.

Further uncertainty arises from consideration of what might be *unsustainable*, i.e., what cannot be continued. If transportation trends are unsustainable (to anticipate later parts of this report) does this mean that the transportation trends cannot be continued or that society as we know it cannot continue if the transportation trends continue?

Development is also a slippery word (in English). It can mean both *progress* and *happening*. The former use has the connotation of movement to a better state; the latter use is less laden with value. A minimal, value-free meaning of *sustainable development* might be “activity that is capable of being continued.”

2.2. The Brundtland Commission’s definition

The term *sustainable development* was introduced in 1980, popularised in the 1987 report of the World Commission on Environment and Development (the Brundtland Commission), and given the status of a global mission by the United Nations Conference on Environment and Development (UNCED) that met in Rio de Janeiro in 1992.⁵

The Brundtland Commission defined *sustainable development* as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs.” The Commission noted that its definition contained two key concepts, *needs*, meaning “in particular the essential needs of the world’s poor,” and *limitations*, meaning “limitations imposed by the state of technology and social organisation on the environment’s ability to meet present and future needs.”⁶

The Brundtland Commission’s definition was thus not only about sustainability in the various senses of the term but also about equity, equity among present inhabitants of the planet and equity among generations. *Sustainable development* for the Brundtland Commission had environmental, social, and economic aspects, but remediation of current social and economic ills came first. The chief tools for the remediation were to be “more rapid economic growth in both industrial and developing countries, freer market access for the products of developing countries, lower interest rates, greater technology transfer, and significantly larger capital flows, both concessional and commercial.”⁷ Such growth was said to be compatible with recognised environmental constraints, but the extent of the compatibility was not explored.⁸

2.3. Environmental limits

The report of the Brundtland Commission nevertheless stimulated debate about the environmental impacts of industrialisation and about the legacy of present activities for coming generations. The report reactivated interest in what might be the physical or ecological limits to economic growth.⁹ Further definitions were proposed that gave priority to such limits. One business writer (Paul Hawken) suggested the following:

“The word sustainability can be defined in terms of carrying capacity of the ecosystem, and described with input-output models of energy and resource consumption. Sustainability is an economic state where the demands placed on the environment by people and commerce can be met without reducing the capacity of the environment to provide for future generations. It can also be expressed in the simple terms of an economic golden rule for the restorative economy: Leave the world better than you found it, take no more than you need, try not to harm life or the environment, make amends if you do.”¹⁰

The author of the above paragraph and others have drawn on the work of Herman Daly, formerly of the World Bank, in considering how the environmental limits might be characterised. Daly suggested that the limits on society’s material and energy throughputs might be set as follows:

1. The rates of use of renewable resources should not exceed their rates of regeneration.
2. The rates of use of non-renewable resources should not exceed the rates at which renewable substitutes are developed.
3. The rates of pollution emissions do not exceed the assimilative capacity of the environment.¹¹

2.4. Global, regional, and local sustainability

Sustainability—or unsustainability—must also be considered in terms of its geographic scope. Activity may be globally unsustainable; for example, it may result in climate change or depletion of the stratospheric ozone layer; several geographic regions, if not the whole world, would be affected. Activity may be regionally unsustainable, perhaps on account of the production and spread of tropospheric ozone or acidifying gases that kill vegetation and cause famine in one region but not in other parts of the world. Activity may be locally unsustainable, perhaps because it results in hazardous ambient levels of carbon monoxide or because the noise it produces makes habitation impossible.

In the long term, sustainability is more a global than a regional or local matter. If an environmental impact is beyond the carrying capacity of the planet then life as we know it is threatened. If it is beyond the carrying capacity of one area, then that area may become uninhabitable but life as we know it can most likely continue elsewhere.

2.5. The environmental component of sustainability

The focus of this discussion on physical limits does not deny social and economic aspects to sustainability. Life may not be worth sustaining under circumstances of extreme oppression or deprivation. Moreover, oppression or deprivation can interfere with efforts to make human activity environmentally benign. Nonetheless, if ecosystems are irreparably altered by human activity, then subsequent human existence may not become merely unpalatable, it may become impossible. Thus the environmental component of sustainability is essential.

The heterogeneity of environmental, social, and economic aspects of sustainability should also be recognised. Environmental and social considerations refer to *ends*, the former having perhaps more to do with the welfare of future generations and the latter with the welfare of present inhabitants of the planet. Economic considerations, often taken to refer to ends, can perhaps more helpfully be seen as referring to *means* to the various ends implied in the environmental and social considerations.

A focus on the environmental aspects of sustainability, particularly global environmental aspects, is often resisted by spokespeople for the world's poorer countries. They argue that such a preoccupation ignores countries' real needs to eliminate poverty and that it may be associated with plans to prevent development in general and industrialisation in particular. The reality is that the poorer half of the world's human population has contributed relatively little to the degradation of the global and regional environments.¹² Of the remaining two to three billion people whose activities do contribute to the degradation of the global and regional environments, the several hundred millions who live in OECD Member countries contribute a disproportionately large share. They are also the people who can collectively more afford the luxury of thinking about the future. Thus a focus within the OECD on the environmental aspects of sustainability may be viewed as appropriate.

3. UNSUSTAINABLE TRANSPORT

This section sets the scene for a consideration of what might be sustainable transport by providing some illustration of those aspects of present transport practices that are unsustainable. Logically, the development of a definition of sustainable transport should be presented first, for unless there is some understanding of what constitutes sustainable transport, there can be no certainty that a particular practice or trend constitutes unsustainable transportation. On the other hand, without a sense that present transport practices are unsustainable, there is no good reason to expend the effort to consider and achieve sustainability.

Generally, it can be argued that if an activity appears not to meet one or more of Herman Daly's three conditions set out in Section 2.3 above, and especially if the trend in occurrence of the activity is away from meeting one or more of the conditions, then the activity is probably unsustainable. In this section, present-day transportation activity is examined briefly in terms of the second and third of Daly's conditions. (The first condition does not seem to be so much at issue for transportation impacts although it is not of negligible importance.)

3.1. Resource use

Present-day transportation systems require a remarkable array of inputs—concrete and steel for infrastructure, plastics and ferrous and non-ferrous metals for vehicles—but the resource impact of major concern is use of fossil fuels, which are inherently non-renewable, particularly oil.

Worldwide, the transport sector accounts for more than 60 per cent of oil products, which constitute about 98 per cent of transport energy use. The latter percentage has increased from 92 per cent in 1960 in spite of efforts by many governments to encourage substitution of other fuels, both non-renewable and renewable. In OECD countries, road vehicles are responsible for more than 80 per cent of oil use for transportation. Most of the remainder is used by air transport. Railways and shipping consume no more than five per cent.¹³

The only major substitution of transport fuels in recent times has involved the **substitution of diesel fuel for gasoline**, a result of the greater use of diesel-fuelled light-duty goods and passenger vehicles. In OECD countries, this raised the share of diesel fuel from 16 per cent in 1973 (primarily heavy-duty vehicle use) to 27 per cent in 1991. (The 1991 share of diesel fuel for the European Union was 43 per cent; for both the United States and Canada it was 17 per cent.)¹⁴

After falling in the early 1980s, **world oil use is rising** again, largely on account of industrialisation in non-OECD countries and transport uses everywhere. In OECD countries, non-transport use of oil is declining but use for transport is increasing at a rate of about two per cent a year, resulting in an overall increase in oil use of just under one per cent a year. In non-OECD countries, oil use is increasing overall at three to four times the rate in OECD countries.¹⁵

Authoritative sources suggest that there are proved reserves of oil sufficient to last 35-50 years at present rates of extraction. This does not necessarily mean that available oil will be exhausted in 35-50 years. Since 1960 the identification of proved reserves has generally kept pace with extraction, meaning that the time horizon of available oil has been within the range of 35-50 years for several decades.¹⁶ Moreover, should what are now regarded as recoverable reserves become exhausted, other reserves will be made available, albeit at a higher cost of extraction. One can also argue that as the resource becomes more

scarce, prices should increase, thus encouraging more cautious use of the resource and development of new technologies.

Notwithstanding the present apparent inexhaustible supply of oil, some (but not all) members of the Task Force have identified resource depletion as the most significant aspect of the unsustainability of transportation. This is on the grounds that an intrinsically non-renewable resource is being depleted more quickly than renewable substitutes are being developed and, to quote a Task Force member, “supply problems will inflict crises earlier and more violently.” There is also a **security** issue for OECD countries whose transportation systems rely almost entirely on a resource that for the most part has to be imported from elsewhere, often from places characterised by a high degree of political volatility; about two thirds of the world’s proved oil reserves are in the Persian Gulf area.

3.2. Pollution resulting from fossil fuel use in motor vehicles

General considerations

Throughout history, improvements in transportation systems have aided economic growth, and efficient transportation continues to be a key ingredient in the overall standard of living in OECD Member countries. However, as transportation systems have expanded, there have been many adverse impacts. The purpose of this section and the next is not to deny the benefits of transportation as such but to note issues that strategies for environmentally sustainable transport might have to address. Many of these issues differ in significance from area to area.

Pollution is defined very broadly in national statutes. Generally, the word is used to characterise activity that results in there being “too much of the wrong substance in the wrong place” or to characterise the “wrong substance” itself. There is some subjectivity as to what constitutes pollution, although there is little doubt that activity resulting in accumulations of material sufficient to cause disease in plants or animals, directly or indirectly, or to affect atmospheric and climatic balance, in present or subsequent generations, should be regarded as pollution. The “wrong substances” are more usually known as *pollutants*. Several comprehensive lists of pollutants have been developed, such as the inventory maintained by the World Health Organisation.

The effects of releasing various substances vary widely in nature, duration, and geographic scale. The discussion below, which focuses on the effects of fossil fuel use in motor vehicles, distinguishes these effects at the global, regional, and local levels.

Motor vehicle emissions into the air are a significant class of pollutants. They are mostly complex and comprise several hundred compounds that reside in the atmosphere as gases, aerosols or particles. Many of these compounds are transformed after emission into secondary (or indirectly emitted) pollutants—including tropospheric ozone (photochemical smog), acid aerosols, and carcinogenic hydrocarbons—that are sometimes more harmful than their directly emitted precursors. Air pollutants emitted by motor vehicles include carbon monoxide (CO), carbon dioxide (CO₂), sulphur oxides (SO_x), suspended particulate matter (SPM), nitrogen oxides (NO_x), and numerous gaseous organic carbon compounds—chiefly hydrocarbons (HC)—referred to collectively as volatile organic compounds (VOCs). The presence of several highly reactive species makes VOCs, acting with NO_x, the major motor-vehicle-related precursors of tropospheric ozone (O₃).

Progress in reducing levels of some types of air pollution has been made in most OECD countries, but air pollution continues to receive much attention from policy makers. This is due primarily

to the persistence of certain familiar problems, including high levels of SPM and photochemical smog (i.e., high tropospheric ozone concentrations) in and near urban areas, and the emergence of several longer-term issues. These longer-term issues include increasing background concentrations of tropospheric ozone, the interactions of tropospheric ozone with climate change and acid deposition, and road transport's growing share (currently around 20 per cent in OECD countries) of fossil-fuel-related emissions of CO₂, which is the major anthropogenic contributor to global climate change.

In areas of high concentration, particularly in cities, motor vehicle emissions pose direct risks to human health. Health effects linked to emissions from mobile sources include aggravated respiratory symptoms and increased cancer morbidity and mortality associated with exposure to 1,3-butadiene, benzene, polynuclear aromatic hydrocarbons (PAHs), and other carcinogens arising for the most part from incomplete fuel combustion. Emissions from gasoline and diesel fuel contain mutagenic or carcinogenic substances in particulate and gaseous form; many individual VOCs in these emissions are known or suspected to have direct toxic effects on humans, including carcinogenic and neurotoxic effects. Other harmful substances linked to motor vehicle emissions, including lead and persistent halogenated organic compounds, reach humans through several pathways, notably direct inhalation, inhalation of re-suspended dust, and ingestion of dust deposited on food items.

The major health and environmental effects of the principal motor-vehicle related air pollutants are noted in Table 1 on Page 16, as well as their sources and exceedances of national and international guidelines.

Usually these pollutants are present in amounts exceeding current air quality guideline values and national standards only in and near urban areas; but they are nevertheless also responsible for several forms of environmental degradation at regional and global levels. Environmental damage linked to motor vehicle emissions ranges from negative aesthetic effects and damage to crops and materials to more profound disruption of regional ecosystems and aggravation of global environmental problems such as greenhouse gas accumulation. As emissions have increased long-range migration of pollution originating in urban areas has resulted in the extension of many environmental problems to the regional level. Consequently, lakes and streams and even remote forests have experienced significant degradation. As evidence of human impacts on the upper atmosphere accumulates, concerns are growing that motor vehicle use contributes to global changes that could alter the climate of the planet. Thus, motor vehicle emissions are associated with virtually all of the major air pollution problems at the global, regional, and local scales.

Global Effects

The recent Second Assessment Report of the United Nations Intergovernmental Panel on Climate Change (IPCC) has reactivated interest in the global impacts of fossil fuel use. It states that "the atmospheric concentrations of the greenhouse gases [such as] carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O) have grown significantly since pre-industrial times ... [and] these trends can be attributed largely to human activities, mostly fossil fuel use, land-use change and agriculture The balance of evidence ... suggests a discernible human influence on global climate."¹⁷

Table 1. Sources, impacts, and exceedances of the principal motor-vehicle-related air pollutants.¹⁸

Pollutant	Type of impact						Source of emission	Health effects of pollutant	Exceedances of ambient air quality guidelines
	Regional			Global					
	Local	Acidification	Photochemical oxidants	Indirect Greenhouse Effect	Direct Greenhouse Effect	Stratospheric Ozone Depletion			
Suspended particulate matter (SPM)	X		X				Products of incomplete combustion of fuels; also from wear of brakes and tires	Irritates mucous membranes; increased respiratory symptoms, pulmonary effects; carcinogenic	WHO guidelines are exceeded by up to more than a factor of two in 17 of 21 cities considered in one survey; in another, the guidelines were exceeded in 20 of 37 cities, with only 5 cities having concentrations within both annual and daily guidelines; the US EPA has designated 82 in 1994 areas as non-attainment areas.
Lead (Pb)	X						Added to gasoline to enhance engine performance	Affects circulatory, reproductive, and nervous systems	People in about one third of the world's cities are exposed to levels above WHO guidelines.
Carbon monoxide (CO)	X		X	X			Incomplete combustion product of carbon-based fuels	Reduced oxygen-carrying capacity of red blood cells	Short-term WHO guideline values are often exceeded in many urban areas in Europe and in southern California; in the USA, the EPA designated 36 regions as non-attainment areas for CO in 1994, with Los Angeles being classified as serious.
Nitrogen oxides (NO _x)	X	X	X	X		X	Formation from fuel combustion at high temperatures	Irritates lungs; increases susceptibility to viruses	Major cities and metropolitan areas in Europe, the USA, and Japan continue to experience high episodic values exceeding applicable standards; concentrations exceeding WHO guidelines by a factor of 2-4 have been measured in some non-OECD megacities.
Volatile organic compounds (VOCs)	X		X	X			Combustion of petroleum products; also evaporation of unburnt fuel	Irritates eyes, causes intoxication; carcinogenic	Emissions and exceedances vary according to the compound. Acceptable emission levels for carcinogens may be zero, as in the case of two of the most important VOCs, 1,3-butadiene and benzene, which respectively account for 32 and 5 per cent of US cancer cases related to air pollution and of which transport is responsible for 94 and 85 per cent of all emissions.
Tropospheric ozone (O ₃)		X	X	X			Not exhaust gas; product of photochemical reaction of NO _x and VOCs in the presence of sunlight	Irritates mucous membranes of respiratory system; impairs immunities	WHO guidelines for short- and long-term exposure are frequently exceeded in large areas of OECD Europe, North America, and Japan; the US EPA has designated 77 areas as non-attainment areas in 1994.
Methane (CH ₄)					X		Leakage during production, transport, filling and use of natural gas		
Carbon dioxide (CO ₂)					X		Combustion product of carbon-based fuels		
Nitrous oxide (N ₂ O)					X	X	Combustion product of fuel and biomass; also formed in catalytic converters		
Chlorofluorocarbons (CFCs)				X	X	X	Leakage of coolant from air conditioning systems		

The combustion of fossil fuel produces carbon dioxide, a gas that in the atmosphere traps the sun's heat causing an increase in the planet's surface temperature. Other radiatively active gases can be produced during combustion of fossil fuels, but the greatest potential impact is believed to arise from atmospheric accumulation of carbon dioxide.¹⁹

Carbon dioxide is an input or an output of the metabolism of plants and animals, and is regularly recycled through the biosphere, atmosphere, and oceans in a complex system that appears set to maintain the surface temperature of the Earth at about +15°C (instead of the average of -15°C that would prevail without the atmosphere). The burning of large amounts of carbon stored in fossilised plants can load the atmosphere beyond the assimilative capacity of the system. Atmospheric levels of the gas have been increasing for about a century, roughly in step with the increased fossil fuel use associated with industrialisation and with the growth in motorisation of transport. The elevation in mean surface temperature over this period may now be attributable in part to the raised atmospheric CO₂ concentrations. The effects of continued climate change will include raised sea levels, expansion of deserts, spread of vector-borne diseases, and widespread destruction of plants, animals, and ecosystems unable to adapt to changes in temperature and other aspects of climate. Developing countries are particularly at risk. There may be beneficial effects in some parts of the world, included expanded food production.

The close link between fossil fuel use and CO₂ emissions means that worldwide success in improving the energy efficiency of industrial and other operations during the last few decades might have reduced accumulated CO₂ emissions. The conspicuous exception is the transport sector, where increases in vehicle-kilometres travelled have mostly offset improvements in efficiency. Indeed, in many countries there have been no overall improvements in efficiency, in large part because new vehicles have become larger and more powerful. Between 1973 and 1988, carbon dioxide emissions from transportation increased by 30 per cent worldwide to 773 million tonnes; CO₂ emissions from other human activities fell overall by about two per cent to 1,969 million tonnes.²⁰ (During the same 15 years, the world's human population increased by about 35 per cent.²¹) In OECD countries the differences are starker. In the U.K., for example, the percentage changes in CO₂ emissions resulting from activity in various sectors between 1970 and 1990 were as follows: overall, -12; households, -24; industry, -34; commerce/public sector, +20; transportation, +65. The proportion of total CO₂ emissions contributed by transportation increased from 13 to 24 per cent during the same period.²²

Emissions of NO_x, VOCs, and CO from motor vehicles also contribute to increasing tropospheric ozone, another important greenhouse gas. Ozone in the "free" troposphere above the boundary layer (beyond 1500 metres) is steadily increasing on a global scale. Background levels have doubled over the past 100 years: global monitoring programmes have revealed that long-term ozone concentrations near the Earth's surface are increasing by about 1-2 per cent per year, and by 2-3 per cent per year in the higher troposphere of the western hemisphere.

Effects of motor-vehicle related air pollution on the global scale include atmospheric accumulation of persistent pollutants. Unlike emissions of conventional pollutants—which, although emitted in very large quantities, have a comparatively brief stay in the atmosphere—persistent pollutants are not reduced or removed from the atmosphere through chemical reactions or other means; they can remain in the environment for several hundred years or more. Because of this durability, even persistent pollutants emitted in very small annual amounts can reach harmful ambient levels across several years. Such pollutants can be widely dispersed, affecting the environment on a global scale. Chlorofluorocarbons (CFCs) are among the more familiar motor-vehicle-related persistent pollutants. The CFCs emitted during the 1990s will continue to damage the ozone layer for 200 or more years. In addition to CFCs, which are discussed further below, motor vehicle emissions of certain heavy metals and organo-metals associated with particulate matter—notably lead and cadmium—PAHs, and organochlorine compounds from fuel

additives (e.g. dichloroethylene and dioxins) all remain in the environment for long periods and pose increasingly serious health hazards as they accumulate.

Regional Effects

The combustion of fossil fuels has regional effects that result chiefly from the production of eutrophication, acidifying, and oxidising gases (chiefly nitrogen oxides, sulphur oxides, and ozone) that are transported within the troposphere, often across national boundaries, and damage plants, animals, and ecosystems. The large-scale formation of photochemical oxidants from the precursor emissions, NO_x, VOCs, and CO, together with secondarily formed acidic aerosols, causes damage to forest ecosystems, impairs the growth of certain crops, and contributes to acid deposition.

The most pervasive air pollution problem in areas with temperate climates is tropospheric ozone, a photochemical oxidant resulting from the reaction of nitrogen oxides and VOCs in the presence of sunlight. Tropospheric ozone is the primary component of photochemical smog, and at ground level, or at low (tropospheric) levels in the atmosphere, is a harmful irritant. Many individuals exposed to tropospheric ozone suffer eye irritation, cough and chest discomfort, headaches, upper respiratory illness, increased asthma attacks, and reduced pulmonary function. Numerous studies have demonstrated that photochemical pollutants inflict damage on forest ecosystems and seriously impact the growth of many crops, causing annual losses of several billion U.S. dollars. Meeting WHO air quality guidelines for ozone would call for a large reduction of present and future motor vehicle emissions of NO_x, VOCs, and CO.

Emissions of sulphur and nitrogen compounds, their chemical transformation, atmospheric transport, and deposition are the causes of acid deposition. NO_x emissions play a major role in the formation of acids and in acid deposition. Motor vehicle emissions are responsible for about 25 per cent of total acid deposition in Western Europe. Furthermore, photochemical oxidants may play a key role in the conversion of sulphur and nitrogen oxides into acids; thus motor-vehicle HC and NO_x emissions also contribute to the acidification problem. NO_x emissions contribute approximately one third of the acidity in rainfall, and even higher shares in the cases of acid fog and snowfall. Increased nitrogen depositions due to the release of large amounts of NO_x into the atmosphere have been found to disrupt the nutrient balance in ecosystems, and are thus significant contributors to forest dieback in Europe.

Local Effects

The local effects of fossil fuel use are similar to the regional effects, but are generally more intense and more notably include the effects of carbon monoxide and combustion-produced airborne particulate matter. Transportation accounts for nearly 90 per cent of emissions of CO, which is produced during incomplete combustion of fossil fuels and is poisonous to humans and other animals in low concentrations.²³ Particulates, particularly those of small diameter, are implicated in lung and other diseases, with diesel engines being the most important sources.²⁴

In addition to producing large quantities of CO, NO_x, SPM, and CO₂, motor vehicles are also an important source of other air pollutants that are emitted in considerably smaller amounts, but present increasing health and ecological concerns. Toxic air pollutants include individual VOCs, including benzene, 1,3-butadiene, formaldehyde, acetaldehyde, PAHs, and some organo-metals associated with particulate matter. Emissions of VOCs, as well as many other toxic air pollutants emitted by motor vehicles, such as lead, sulphate particulate matter, aromatics, and certain halogenated organics (e.g. dichloroethylene and dioxins), are largely related to fuel composition or fuel additives, and result from incomplete combustion. An important fraction of overall motor-vehicle related hazardous emissions of

VOCs is contributed through evaporative losses during fuel distribution, storage, transfer, and refuelling of vehicles, as well as from running losses during vehicle use.

Numerous studies in OECD Europe and North America have found that in individual metropolitan areas, mobile sources are one of the most important and possibly *the* most important contributor to health risks associated with toxic air pollutants.

3.3. Other potentially unsustainable effects of transportation

Motorised transportation results in several harmful emissions that are not directly related to the use of fossil fuels in internal combustion engines. These include emissions into air and water arising from the manufacture and disposal of vehicles and infrastructure—for example, those from the production and recycling of lead and other batteries and from the production of cement for roads and bridges. They also include emissions related to the recovery, processing, and distribution of fuels, emissions from the fuels themselves (e.g. evaporative losses) and other emissions from use of vehicles including dust and particulate matter from brake linings and tyres. Several of the just-noted emissions include the same pollutants as those emitted during the operation of motorised vehicles with internal combustion engines (e.g. CO₂, NO_x, etc.). Some of these pollutants are carcinogenic, and others have particular toxic effects (e.g. lead).

Another example of such emissions is the use of **chlorofluorocarbons (CFCs)** as the coolant in vehicle air-conditioning systems. CFCs deplete the stratospheric ozone layer, causing life-damaging increases in the amount of ultraviolet radiation reaching the planet's surface, and are strongly radiatively active (although their contribution to potential global warming is reduced because ozone is also radiatively active). About half of the vehicles produced in the world are equipped with air conditioning (more than 80 per cent in North America).²⁵ Vehicle air conditioners brought into service in OECD countries since 1993 mostly make use of a hydrofluorocarbon (HFC) rather than a CFC. HFCs do not appear to deplete the ozone layer, but air conditioners equipped with HFCs are less efficient, and thus more vehicle fuel is required to operate them; consequently, more combustion-related compounds are emitted.

Vehicle air conditioning systems produced before 1993 continue to use substantial amounts of CFC-12. The cost of CFC-12 has increased by a factor of about ten during the last few years on account of taxes and shortages (by international agreement, CFCs are no longer produced in OECD countries). The cost increase, together with regulations concerning the handling of CFCs, have reduced the amounts of CFCs vented into the atmosphere. Non-OECD countries are exempt from the production ban until 2006. A black market in CFCs based on illegal imports has already emerged, weakening the impact of the ban in OECD countries and causing legislators in the United States to question its value.²⁶

Yet other effects of motorised transportation include noise, urban sprawl, congestion, and interference with natural drainage through paving of roads and parking lots. Transportation has been identified as the main cause of **environmental noise**. In OECD countries, 16 per cent of the population is exposed to noise levels from transportation capable of severely disturbing sleep and communication, and thereby contributing to disease; an additional 50 per cent is exposed to “unsatisfactory” noise levels from transportation.²⁷ In Europe in particular, transport noise is often felt to be more of a concern than transport-related air pollution.

Transport is a major **consumer of land**. For example, five per cent of the total land area of the former West Germany is estimated to be used for transport routes; a further, unstated proportion is devoted to off-route transport purposes such as parking, manufacturing, and maintenance facilities.²⁸ Outside urban

areas, transport infrastructure can break up or destroy natural habitats and adversely affect ecological balances. Within urban areas, higher proportions of land area are devoted to transportation. Various imprecise estimates have been made as to the actual proportions. The range most often cited is that 25-35 per cent of the land is devoted to streets in modern cities, compared with less than 10 per cent in cities designed before the advent of motorised transport.²⁹ These proportions do not include land used for auxiliary transport purposes such as parking, which can raise the proportion of land paved for transportation purposes to very high levels; in Los Angeles and Indianapolis, more than 65 per cent of the land is said to be so paved, in Toronto it is more than 40 per cent.³⁰ An adverse environmental impact of such paving is the typically increased flushing of pollutants into water courses, rather than their slow dispersal within natural drainage systems.³¹

As well as adverse environmental impacts, the devotion of large areas of land to motorised transport can reduce the liveability of cities. In rural areas, the introduction of major roads—as well as harming ecosystems—can diminish the quality of life of nearby residents.

Urban sprawl is made possible by motorised transportation and creates further demand for it, thereby magnifying its adverse effects. It often consumes good agricultural land; for example, in the Toronto region between 1966 and 1986, 33,000 hectares of rural land at the edge of the urban area, almost all prime agricultural land, were converted to urban use.³² Such conversion increases demand for agricultural produce shipped from afar, and thus creates further demand for transportation.

Sprawl is mostly associated with low-density development of land that in turn is associated with high rates of automobile ownership and use. For example, in the Toronto region's central area, where residential densities average 7,340 persons per square kilometre, 49 per cent of households own a car, the average distance travelled by car is 7.5 kilometres a day, and emissions of CO₂ per person on account of travel within the region average 1,710 grams a day. In the outer suburbs of the Toronto region, where residential densities in the urbanised areas average 1,830 per km², 96 per cent of households own one or more cars, average daily distance travelled by car is 25.6 kilometres, and CO₂ emissions from travel within the region average 5,200 grams per person per day.³³ Sprawl can also have adverse economic impacts in that low-density development is generally more costly to service.³⁴

Congestion magnifies the adverse effects of transportation by causing vehicles to function at sub-optimal speeds and thus use more fuel and pollute more. It has economic impacts in that it raises the cost of goods delivery by road and impedes productive human activity. However, simply expanding road networks to reduce congestion can have the counter-productive effect of increasing the volume of traffic with potentially offsetting or, in some cases, even more severe environmental consequences. On the other hand, congestion may deter automobile use and thus be an impetus to public transport use that may be more environmentally benign; but it can delay buses as well.

Accidents involving road vehicles are not always considered to be an environmental issue but they can nevertheless contribute to the unsustainability of transportation. They are a major component of accidental deaths: some 40 per cent of the total in the U.K. in 1992.³⁵ Road-vehicle accident rates vary from country to country but have generally declined over the past two decades with improvements in the design of vehicles. The effects of the design improvements have, however, been offset by increased vehicle use and possible increased risk-taking by drivers.³⁶ Some road safety measures have segregated transport modes in a manner that has discouraged pedestrians and bicyclists, particularly children. In the U.K., the proportion of children between 7 and 11 years of age taken to school by car increased from one to 30 per cent between 1965 and 1990, the main reason for the change being concerns about danger from traffic.³⁷ Similar observations have been made in the Netherlands, where the average age of children riding bicycles in the streets has risen by two years in the last two decades.

Finally, although the environmental aspects of sustainability are being emphasised here, a comment might be made about the possible social and economic unsustainability of present transportation systems. As societies move towards increased dependence on the private automobile as the main method of transport (see Section 3.4), they become increasingly structured, physically and culturally, around the automobile, thereby marginalising a large minority that has little or no access to this method of transportation. This minority includes many elderly, young, poor, and handicapped people. Such marginalisation is a challenge in terms of addressing opportunities for the affected individuals and also in terms of the coherence and functioning of society.

Transportation is mostly a means to an end rather than an end in itself. Among the ways of providing for this means in a society, the method involving provision of personal automobiles for most adults may be among the most expensive. Moreover, the costs of urban sprawl and congestion have already been noted. Transportation systems that rely on personal vehicle transport can also result in disproportionately adverse economic effects on lower-income citizens: with no alternatives available, lower-income citizens need to own and operate personal vehicles to meet their transportation needs at great relative cost. Moreover, they tend to operate older vehicles in poorer states of tune, increasing the amount of relatively high emitting traffic and perhaps prolonging the operating life of high-emitting vehicles.

3.4. Trends

Movement of people and goods is increasing, particularly movement by road and air, which are generally the most energy-intensive and polluting modes (see Appendix 2). Throughout the world, most of the trips that people make in their everyday business are likely still by foot or bicycle and are, in consequence, presumably sustainable (relevant data are few).³⁸ **Among the less than 20 per cent of the world's population that lives in OECD countries, by far the predominant means of travel is the personal automobile**, which accounts for about 80 per cent of person-kilometres in the U.S.A., 70 per cent in several countries in Europe, and 50 per cent in Japan.³⁹ (The proportion of trips made by personal automobile is lower—as opposed to proportion of distance travelled—but is nevertheless greater than 50 per cent in several European countries⁴⁰ and well above 50 per cent in North America.) These proportions have changed a little in favour of automobile use during the past 20 years, but the amount of travel overall, and therefore the amount travelled by personal automobile, has increased substantially.

Travel by personal automobile is becoming the preferred mode in non-OECD countries. For example, percentage increases in the numbers of passenger cars in use in selected countries in the 1970s and 1980s were as follows: Brazil, 250 and 40; India, 65 and 180; South Korea, 350 and 680, Thailand, 100 and 200.⁴¹

In freight transportation, the shift during the 1970s and 1980s towards road-based, motorised means (i.e., van, trucks or lorries) was much stronger, although the overall rate of growth in tonne-kilometres has been a little lower than the rate of growth in passenger-kilometres.⁴² For example, in 1970 in western Europe, 51 per cent of freight went by road; in 1990 it was 70 per cent (both on a tonne-kilometre basis).⁴³ The proportion of vehicles on the road that are freight vehicles varies greatly from country to country within the OECD; some 1991 percentages were: Japan, 41; U.S.A., 29; France, 20; Germany (west), 10; and Sweden, 8.

In OECD countries, the mode of transport showing the largest relative increases has been **transport by air, both passengers and freight**. For example, the number of passenger-kilometres travelled by aircraft on domestic and international trips originating in the U.S.A. increased by 260 per cent between 1970 and 1990,⁴⁴ while the number travelled by personal automobile increased by less than 40 per

cent,⁴⁵ although in the latter year there were still seven times as many passenger-kilometres by automobile as by air.⁴⁶ The corresponding increase in tonne-kilometres of air freight was lower—220 per cent—but of the same order.

Although air transport remains a small proportion of kilometres travelled, its potential for further growth, and its potential impact on the environment, mean that it should not be ignored. For example, available data, elaborated here in Appendix 2, suggest that the contribution per person-kilometre of air travel to CO₂ is about three times that of travel by personal automobile; the contribution per tonne-kilometre of air freight is about seven times that of freight moved by a 40-tonne truck. Thus air transport may have more intense global effects on the atmosphere than road transport on a per passenger-kilometre or tonne kilometre basis; its local effects on air quality, on the same comparative basis, are likely less intense.

In summary, movement of people and goods by road has become the preferred mode and continues to increase, although movement of people and goods by air has increased at a much higher rate.

3.5. Outlook

Projections of road vehicle numbers and use have been made recently for the OECD.⁴⁷ The projections assumed a continuation of present trends, taking into account likely changes in emission control systems, fuel type, quality, fuel efficiency improvements and modal shift; they were made for 2000, 2010, 2020 and 2030. The projected percentage increases from 1990 to 2030 are shown in Table 2 for both light-duty vehicles (those chiefly used for passenger transport: cars, motorcycles) and heavy-duty vehicles (those chiefly used for freight transport: heavy trucks).

Table 2. Projected percentage increases in transportation indicators, 1990-2030, for OECD and other countries.⁴⁸

	Light vehicles	Heavy vehicles	All vehicles
OECD countries			
Number of vehicles	73	94	74
Kilometres travelled	76	100	79
Weight of fuel used	-8	97	18
Non-OECD countries			
Number of vehicles	305	300	305
Kilometres travelled	318	288	312
Weight of fuel used	136	289	206
All countries			
Number of vehicles	137	190	140
Kilometres travelled	137	192	144
Weight of fuel used	25	181	73

According to these conservatively estimated projections, every aspect of vehicle and fuel use is expected to increase except fuel use by light-duty vehicles in OECD countries. Worldwide, the number of vehicles and the distance travelled by road will more than double; fuel use will increase by more than 70 per cent. For every measure, the relative increases are very much greater for non-OECD countries than for OECD countries. In 1990, non-OECD countries accounted for less than 30 per cent of each of vehicles, vehicle-kilometres, and fuel use. In 2030, according to the projections, they will account for approximately 50 per cent of each measure.⁴⁹

Work done for the German government indicates that, for that country since 1950, estimates of growth in the passenger car population have consistently been exceeded;⁵⁰ similar conclusions might be drawn for many other countries.

3.6. Conclusion

Transportation constitutes the major use of a non-renewable natural resource, oil, for which renewable substitutes are not being developed at a commensurate rate. In several respects, perhaps most persistently in terms of raised levels of atmospheric carbon dioxide, transportation results in emissions that appear to exceed the assimilative capacity of the environment. Moreover, present trends are for transportation activity to increase and, consequently, for the impacts of transportation to worsen unless measures are adopted that more than offset these trends.

4. REVIEW OF PLANS AND PROGRAMMES OF MEMBER COUNTRIES

4.1. Basis for the country reviews

The review of plans and programmes of Member countries with respect to transportation and the environment was requested to provide the Task Force with what might be intrinsically valuable information and also to provide input into work on EST. Members of the Task Force were asked to provide the OECD secretariat with the following:

1. Comprehensive information about your country's current and proposed transport and environment strategies or action plans, initiatives, and measures that involve environmental criteria in transport policies. This includes regulatory actions regarding transport and land-use planning related to environmental goals (e.g. urban air quality, CO₂, noise, congestion, etc.). Also needed are studies on the mix of policy instruments and measures that can be used for meeting these goals.
2. Details of the best thinking about environmentally sustainable transportation in your country, including the work of government, industry, academic, and other sources.

Fourteen responses from Member countries and the European Union were received. They are summarised in Sections 4.3 to 4.16, inclusive. The Member countries represented were Austria, Canada, Denmark, Finland, France, Germany, Japan, the Netherlands, Norway, Switzerland, Sweden, the United Kingdom, and the United States. Appendix 4 lists by country the documents reviewed in connection with the study.

In compiling the reviews in Sections 4.3 to 4.16, four questions were asked about each set of material:

Measures and plans: To what extent does the material provide comprehensive information about current and proposed plans and measures concerning transportation and the environment, with some reference to the use of mixes of policy instruments?

Goals for air emissions: To what extent does the material set out goals concerning transportation-related emissions responsible for atmospheric accumulation of CO₂, carbon monoxide, NO_x, ozone, VOCs, and particulates?

Other goals: To what extent does the material set out goals pertaining to other matters of environmental relevance and concern, including noise, impacts on land and water, and the management of potential waste during production of vehicles and fuels and at the end of vehicle life?

Best thinking about EST: How does the material portray the “best thinking” about EST in the respective country?

4.2. Overview of responses

The review of the responses of Member countries leaves several impressions. The most powerful is the serious commitment within Member countries to change present practices concerning transportation, and the growing awareness of the need for environmental sustainability. No country has yet defined EST, but there is evidently much grappling with issues of sustainable development in general and sustainable transportation in particular. The most common approach of the last four decades has been for governments to meet what has turned out to be an inexorable demand for more road transportation. This approach is clearly no longer affordable or even popular, but exactly what is replacing it is unclear.

Some parts of Member countries' plans are represented in Table 3, which concerns reduction targets for transportation-related air emissions. What is apparent from the table is that more countries appear to have target for reduction—or at least stabilisation—of CO₂ levels than have targets for reduction of NO_x and VOCs. However, the targets for reduction of CO₂ levels are much more modest than those for the other compounds; and there are frequent references in the country material to the difficulty in achieving even these more modest targets. Another feature of Table 3 is the lack of consistency among Member countries in their long-term targets, in both target values and target years. One of the outcomes of the present work may be to provide a technical basis for the adoption of common long-term targets consistent with sustainability.

Many of the aspects of the plans of Member countries are not represented in Table 3. One notable exception concerns targets for vehicle performance, such as the EURO2 and California requirements. Also missing is information about targets concerning emissions other than those indicated, e.g. targets concerning particulates and sulphur dioxide, and targets concerning other impacts of transportation such as noise, waste, and accidents. No country has a target concerning land use.

Inasmuch as this preliminary attempt to portray the plans and programmes of Member countries is useful, an annual review by OECD might be of continuing value, especially if it monitored progress towards EST according to a characterisation accepted by Member countries.

4.3. Austria

Overview

The Austrian submission consists primarily of the nation's first long-term, comprehensive National Environment Plan (NUP), a 324-page document released by the Ministry of the Environment in 1995 that outlines currently legislated environmental standards as well as actions recommended for the transportation and other environmentally relevant sectors. The NUP has the status of an ecological guideline for the policies of the Austrian Government as decided by the Council of Ministers and contains an extensive chapter dealing with transportation measures to be planned and implemented over the coming five to ten years; it is to be updated every four years.⁵¹ The NUP addresses sustainability concepts explicitly and incorporates such general concepts into a definition applicable to the transportation sector.⁵²

Table 3. Reduction targets for atmospheric levels of air emissions pertinent to the transport sector.

OECD Member ^a	CO ₂			VOCs			NO _x		
	Base Year	Target Year	Reduction Goal ^b	Base Year	Target Year	Reduction Goal ^c	Base Year	Target Year	Reduction Goal ^d
Austria	1988	2005	20%	1988	2006	70%	1985	2006	70%
Canada	1990	2000	0%						
Denmark	1988	2030	25%		2030	60%		2030	60%
Finland	1990	2000	0%	1988	2000	50%	1980	2000	30%
Germany ^e	1990	2005	25%	1988	2005	80%	1988	2005	80%
Japan	1990	2000	0%				1990	2000	30% ^f
Netherlands ^g	1986	2010	10%	1986	2010	75%	1986	2001	75%
Norway	1989	2000	0%	1989	1999	30%	1986	1998	30%
Sweden	1990	2000	0%	1988	2000	50%	1980	1995	30%
Switzerland	1990	2000	0%	1984	2000	24%	1984	2000	47%
UK	1990	2000	0%						
EU	1990	2000	0%						

^a The countries listed here are those that provided information about reduction targets; other countries may well have reduction targets or targets of a different kind.

^b The targets in this column are general targets, i.e., not specific to the transport sector, except in the cases of Denmark, the Netherlands, and perhaps Switzerland. An entry of 0% in this column means that CO₂ levels are to return to the level of the base year by the target year. In the cases of Canada and Finland, the targets apply to all greenhouse gases.

^c The targets in this column are specific to the transport sector, except those for Austria, Norway, and Sweden.

^d The targets in this column are specific to the transport sector, except those for Austria, Norway, and Sweden.

^e These emissions targets are proposed by the German Council of Environmental Advisors and the German Federal Environmental Agency.⁵³

^f This target applies only to total emissions for the metropolitan areas of Tokyo and Osaka.

^g The reduction targets of the Netherlands for emissions of NO_x and VOCs refer to passenger vehicles only; for trucks the target for each kind of emissions is a reduction of 35 per cent by 2000 and reductions of up to 75 per cent by 2010.

The Austrian Transportation Concept had been released by the Federal Ministry of Public Works and Transport in 1991. This concept contains the guidelines of the Ministry of Transport and Public Economy related to transport policy. It gives proposals for measures in all transport branches and describes scenarios for “business as usual” and “ecologically liveable”. There it is stated that the ministry aims at a realisation of the scenario “ecologically liveable transport”.

Measures and plans

Projections under current transportation policies assume a further expansion of the automobile’s and airline’s share of total personal transport. The number of private automobiles is expected to increase from 3.10 million in 1991 to 4.44 million by 2021. Rail capacity will increase, although, in relative terms, it is expected to lose ground to both cars and air transport. The transportation of goods is expected to grow more or less linearly, with the greatest increases occurring in road transport.⁵⁴

Emission reduction targets outlined in the NUP for precursors of tropospheric ozone (established under the *Ozone Law*) and CO₂ are not specifically based on transport-related emissions, but rather encompass emissions from all relevant sectors.⁵⁵ These targets are, however, to serve as guidelines for transportation policies. Since Austria’s accession to the European Union in 1995, it must conform to the EU’s stricter emission control standards for personal vehicles and trucks (EURO 2). Austria’s emission standards for two-wheelers will remain valid and are to be advocated for adoption by the EU. Emissions from air transport—which make up six per cent of Austria’s air pollutants and about 20 per cent of its transport-related CO₂ emissions—were not included in the package of measures recommended in the NUP.⁵⁶

The general measures listed in the NUP to attain transport-related emission reductions and other goals discussed below include: (i) decreasing overall transportation demand; (ii) shifting to transportation means with greater energy efficiency and lower emissions; (iii) optimising conventional and alternative-power vehicles; (iv) improving infrastructure (e.g. erecting noise protection walls, increasing low noise road surfaces, integrating transportation nodes); and (v) raising public awareness and regulating traffic flow to alter driver behaviour.⁵⁷ In addition, considerable emphasis is placed on the need for economic instruments that internalise some of the external costs of certain forms of transportation—e.g. a surcharge to the mineral-oil tax, road pricing, increased fuel prices, management of parking spaces—many of which would require co-ordination with the EU and with other neighbouring countries.

As noted above, measures within the NUP are not restricted to reducing emissions. Recommended actions that address noise levels include: (i) research to secure quieter cars; (ii) advocating noise control levels internationally; (iii) establishing more measuring stations; (iv) entering negotiations to forbid “noisy planes” from passing over Austria; and (v) when these measures prove inadequate to reduce noise levels in the short term, increasing use of passive measures, for example, noise protection walls. Noise levels are currently controlled for each means of transport through legislated standards, such as speed limits for trucks at night (60 kilometres per hour), the *Rail Transport Noise Protection Ordinance* (SchLV), the *Civilian Airline Permissible Noise Ordinance* (ZLZV), and the *Ship Transport Law* (SFVO).

The NUP also calls for regional and local planning that considers the needs of pedestrians and cyclists as well as the links between settlement expansion and public transit corridors. With regard to public transit, networks are to be expanded and waiting internals reduced. The Plan recommends that all planning measures undergo an environmental assessment.

The Austrian Transport Concept defines the following guidelines for Austrian transport policy such as: (i) avoidance of unnecessary transport; (ii) promoting environmentally friendly rail, shipment and

non-motorised transport; (iii) using best available technology as early as possible; (iv) involvement of concerned citizens; (v) true cost accounting for internalisation of external costs and polluter pays principle; (vi) developing intermodal transport carriage facilities; (vii) assessment of transport legislation; (viii) reducing the impacts of transit traffic; ix) ecologically and social liveable transport in urban areas; and x) open borders to the eastern neighbour states.

Goals for air emissions

Austria's transport sector accounts for approximately 20 per cent of all energy use and for 27 per cent of its CO₂ emissions. Austria has adopted the Toronto Target, which calls for a 20 per cent reduction by the year 2005 based on 1988 levels. This target is not transportation specific but has been set as a comprehensive goal for all sectors. Furthermore, 62 cities including Vienna and nine of the ten Länder have joined the European Climate Alliance, whose members have agreed to a 50 per cent CO₂ reduction by 2010. The NUP states that realising the Toronto Target for the transportation sector is unlikely. Even with an expected 50 per cent increase in the average overall costs of road transport and an assumed 1.8 per cent annual reduction in fuel consumption for private automobiles, a reduction of only 6 per cent in transport-related emissions of CO₂, rather than 20 per cent, can be expected by the year 2005.⁵⁸

As in the case of the CO₂ reduction targets, emission reduction goals for precursors of ozone are not confined to the transportation sector. The *Ozone Law* regulating emissions of both NO_x and VOCs calls for a 40 per cent reduction by 1997, a 60 per cent reduction by 2002, and a 70 per cent reduction by 2007. The base years for the NO_x and VOCs targets are 1985 and 1988, respectively. The NUP projects that all targets for NO_x emissions will be realised, whereas, due to technical limitations, the sought emission reductions for VOCs will remain unattainable.⁵⁹

Other goals

The NUP states that noise levels from transportation must not rise, which means that in view of the projected increase in transportation volume noise levels per vehicle-kilometre must fall. Additionally, the number of dwellings seriously affected by noise is to be reduced sharply, which will require further reductions in vehicle noise. Future goals—to be attained within an unspecified time frame—for peak noise levels in front of residential areas are 60/50 dBA (day/night). Within dwelling rooms the future goals have been set at 40/35 dB. A law addressing noise in the vicinity of airports does not yet exist.⁶⁰

Other, less quantifiable goals include a minimisation of land use through efficient infrastructure and planning, an avoidance of non-biodegradable substances, an avoidance of natural corridor partitioning, and overall protection of the landscape.

Best thinking

The NUP argues that “the development of the transportation system has to orient itself on the basic principles of the National Environment Plan as well as the ‘protection principle’ and the ‘precautionary principle.’ According to the protection principle, no emissions must be permitted that threaten human health, impair well-being or cause a dangerous deterioration of the environment. The precautionary principle states that future generations must not be limited in their capacity to satisfy their needs and that potential future human and environmental hazards are to be avoided whenever possible.”⁶¹

In addition, the NUP outlined the following as qualitative elements of sustainable transportation systems: (i) minimisation of ecological and health risks; (ii) minimisation of accidents; (iii) precaution before repair; (iv) optimal energy efficiency and resource management; (v) employment of the most

resource- and environmentally-friendly transportation technology and means of transportation; economic efficiency to reach the best possible economic use with the least possible damage; (vi) enhanced mobility for all; and (vii) support of transport systems which enhance the above principles in the most environmentally-friendly, resource-friendly and energy-efficient manner.⁶²

4.4 Canada

Overview

The contribution by the Government of Canada was a single, comprehensive 160-page document prepared for the present study. Also reviewed were a document commissioned as the Canadian contribution to the OECD study on “Urban Travel and Sustainable Development,” and a speech by the author of that document.

Measures and plans

The government document details measures in place and proposed by national, provincial, regional, and local governments in this highly decentralised country. A total of 25 “sustainable transportation initiatives” are identified and rated as to their impact on eight scales.⁶³ (Achieving compact mixed land use is the initiative identified as having the largest number of significant positive impacts.) The document is designed to serve as a contribution to priority-setting by the Government of Canada with respect to its future support of the “sustainable transportation programmes” of the four indicated levels of government.

Programmes identified as deserving the highest-priority attention are these: at the local level, transport systems and transport demand management; at the regional and provincial levels, area-wide public transport including commuter rail and system integration; and at the national level, tax incentives.⁶⁴ Mention is also made of the task force established by the national, provincial, and territorial environment ministers to study options for addressing emissions in the transportation sector. A paper is being prepared that will examine the feasibility and implications of three options of vehicle emissions standards for possible adoption: (i) U.S. federal standards; (ii) California standards; and (iii) more stringent standards developed for the main purpose of reducing carbon dioxide emissions.⁶⁵

Goals for air emissions

The government document identifies the contributions of transportation in Canada to various air emissions (e.g. 63 per cent of the NO_x total and 43 per cent of the VOCs total in 1985; and 30 per cent of greenhouse gas emissions in 1990) but does not identify goals for air emissions other than the national commitment to return greenhouse gas emissions to 1990 levels by 2000. The document notes that allowable emission levels have been progressively lowered since 1971 and that the standards applied in Canada are generally similar to those applied in the United States.⁶⁶

The province of British Columbia has announced tighter emissions standards for that province, corresponding in part to the standards for California.⁶⁷

Other goals

Other goals related to transportation and the environment are not identified. There is some discussion of impacts on land but no discussion of transportation-related noise or waste management.

Best thinking about EST

The Transport Association of Canada's *New Vision for Urban Transportation* is described. This document proposes a series of principles or directions that, if adopted, would result in cities that are more economically competitive, socially desirable, and environmentally friendly, and that would allow greater mobility and easier access to a wider choice of transportation options. The principles address land use, walking, bicycling, public transport, automobile traffic mitigation, parking, goods movement, inter-modal integration, new technology, and system integration. The document proposes that transportation master plans should balance community needs, economy, and environment through achievement of equitable access, participatory planning, and least-cost implementation.⁶⁸ Other submitted information sets out the general characteristics of urban form that provide the "maximum potential for sustainability." These include: (i) a compact form, with densities of at least 4,000 persons per square kilometre; (ii) concentration in mixed-use nodes and corridors; (iii) orientation of buildings close to and facing the street, with parking minimised; (iv) a road pattern providing maximum walking distances of about 400 metres from interior sites to main roads; and (e) wide sidewalks and other pedestrian amenities.⁶⁹

Other material from Canada provides the following five criteria that "make a transportation system sustainable": (i) capability to deliver the capacity and levels of service required; (ii) compatibility with the kind of places people want to live in; (iii) affordability to construct and maintain transportation systems; (iv) technology and energy that are renewable, portable, and sufficient; and (v) clean waste, in that a system which generates injurious waste is incompatible with human health and environmental concerns.⁷⁰

4.5. Denmark

Overview

Three documents were submitted: a short paper on the Danish policy on transport and environment, a summary of the Danish government's white paper on transport and its 1993 general traffic plan for all public works and investments necessary to 2005, and a list of 14 Danish projects related to EST.

Measures and plans

The general traffic plan, *Traffic 2005*, is described as the start of a new planning process rather than the elaboration of a series of initiatives for immediate implementation. It addresses three main subjects: a "traditional" transport policy; environmental, energy, and road safety considerations; and investments. The plan assumes that the energy efficiency of transport will increase by 15 per cent over the period, but notes that increases of 25 per cent in passenger transport and 40 per cent in goods transport can be expected.⁷¹

Five strategies are defined: (i) curbing the volume and influencing the mode of transport; (ii) promoting alternatives to the private automobile; (iii) curbing environmental impacts; (iv) setting new priorities for transport investments; and (v) enhancing transport planning and research.⁷² Specific measures addressed include: (a) increasing fuel taxes beyond increases committed until 1998; (b) imposing charges for the use of certain roads by heavy vehicles; (c) promotion of rail and sea transport, and combined transport (truck and rail/sea) for international traffic, including establishment of a common Danish-Swedish rail system on the opening of the Øresund fixed link; (d) local rather than major road improvements, after the Danish section of the trans-European transport network is completed;

(e) improvement of public transport and regulation of fares to ensure the competitiveness of bus and train with car and air transport; (f) promotion of bicycle use; and (g) restrictions on access to city centres.⁷³ Municipalities with populations of 10,000 are to begin work on specific action plans for transport and the environment. The whole is to be conducted in the most cost-effective manner and increasingly within the framework of EU directives, which Denmark is helping steer towards their constituting a sustainable European transportation policy. There is no account of measures presently in place.

Goals for air emissions

Specific goals for air emissions from transportation include stabilisation of CO₂ emissions before 2005 and a 25 per cent reduction before 2030; a reduction in emissions of NO_x and VOCs of 40 per cent by 2000 and 60 per cent by 2030; and a 50 per cent reduction in solid particle emissions by 2010 and more thereafter. Achievement of CO₂ objectives is expected to provide the greatest challenge; hence the focus on curbing the growth in the volume of traffic. Other air emissions objectives are likely to be met without further intervention except as may be required by the EU.⁷⁴

Other goals

Noise levels from transportation are to be reduced by 65 per cent by 2010, the objective being that not more than 50,000 homes should be subject to levels greater than 65 dBA. Accidents are to be reduced by 40-45 per cent by 2000. Waste management issues are not addressed in the documentation.⁷⁵

Best thinking about EST

Topics addressed in ongoing research relevant to EST concern: (i) evaluation of environmental and other impacts of proposed traffic plans; (ii) barriers to the use of public transport; (iii) environmental objectives for transport and means of achieving them; (iv) demand for mobility; (v) the potential for bicycle use in cities; (vi) efficiency of goods transport in cities; (vii) production systems and sustainable mobility; and (viii) internalising the external costs of transportation.⁷⁶

4.6. Finland

Overview

The submitted documents included the newly adopted environment programme of the Ministry of Transport and Communications and a summary of transport-related studies provided by the Finnish National Road Administration.

Measures and plans

The programme sets out guidelines to be followed, specific objectives to be met for 2000, the present situation in relation to each objective, a schedule of actions required to meet each objective, likely impacts of the actions by 2000 and beyond, the agencies responsible for implementation of each action, and the financial costs of each action. The whole is framed within Finland's commitment to international obligations concerning greenhouse gases and emissions causing acidification, and is to be consistent with the requirements for the harmonisation of measures within the EU.

The action programme deals both with the attainment of specific objectives by 2000 and with continued reductions in the environmental impacts of transportation in the longer term, i.e., beyond 2000. The programme aims at approaching sustainable development with a low level of short-term impacts and

with impacts that are fairly distributed. Most measures concern road traffic, which is considered to have the most environmental impacts. The six guidelines address: (i) alleviation of traffic growth; (ii) the need for a balanced regional structure and integration of communities; (iii) reduction in energy use and hazardous emissions, taking into account environmental tolerance, human health and comfort, and technical feasibility; (iv) the application of economic instruments, particularly taxation of the use of vehicles, to achieve internalisation of social costs and predictability, within the context of employing a mix of instruments; (v) the need for greater public awareness of the environmental impacts of transportation; and (vi) the need to conserve natural resources.⁷⁷

The guidelines are to apply to the entire life-cycle of transportation systems. The 14 objectives for 2000 include the specific goals noted below and speak as well to the following: (i) achieving denser community structures; (ii) avoidance of environmentally and culturally sensitive areas; (iii) the use of environmental impact assessments of both strategic plans and individual projects; (iv) greater public awareness of environmental issues; (v) the use of internationally approved practices in environmental management; (vi) systematic monitoring of the environmental impacts of transportation; and (vii) international co-operation in transportation research.⁷⁸

Goals for air emissions

Greenhouse gas emissions are to be kept at no more than the 1990 level until 2000 and then reduced. Emissions of NO_x from vehicles overall are to be 30 per cent below the 1980 level in 2000, but this degree of reduction is to be achieved later in the cases of heavy trucks and ships. Emissions of VOCs in 2000 are to be 50 per cent or more below the 1988 level. There is no specific target for carbon monoxide; however, as an indirect implication of measures to reduce NO_x and VOCs, emissions of carbon monoxide are expected to fall to 60 per cent below 1990 levels by 2003.⁷⁹

Other goals

Proposed measures are to reduce overall noise levels from traffic by 2-4 dBA to a maximum of 65 dBA. (A 3-dBA reduction is noted in the action programme as what is achieved with a 50 per cent reduction in traffic volume or with a 20 kilometre-per-hour reduction in average traffic speed.) Noise from heavy trucks is to be reduced by 4 dBA. Regarding waste management, the rate of reclamation of scrap vehicles and batteries is to be at least 95 per cent by 2000 and that of used tires and catalytic converters at least 90 per cent. Hazardous waste from transportation is to be properly managed and the environmental risks of transporting hazardous waste are to be further reduced. Life-cycle impacts of transportation and its infrastructure are not to increase contamination of ground water and surface water.⁸⁰

4.7. France

Overview

One document was submitted in two volumes—a total of some 300 pages—aimed towards the development of a coherent and sustainable transport policy.⁸¹ The document comprised a review requested by the Ministry of the Environment from three research groups assembled for the purpose. The groups were concerned with (i) the optimisation of the vehicles (including design and fuel improvements); (ii) the impacts of urban traffic on the environment; and (iii) the impacts of interurban movements of people and goods on the environment. The submitted document focused on providing an assessment of potentially harmful effects of transportation rather than on measures currently in place or officially proposed. A subsequent communication briefly described three other French studies that are not otherwise noted here.

The studies respectively concern: (i) effects on the environment of transportation subsidies; (ii) the environmental implications of free trade; (iii) the reduction of CO₂ emissions from vehicles.⁸²

Measures and plans

The first research group outlined the key implications of some current trends in transportation,⁸³ and made the following suggestions for action: (i) Implementation of a taxes and charges on vehicles based on use and performance, e.g. further fuel taxes; road-pricing in urban areas; and taxes on parking.⁸⁴ (ii) Limitation on benzene components in fuel to a maximum of two per cent.⁸⁵ (iii) Reduction of the use of internal-combustion-engine vehicles in urban areas; promotion of electric vehicles.⁸⁶ (iv) Taxation of aircraft fuel for intra-European flights.⁸⁷ (v) Limitation on emissions of sulphur from ships' engines.⁸⁸

The research group concerned with urban areas set some key objectives for transportation policy, as follows: (i) to reduce noise from transportation; (ii) to reduce the fragmentation of land caused by the construction of transportation infrastructure in urban areas; (iii) to protect the local ecosystems; and (iv) to encourage the formation of a coherent transportation network that would encourage and facilitate the use of alternative modes of transport.⁸⁹ The following actions were proposed in support of these objectives: (a) More equitable sharing of the roads among vehicles and alternative modes of transportation, in part by the appropriation for walkers and cyclists of space currently allocated to motor vehicles.⁹⁰ (b) Creation of reserved corridors for collective transport and priority arrangements for collective transport on regular roads.⁹¹ (c) Imposition of taxes and charges on users of motorised vehicles in urban areas.⁹² (d) Implementation of incentives for car pooling.⁹³ (e) Tightening of control of parking areas—i.e., fewer free spaces on roads and at places of employment—in order to promote the use of collective transport.⁹⁴ (f) Securing better co-ordination among policies concerning land-use planning, transportation, and environmental policies.⁹⁵

The objectives of the research group working on inter-urban movement of people and goods were, on a medium and long-term basis, to maintain biological and geographical diversity; to protect natural sites; to maintain air, water, and land quality; and to preserve natural resources; and finally to limit changes that might alter the planetary biosphere such as enhanced greenhouse effect and reduced stratospheric ozone layer.⁹⁶ To pursue these objectives, the group recommended adoption of regulations to limit the fragmentation of land, especially in sensitive zone, and co-ordination of the policies developed in different sectors and at different levels of organisation.

Two proposed actions of note are: (i) a law to improve air quality in urban areas by regulating transport of people and goods; and (ii) a national plan for the management of land and infrastructure. There will be presented to the French parliament in 1996 or 1997.⁹⁷

Goals for air emissions

As well as the already-noted proposed limit for benzene in fuel, and actions to reduce use of internal combustion engines, some specific air-quality standards for 2005 were proposed: NO_x, 40 µg/m³; benzene, 5 µg/m³; particulates, 20 µg/m³; SO_x, 20 µg/m³.⁹⁸

Other goals

Measures concerning noise in settled areas were discussed. Targets discussed included the establishment of "silent zones," where noise levels would be required not to exceed 40 decibels, the institution of interurban "calm zones," cessation of the extension of "grey areas," where noise levels are 55-65 decibels, and, within 10 years, avoidance of areas where average daytime noise levels exceed 65

decibels. Further increases in waste from transportation were anticipated, including old tires. Progressive limits on the inclusion of non-recyclable materials in new vehicles were proposed—15 per cent by 2005, 10 per cent by 2010, 5 per cent by 2015, with respective upper limits of 150, 100, and 50 kilograms per vehicle⁹⁹—corresponding to recommendations of a European working group.

Best thinking

Regarding future transport policies, the following points were advanced: (i) Decision-making concerning infrastructure suffers from the persistence of several myths such as the myth that expressway construction results in greater accessibility and economic development. One must go beyond simply supplying infrastructure to analysing what is truly needed, especially at a time of government deficits and growing scarcity of natural resources. (ii) A debate should occur in each country on the options for a coherent, long-term transport policy; at the local level, more dialogue leads to less public expenditure and fewer setbacks. (iii) Charges for road transport must be equalised with those for rail: in respect of social and technical rules, internalisation of infrastructure costs (axle fees), and collective costs (health, ecosystem damage, degradation of heritage properties, disruption of local economies, etc.).

4.8. Germany

Overview

The German submission includes relevant legislation and pending government action outlined by the Federal Ministry for the Environment (BMU), comprehensive studies and recommended measures from supporting bodies such as the Federal Environmental Agency (UBA), the German Council of Environmental Advisors (SRU), and the Enquete Commission of the Lower House of Parliament, as well as analyses for certain transportation sectors by NGOs.

Measures and plans

The combined effects of growing economic liberalisation within the EU, the five-year-old German unification, and the increasing integration with Eastern Europe are expected to—under business-as-usual scenarios—increase the traffic volume of personal and freight transport by 37 and 78 per cent respectively by the year 2010.¹⁰⁰ Increases in transportation volume are projected to be greater in the five new federal states (Länder) of the former East Germany.¹⁰¹ With regard to emission reductions, the federal government has emphasised the importance of non-technical measures (e.g. shifts in modes of transport, transit-oriented urban planning) to supplement technical improvements in fuel consumption and emission controls, because technical advances may only be overwhelmed by increasing kilometres travelled.

In light of these projections, the federal government has altered its long-term goals for infrastructure development under the 1992 *Federal Transportation Infrastructure Plan* (BVWP)—Germany's first plan to call for greater investments in rail infrastructure than road.¹⁰² This and other approved measures discussed below are consistent with the following principles established by the government to guide transportation policy: avoiding increases in transport volume; shifting traffic to more energy-efficient and environmentally friendly modes of transport; optimising the technical efficiency of all means of transport; and providing information and increasing public awareness about the environmental effects of transportation systems.¹⁰³

Effective January 1994, Germany's mineral-oil tax, last increased in 1991, was raised for leaded gasoline (0.92 to 1.08 DM/litre), unleaded gasoline (0.82 to 0.98 DM/litre) and diesel fuel (0.55 to 0.62

DM/litre). To compensate for the smaller tax on diesel fuel, the motor vehicle tax on diesel-powered vehicles was increased. The first phase towards reorienting the motor vehicle tax from the current engine-displacement base to an emissions-oriented base was implemented in 1993. Currently, this new base applies only to freight vehicles above a certain weight (3.5 tonnes); it is eventually to include personal vehicles, motorcycles, and lighter freight vehicles, for which air emissions and perhaps even noise emissions will be the tax-dependent criteria.¹⁰⁴

Local and regional public transit systems are supported through the *Act on Financing Community Transport* (GVFG), whose funds are generated through the federal mineral-oil tax but distributed by the 16 Länder. Recent amendments to the GVFG have provided the Länder with greater flexibility with regard to their investment priorities, which has led to even greater investments in public transportation systems. Further recent reforms include the privatisation of the German railway system (Deutsche Bundesbahn—DB), with the expectation that the DB will become more competitive and increase its share of the transportation market.¹⁰⁵

Hazardous air emissions are regulated under the *Federal Emission Protection Law* (BImSchG), the periodic strengthening of which has resulted in significant declines in emissions of VOCs, NO_x, and carbon monoxide since 1980.¹⁰⁶ Air emission standards introduced at the EU level in March 1994 are expected to result in even further reductions within Germany. A 1995 amendment to the BImSchG states that when the ground-level ozone concentration in an area exceeds 240 µg/m³ (one-hour average), vehicle traffic in the area may be prohibited.¹⁰⁷

Measures awaiting legislative approval or under consideration include: (i) implementing phase two of the emissions-oriented motor vehicle tax discussed above; (ii) road-use tolls in conjunction with the Benelux countries and Denmark (actually in force since 1995 but for heavy trucks of 12 tonnes GVW only); (iii) the “Railways Site Concept,” which calls for construction or expansion of railway freight stations at 44 sites throughout Germany; (iv) taxation on aircraft fuels; and (v) a required “traffic-impact assessment” for all relevant pieces of legislation.¹⁰⁸

Goals for air emissions

The transportation sector accounts for about 20 per cent of all energy-related CO₂ emissions within Germany. This proportion is projected to increase due to an anticipated increase in overall traffic volume and a decline in emissions from other sectors. The federal government has committed itself to a 25 per cent CO₂ reduction target by 2005 (base year 1990) covering all sectors. It has not been explicitly stated that this target applies to the transportation sector notwithstanding a recommendation to this effect by the Federal Environmental Agency (UBA).¹⁰⁹ In addition to federal action, some Länder and numerous municipalities have initiated their own CO₂ reduction plans. Many of these governments are members of the European Climate Alliance, which advocates an ambitious, comprehensive—i.e., with reference to all sectors—reduction target of 50 per cent by 2010.

Projections demonstrate that realising a 25 per cent reduction in traffic-related CO₂ emissions by 2005 compared to 1990 levels is highly unrealistic.¹¹⁰ For instance, stabilising traffic-related CO₂ emissions is only feasible if fuel consumption limits and price increases are supplemented by other measures which significantly reduce the use of private vehicles.

The amended BImSchG referred to above calls for an immediate 40 per cent reduction in emissions of precursors of ozone (NO_x and VOCs). Recommendations concerning these emissions by the UBA and the German Council of Environmental Advisors (SRU) propose an 80 per cent reduction by 2005 based on 1987 levels.¹¹¹ Likewise, these government bodies have appealed to the federal government

to adopt stringent reduction targets—90 per cent reductions by 2005 based on 1988 levels—for emissions of carcinogenic substances such as gasoline and diesel soot.

Other goals

Current minimum permissible noise levels are prescribed under the *Transportation Noise Protection Ordinance*. These include 59 dBA by day and 49 dBA by night in residential areas, and in mixed-use areas 64 dBA by day and 54 dBA by night. The UBA has suggested longer-term—by the year 2030—goals of 50/40 dBA for residential areas and 60/50 dBA for mixed-use areas.¹¹²

Waste reduction goals in the transport sector have been addressed by the pending legislation initiated by the Federal Ministry for the Environment. The current draft proposal calls for greater longevity of automobiles and their parts, and for a requirement that all automobile parts be capable of being re-utilised in some way. Examples of specific reuse targets for materials in the transport sector include: 100 per cent for steel by 1997; 20 per cent for plastics by 1997, 80 per cent by 2000; 70 per cent for tires by 1997, 80 per cent by 2000; 30 per cent for glass by 1997, 50 per cent by 2000.¹¹³

Recommendations for future goals concerning landscape and ecosystem disturbances are largely based on those discussed at the Environment Ministers' Conference in 1992. Such goals include the avoidance of further natural corridor partitioning and the optimisation of current infrastructure rather than expansion of capacity. The UBA has suggested that the next *Federal Transportation Infrastructure Plan*, expected in 1998, prohibit further expansion of the FRG's transportation infrastructure.¹¹⁴

Best thinking

Some relevant statements in the submitted material include the following: "Individual transport is appropriate only when both its social and environmental effects adhere to the definitions of sustainability."¹¹⁵ "Mobility must be capable of being measured according to criteria for sustainability."¹¹⁶

German thinking with regard to EST (or ESMobility) advocates a comprehensive approach, in which both technical and non-technical measures must be employed to achieve environmental as well as socio-economic goals. Accordingly, the following (in no particular order) must be addressed in any long-term EST strategy: air pollutants; climate protection; noise abatement; land and nature conservation; quality of residential surroundings and urban liveability; waste management/reduction; and enhanced mobility. The point is made that indicators or targets for such elements as land and nature conservation, the quality of urban life, and enhanced mobility are not readily definable.¹¹⁷

4.9. Japan

Overview

Five substantive documents were submitted. The most fundamental of these documents is the 60-page Basic Environment Plan, approved by the national government in December 1994, which makes numerous references to transportation. Other documents concern legislation to reduce NO_x emissions in the Tokyo and Osaka regions. A further document is a comprehensive review of traffic pollution control.

Measures and plans

The comprehensive review notes measures in place in 1993. The Environment Basic Plan is predicated on the need “to question the present civilisation and change production and consumption patterns to sustainable ones.”¹¹⁸ The Plan’s long-term objectives are: (i) closed material circulation to avoid production of waste and pollution that interfere with natural material cycles; (ii) harmonious coexistence between nature and human beings; (iii) participation of all people in environmental protection, and the fair sharing of its costs; and (iv) international co-operation to maintain a healthy global environment.¹¹⁹ The Plan lists numerous specific objectives that must be met to reduce the environmental impacts of transportation including: (a) reductions in fossil-fuel use; (b) promotion and sustenance of public transport; (c) improvement of goods-carrying efficiencies; (d) road construction to reduce congestion; and (e) use of sophisticated traffic control schemes.¹²⁰

Goals for air emissions

Total per-capita CO₂ emissions are to be stabilised in 2000 and beyond at 1990 levels. Voluntary fuel economy standards have been set by the government for light passenger cars and light trucks. For passenger vehicles, the improvement will be 8.5 per cent by 2003 compared to 1993 levels, and for gasoline light trucks, a 5 per cent improvement is to be achieved by 2003 compared to 1993. The long-term targets of NO_x emissions aim for reductions of between 16 and 65 per cent, according to the type and size of vehicle, and refer to the standards in place in the late 1980s. For particulate matter from vehicles, the corresponding range of required reductions is about 60 to 64 per cent.¹²¹ In designated metropolitan areas of Tokyo and Osaka, the “Automobile NO_x Law” requires a total reduction of NO_x emissions from automobiles by about 30% by the fiscal year 2000 compared to the 1990 level.

Other goals

Much attention is paid to reducing noise from transportation. Environmental Quality Standards (EQS) exist for road traffic noise, for airports, for “Shinkansen” (bullet trains); and, since January 1996, for railway noise other than Shinkansen. Concerning road traffic noise, temporary goals of 5 dB to 15 dB higher than EQS for high-density traffic roads have been provided in a recommendation by the Central Environmental Council made in March 1995.

Best thinking about EST

A concept of sustainability is implicit in the Environment Plan’s principles. An important caution in the Plan concerns indicators of progress towards the long-term objectives, which are said to be inadequate and to require urgent development.

4.10. Netherlands

Overview

The 1995 OECD Environmental Performance Review submitted by the Netherlands government outlines current policies and goals for the transport sector and is based on, inter alia, recent data that is produced in yearly evaluations of current policies. Non-governmental reports include a 12-page working note by Dutch experts on studies and initiatives related to environment and sustainable transport and to backcasting analyses for EST-related scenarios.

Measures and plans

Reference is made to three government strategy documents. The Second Transport Structure Plan (SVV 2/1990) provides for an overall transport strategy up to 2010, emphasises the concept of sustainability, and contains specific targets for the limitation of vehicle use by the years 2000 and 2010. Environmental targets within the SVV 2/1990 were derived from those of the National Environmental Policy Plan (NEPP/1990, updated in 1993), and were translated into mobility targets for 1986-2010, i.e., a reduction of VKT growth from a “business as usual” growth of 70 per cent down to a “SVV package” growth of 35 per cent over this period. The NEPP/1990 sets out three general objectives: (i) use of cleaner, more fuel-efficient, and safer vehicles; (ii) for passenger transport, a modal shift that decreases energy consumption and reduces pollution; and (iii) improved integration between land-use and transportation planning to locate activities so as to minimise travel.¹²² In support of the third goal, the Supplement to the Fourth Report on Physical Planning in 1991 established a framework for land-use planning until 2015. Other government notes relevant to transport and the environment cover government policies regarding speed limits and air pollution and aviation; the latter was presented in a concise overview report of current problems and technologies in emission control strategies for the rapidly expanding aviation sector.

Measures enacted and proposed toward meeting these policies include a number of measures, such as (i) fiscal incentives for “clean” cars (1986-1992) and for unleaded petrol; (ii) subsidies provided (phased out in 1994) to encourage the purchase of trucks that would satisfy future EU emission standards; (iii) “environmental inspection” of cars; (iv) increases in the tax on gasoline; (v) fiscal incentives for fuel-efficient vehicles (postponed to 1997); (vi) road pricing (which is being researched for possible introduction after 2000); (vii) speed-limit enforcement programmes; (viii) educational programmes and public communication; (ix) co-operative projects with shippers and haulier companies and organisations to take concerted action and voluntary measures for reducing emissions and fuel consumption (so-called “Transactie” programme; (x) voluntary introduction of econometers and cruise control as standard in-car devices for fuel savings; (xi) allocation of 20 billion guilders for investment in public transport until 2010; (xii) further development of measures that structurally support governments, at a local or regional level, for cycling and public transport facilities and programmes;¹²³ and (xiii) parking policies for local governments, such as stricter parking quota per numbers of employees, and fiscal instruments for enforcement of parking rules.

Goals for air emissions

Under the NEPP, road transportation-related emissions of CO₂ are to be stabilised by 2000 based on 1986 levels, with a 10 per cent reduction by 2010. Compared with 1986 levels, emissions of both VOCs and NO_x are to be reduced by 2000 by 75 per cent for passenger vehicles and by 35 per cent for freight vehicles, with reductions for freight vehicles and passenger cars of up to 75 per cent by the year 2010.¹²⁴ These reduction targets are also set as absolute total emission levels in tons per year for the categories as mentioned.

Other goals

Concerning noise emissions, according to the NEPP there is to be no ambient deterioration beyond 2000 and no “serious annoyance” beyond 2010. Specifically, goals have been set for 74 dBA in 2000 and 70 dBA by 2010 for passenger cars, and 75-80 dBA in 2000 and 70 dBA by 2010 for trucks and buses. Recycling of 85 per cent of materials used in connection with transportation is to be achieved by 2000.¹²⁵ According to WHO standards, ambient air quality guidelines are legally implemented for several compounds, such as CO, NO₂, SO₂, lead and benzene, for which (urban) road traffic is a main contributor.

Apart from international emission standards and mobility policies, these air quality standards require local and regional authorities to develop urban and regional traffic management programmes.

Best thinking about EST

Several scenario and other studies are described, some of which were presented at the December 1994 Expert Meeting for this project, including the Freight Transport “Trendbreach” Scenario study, the FORWARD study, and the SVV/NEPP Evaluation Report. Targets established in connection with one of these studies (Netherlands Travelling Clean Study of the NL Friends of the Earth) speak of long-term reductions by some 90 per cent in CO₂, NO_x, and SO_x emissions from passenger transport that would be achieved through radical shifts in modal split away from automobile use and would imply a 50 per cent car ownership reduction.¹²⁶ In another briefly described study (Mobility in a Sustainable Society—MODUS), these long-term targets, with the additional target of full recycling of scrapped vehicles, were found to be impossible to meet; four theoretical scenarios were examined that varied in aspects of land use, social and individual behaviour, economic factors, and available technology.

Recent socio-psychological studies in the Netherlands on automobile use and owners’ preferences show that although owners are generally well aware of the environmental effects of their behaviour they are unwilling to reduce automobile use for energy or environmental reasons. Such unwillingness is a major barrier to the attainment of EST.

4.11. Norway

Overview

A four-page note was submitted concerning environmental objectives and strategies for sustainable transport; it addressed the following: (i) Norway’s general approach; (ii) regulatory instruments including environmental criteria in transportation planning and operation; (iii) major policy instruments; (iv) studies on the mix of policy instruments; and (v) action plans. Also submitted were the *Planning and Building Act*, national policy guidelines for co-ordinated land use and transport planning, a national overview prepared for OECD’s Ecological City project, reports on several studies, and a recent report to the national parliament concerning policies and measures to limit emissions of NO_x, CO₂, and other greenhouse gases.

Measures and plans

The key principle of Norwegian environmental policy is to adopt specific targets related to sustainable development and then to seek the most cost-effective ways to reach the targets. Targets are developed through the precautionary principle, the critical load approach or environmental quality guidelines—for regional and global problems in the context of international co-operation and harmonisation.¹²⁷ No specific sector targets have been or are intended to be established. Cross-sectoral instruments such as the CO₂ tax comprise the principal strategy where appropriate.¹²⁸ Action plans address specific sectors and groups of sectors. Long-term (four- to ten-year) plans are about to be developed for road, rail, and air transport. They will consider four strategies designated *accessibility*, *environment*, *safety*, and *district*, each based on certain minimum standards.

Currently, Norway does not have specific goals for the reduction of local air pollution and noise; however, the State Pollution Authority, in 1992, recommended air quality criteria for towns and urban areas concerning NO₂, ozone, particulates, SO₂, and CO, established at levels that prevent direct effects on

health. Recommendations concerning noise from road traffic and aircraft were also made. Regulations on air quality and indoor noise pursuant to the *Pollution Control Act* will be implemented early in 1996. This will bring Norwegian regulations into conformity with EU directives.¹²⁹

Proposed measures with respect to transport and potential climate change include: (i) reorganisation and enhancement of the CO₂ tax; (ii) voluntary agreements to limit emissions of greenhouse gases not covered by the CO₂ tax; (iii) further grants for energy efficiency and renewable energy sources; and (iv) further international co-operation.¹³⁰ Proposed measures with respect to NO_x emissions include: (a) taxing vehicles according to their environmental quality; (b) further grants for alternative fuels; and (c) improved co-ordination of land-use and transportation planning.¹³¹

Goals for air emissions

Specific environmental goals for the transport sector have not been established. Like all of its air emission targets, the Norwegian CO₂ target—return to the 1989 level of emissions by 2000—is not transport-specific. Other comprehensive emission targets include a 30 per cent reduction from 1989 levels of emissions of VOCs by 1999 and a 30 per cent reduction from the 1986 levels of NO_x by 1998.

Best thinking about EST

The document *Sustainable Development in Transportation: Preparations for the 21st Century*, prepared for the Nordic Council of Ministers, sets out the following statement concerning EST: “The move towards a transport sector that man and environment can bear.”¹³² The *National Policy Guidelines for Co-ordinated Land-Use and Transport Planning*, issued by the Norwegian Ministry of the Environment, proposed as follows: “The use of land and the system of transport shall be developed in a way that promotes a socio-economically effective use of resources, with environmentally sound solutions, safe local communities and residential environments, good traffic safety and effective flow of traffic. Planning shall be based on a long-term, sustainable perspective. Emphasis shall be placed on achieving good, regional overall solutions across municipal boundaries.”¹³³

4.12. Sweden

Overview

Seven substantive documents were submitted, as well as an overview document and some other documents. The overview notes that a special parliamentary committee was appointed in December 1994 to draft an action plan for future transportation and communication in Sweden, to report by December 1996. The seven documents include the plan for an ongoing project by ten organisations (government, industry, research), led by the Swedish Environmental Protection Agency (SNV), to devise an action programme for an environmentally sustainable transportation system. This work will now be scheduled so that its results can be of use to the special parliamentary committee. Other documents relate to current measures concerning transportation and the environment and their impacts.

Measures and plans

Current measures are fully described in the documentation, which notes that Sweden did not have to abandon her stricter requirements on vehicles and fuels on accession to the European Union. There is no indication in the material of proposed measures. Preliminary environmental goals have been established in an interim report on the ongoing SNV-led project that is available in Swedish only. (An

English version will be available early in 1996.) These preliminary goals reflect “the limits that humans and nature can tolerate,” in contrast to the previous practice of putting economic considerations first. The goals concern or will concern global and local air emissions, impacts on soil and water, noise, recycling, and protection of land uses.¹³⁴ Other features of the ongoing work are its holistic approach, its involvement of numerous stakeholders including industry and local governments, and its commitment to management of demand for transport. Subsequent phases of the ongoing work involve thorough analyses of potential measures, scenario studies that incorporate the definition of EST as the starting point for a backcasting exercise, and refinement of policy instruments. The objective is the attainment of EST by 2020.¹³⁵

Goals for air emissions

The Swedish Parliament has stated that CO₂ emissions should not exceed 1990 levels in the year 2000. Targets for air pollutants include a 30 per cent reduction in emissions of NO_x by 1995, from 1980 levels, a 50 per cent reduction in emissions of VOCs by 2000, from 1988 levels, and an 80 per cent reduction in emissions of sulphur dioxide by 2000, from 1980 levels.¹³⁶ Except for noise, these targets are not specific to the transport sector. Their implications for the transport sector may be such as to require larger-than-average reductions for this sector.

Other goals

The target for noise levels has been set at 55 dBA for urban areas and for residential areas. The Swedish Road Administration noted in 1993 that this target cannot be attained by 2000 if only currently implemented measures are in place. Waste reduction and land use are mentioned in the documentation, but no specific targets are available.¹³⁷

Best thinking about EST

This is embodied in the ongoing SNV-led work, which states that long-range environmental goals concerning transport activities should be compatible with “what man and nature can tolerate.” There is also reference in the documentation to work being conducted by public agencies concerned with housing, land-use planning, and transportation. County administrative boards have been asked to submit regional proposals for EST during 1995. Most municipalities are working on local Agenda 21 programmes pursuant to the United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro in 1992. Non-governmental organisations have published proposals and visions relevant to the achievement of EST.¹³⁸

4.13. Switzerland

Overview

Several documents were submitted concerning the national government’s strategies concerning air pollution, energy, transportation, and trans-Alpine traffic, and its response to 65 measures concerning air pollution (mostly transport-related) proposed by the cantons.

Measures and plans

Concern is expressed in the documentation that although measures taken during the past decade to improve public transport are bearing fruit (public transport has been gaining ground at the expense of the private automobile since 1985, contrary to the OECD trend) substantial problems are apparent, especially with regard to the transport of goods and to patterns of urbanisation. Emission standards for

private automobiles are represented; 1987 standards for NO_x, carbon monoxide, and hydrocarbons are stricter than the European Union's 1992 standards, but less so than those set for the United States for 1994.¹³⁹ Harmonisation with EU standards is sought, including those for heavy vehicles.

It has been determined that the goal of returning CO₂ emissions to the 1990 level by 2000 can be achieved through enforcement of vigorous policies concerning fuel efficiency and travel demand, but that the level will then begin to rise above the 1990 level unless there is also a tax on CO₂ emissions. With the policies and the tax, levels will remain below the 1990 level beyond 2025.¹⁴⁰

As well as European co-operation, there are six recommended directions concerning transport: (i) reform of public transport including establishment of a national co-ordinating organisation; (ii) modernisation of public transport infrastructure; (iii) true-cost pricing of transport; (iv) encouragement of several individual initiatives including car-pooling, car-sharing, and charging for employee parking; (v) more rigorous management of land uses; and (vi) improvement of vertical and horizontal co-operation among governments and agencies concerned with transport.¹⁴¹ Cantons have called on the federal government to impose a CO₂ tax as well as taxes on hydrocarbon emissions and on heavy vehicles according to performance.¹⁴² The federal government has established an interdepartmental working group, "IDA-Luft," to estimate the effects of the proposed measures and to co-ordinate implementation. A significant measure that will likely reduce transportation impacts is the requirement that by 2004 all trans-Alpine traffic be by rail.¹⁴³

Goals for air emissions

Specific goals for reductions in overall air emissions by 1995 and 2000 were set out in the 1986 Air Pollution Strategy. By 1990, emissions of sulphur dioxide were to be reduced to the 1950 level (maximum goal) and by 1995 the emissions of NO_x and VOCs are to be reduced to the 1960 level (minimum goal) in order to reach the air quality of the 1950s. These goals were motivated by estimates that such emission reductions are needed to meet the effect-oriented Swiss air quality standards. The gaps between overall emissions of 1984 and 1960 were calculated and measures were proposed as to how the gaps can be closed. By 2000, CO₂ emissions are to return to the 1990 level, according to a parliamentary decision on the use of energy.¹⁴⁴ By 2000, in comparison with 1984 values, NO_x emissions are to fall by 36 per cent, by 47 per cent if specified measures are implemented; emissions of hydrocarbons are to fall by 16 per cent; by 24 per cent if specified measures are implemented.¹⁴⁵

Other goals

Noise levels are not to increase beyond 2002. Goals for other transport-related environmental impacts were not identified.

Best thinking about EST

There is no specific mention of sustainable transportation in the documentation. However, the federal government has elaborated new perspectives on the evolution of transportation in Switzerland until 2015. Even if suitably restrictive measures are implemented, growth in traffic of all kinds is expected during the next decade, although more in the case of public rather than private passenger transport and more in the case of rail rather than road transport of goods. Rates of growth of all kinds of traffic are expected to decline in the subsequent decade.

4.14. United Kingdom

Overview

Several documents relevant to the project were submitted including the chapter on transport in the UK's Sustainable Development Strategy, a series of six speeches made during February-April 1995 by the then Secretary of State for Transport designed to encourage wide debate about the future of transportation policy, the national government's planning policy guidance to local authorities and others on transport and on noise, and reports of the government's Expert Panel on Air Quality Standards (EPAQS). One of the speeches noted that sustainable development has been firmly at the top of the government's agenda for six years, and that environmental protection must be balanced with the need for a successful economy. The covering note to the documentation contains several cautions, among them the following: (i) that the complexities of developing any definition of EST are not fully reflected in the proposal as drafted—the underlying assumption that some objective, simply quantifiable and readily agreeable definition may be found to be optimistic; (ii) that in most countries sustainability appears to be a direction for policy development rather than a clear goal or target, which implies a flexibility and ability to adjust aims that needs to be reflected in any attempted definition; (iii) that in order to try and achieve a meaningful definition of EST work should concentrate on the range of measures in place or under consideration, and on their expected or potential effects in contributing to environmental objectives; (iv) that economic and social benefits should be recognised in defining EST, and that economic considerations should be reflected fully in the definition; and (v) that rigid sectorally-specific sustainability targets could preclude shifts in effort among sectors, shifts that could be cost-effective without being environmentally harmful.¹⁴⁶

Measures and plans

A key principle of the UK government's approach is that the prices of goods should not be too high because of poor transport nor artificially low because transport costs fail to reflect the full cost of environmental damage. Accordingly, annual five per cent increases in real fuel prices have been mandated, directed above all towards reducing CO₂ emissions.¹⁴⁷ In general, the UK closely follows European Union standards with respect to air emissions from vehicles, specifically with respect to the use of catalytic converters in new automobiles sold or used since the end of 1992 and through tighter fuel and evaporative emission standards. The documentation does not include a systematic account of current measures and plans, but elements of a sustainable transport policy are elaborated. They include recognition of the need for: (i) provision by government of a framework within which people can exercise their transport choice in ways compatible with environmental goals; (ii) striking the right balance between serving economic development and protecting the environment, and future ability to sustain quality of life; and (iii) reflecting in user costs the full costs of transport, including environmental costs.¹⁴⁸

Present measures, in addition to the annual real cost increases and the implementation of EU standards, include: (i) advice to local governments as to how to plan settlements to reduce travel, particularly travel by automobile; (ii) road construction to reduce congestion; and (iii) guidance as to environmental assessment of road and bridge schemes to reflect current good practice.¹⁴⁹ Anticipated measures include: (a) electronic tolling of major roads; (b) subsidies for rail freight; (c) exploration of the transport implications of trends in telecommunications and of travel demand management techniques; (c) tighter air emissions standards; and (e) pursuant to Agenda 21, the development of comprehensive approaches to urban transport management and planning.¹⁵⁰

Goals for air emissions

The only stated air emissions goal is the commitment to return CO₂ levels to those of 1990 by 2000. Most other air emissions are expected to be reduced on a per-vehicle basis over the next decade or so but, because of increased traffic, overall levels will begin to rise again in 2012 unless further measures are taken. Details of expected declines in emissions as a result of current and planned actions are presented—but not in the form of goals, and not in ways that are specific to transportation. For example, by 2000 exceedances of the 5-ppb benzene standard recommended by the EPAQS should be virtually eliminated, as should the EPAQS-recommended 1-ppb standard for 1,3-butadiene and the 10-ppb 8-hour running average standard for carbon monoxide.¹⁵¹ The frequent exceedance in the UK of international criteria for ozone is noted; a 30 per cent reduction in emissions by 1999 is expected, but exceedances of the EPAQS-recommended 8-hour running average standard of 50 ppb may well continue.¹⁵²

Other goals

Noise and waste from transportation are addressed in the submitted documentation, but there is no indication of goals or expected changes.

Best thinking about EST

The UK government's thinking about EST is fully explained in the documentation, which includes a list of examples of research projects under way or planned within the Department of the Environment and notes that pertinent projects are also being undertaken or planned by the Department of Transport. There is no elaboration of other thinking in the UK but there are several references to the heightened level of debate on the topic, no doubt carried further by the Secretary of State's recent speeches and the October 1994 report on *Transport and the Environment* by the Royal Commission on Environmental Pollution.¹⁵³

A note submitted by the UK government to the United Nations Economic Commission for Europe¹⁵⁴ discusses the part that integration of land-use and transport planning can contribute towards delivering policies that work in the direction of sustainability. Overarching objectives for transport and land-use planning were proposed: (i) reducing the need for travel, particularly by automobile; (ii) promoting alternative modes of transport that have a less damaging impact on the environment; and (iii) making the best use of infrastructure. Key issues in the development of measures to meet these goals were stated to include: (a) locating development so as to reduce travel; (b) limiting low-density urban sprawl; (c) promoting use of public transport, bicycling, and walking; (d) rationalising the provision of parking; (e) facilitating the transport of freight by rail and water; and (f) managing infrastructure so as to reduce congestion, protect residential neighbourhoods, ensure efficient operation of public transport, and optimise maintenance.

4.15. United States

Overview

The submitted documentation comprises a comprehensive 41-page review prepared for the present study and supporting items. The review's introduction notes the major successes of the U.S. in reducing air emissions per vehicle-kilometre travelled, through mandated vehicle-design improvements and fuel improvements, and the lesser success in controlling the number of vehicle-kilometres travelled.

The review focuses on road vehicles but notes that control of non-road mobile sources and stationary sources must be part of a total air quality improvement plan. The broad scope and complexity of U.S. programmes cannot be captured in the space available here; accordingly, the present description is supplemented by Appendix 3, which lists the headings of the report submitted by the U.S. government.

Measures and plans

The main instrument driving improvements in the air quality impacts of transportation in the U.S. is the 1990 *Clean Air Act Amendments*. Geographic areas were designated according to the degree of non-compliance with National Ambient Air Quality Standards for ozone, carbon monoxide, and particulate matter. Target dates for compliance were set that varied with the degree of non-compliance. In the case of ozone, six types of area were designated, with compliance required by 1993 for the least non-compliant areas and by 2020 for the most non-compliant areas. In the case of carbon monoxide, the range in compliance dates for the three designated types of area was 1995 to 2000.¹⁵⁵ The schedule for particulate matter is under review, in part to put a stronger focus on the finer particulates emitted by diesel engines. All but the least non-compliant areas for ozone were required to submit plans showing how a 15 per cent or more reduction in ambient ozone levels would be achieved by 1996. Compliance is considered to be difficult for several of the areas showing severe or extreme ozone non-compliance. In the case of carbon monoxide, difficulty is expected only in the one geographic area in the most serious non-compliance category: the Los Angeles–South Coast Air Basin. For this air quality management district, especially effective vehicle inspection and maintenance (I/M) programmes will likely be required, as they will be to remedy ozone non-compliance.

The *Clean Air Act* requirements are buttressed by vehicle emissions standards issued by the U.S. Environmental Protection Agency, which are detailed in the submitted documentation.¹⁵⁶ Other requirements on manufacturers or users are also detailed, including inspection arrangements, mandatory on-board diagnostic systems for light vehicles, and requirements designed to reduce evaporative emissions. Proposed regulations concern shortcomings in testing procedures with respect to several matters include start-up, rapid speed changes, and the use of air conditioning. A tightening of standards for emissions of NO_x and particulate matter from heavy-duty vehicles is also expected.¹⁵⁷ Use of oxygenated gasoline is mandated in winter in metropolitan areas that do not meet carbon monoxide standards. Use of reformulated gasoline is required in several areas of ozone non-compliance.

Special requirements apply to California (and, recently, Massachusetts and New York) that are progressively increasing the proportion of sales of low-emission vehicles and will require manufacturers' sales to include 2, 5, and 10 per cent zero-emission vehicles in 1998, 1999, and 2003, respectively (i.e., zero emissions at the vehicle).¹⁵⁸ Fleets of ten or more centrally-fuelled vehicles in several other large ozone non-attainment areas are required to comprise progressively increasing proportions of low-emission vehicles. Other relevant programmes concern fuel additives and renewable fuels. The foregoing measures are supported by programmes to reduce solo commuting by automobile, fund public transport projects, promote bicycling, and secure better knowledge of travel behaviour.¹⁵⁹

Continuing measures with a specific impact on carbon dioxide emissions include the long-standing Corporate Average Fuel Economy (CAFE) requirements for progressive reductions in the rated fuel efficiency of vehicles sold and the graduated tax on inefficient vehicles (gas guzzler tax). The focus of current work is the Partnership for a New Generation of Vehicles (PNGV), which aims to develop by 2004 a prototype of an acceptable six-passenger automobile that has three times the fuel efficiency of current mid-sized vehicles and that meets rigorous emissions standards.¹⁶⁰

Goals for air emissions

Goals are expressed in terms of both ambient air quality and vehicle emissions. The ambient air quality goals for ozone and carbon monoxide are 0.12 ppm and 9.0 ppm, to be attained in different years, as late as 2020 in the case of ozone and 2000 in the case of carbon monoxide, according to the degree of non-attainment designated by the 1990 *Clean Air Act*.¹⁶¹ The goals for emissions from light-duty automobiles and trucks are too complex to be properly summarised here. They are broadly designated as Tier 1 and Tier 2 standards, with the former to be attained by 2002 and the latter after 2002. Compared with 1993 standards, Tier 2 speaks to reductions of 50 per cent in emissions per vehicle-kilometre of carbon monoxide and particulate matter and 80 per cent in emissions of NO_x. Tier 1 introduces standards for non-methane organic gas and non-methane hydrocarbons (i.e., VOCs); Tier 2 would lower permitted levels of these substances by 60 per cent. In California (and in other states that adopt its standards), the tighter standards are designed to result in even lower levels of these emissions other than carbon monoxide. There are no goals with respect to greenhouse gases, except those implied in the PNGV programme; i.e., a reduction of at least two thirds in carbon dioxide emissions per vehicle-kilometre.¹⁶²

Other goals

There was no mention in the submitted material of programmes or goals with respect to transportation-related noise or waste, or to transportation-related impacts on soil or water (except a note on wetlands protection).

Best thinking about EST

The submitted documentation lists several provisions in U.S. laws that are considered relevant to sustainable transportation. An itemisation appears in Appendix 3. Various other studies and activities are mentioned including U.S. participation in international research efforts, work on the total environmental impacts of transportation, work on the economic and environmental implications of different urban land-use and transportation configurations, and work on social equity considerations in transport improvements.

4.16. European Union

Overview

Six documents were submitted, three from the European Council of Ministers and six from the European Commission, devoted in large part to the Common Transportation Policy and to the concepts of sustainable development and sustainable mobility.

Measures and plans

The impetus for the Common Transportation Policy (CTP) of the European Union is the fostering of the economic and social cohesion of the Union, in accordance with Article 130b of the Maastricht Agreement.¹⁶³ Since the Fifth Environmental Action Programme, the need for improved integration between environmental and transportation policy has been recognised,¹⁶⁴ adding an increasing number of both continental and global environmental challenges to the CTP.

The Commission's Action Programme for the CTP for the period 1995-2000—the purpose of which is to give all institutions of the European Union and interested parties a clear indication of the Commission's policy intentions—comprises policies and initiatives in three areas: (i) improving the

quality of the transport system in terms of environment and safety; (ii) improving the functioning of the single market to promote efficiency, choice, and a user-friendly provision of transport services; and (iii) improving links with third countries and fostering the access of EU operators to other transport markets.¹⁶⁵

For reasons of environmental and health protection, and to ensure environmentally and socially compatible mobility, the Council believes Member states must consider the following in relation to their costs and benefits: (a) further optimisation of technology; (b) measures in all relevant fields that can reduce environmental impairment due to transportation to the greatest extent; (c) an overall shift from road and air traffic to rail and waterways; (d) payment of infrastructure costs and external costs by users of transport infrastructure, to the greatest extent possible, taking into account fair competition; and (e) measures to increase public awareness of the need for sustainable mobility.¹⁶⁶

Although the formulation of the CTP occurred at the EU level, the EU's concept of subsidiarity requires that decisions regarding the CTP be made at the most appropriate level.¹⁶⁷ Regarding aviation under the CTP, emphasis will be placed on completing harmonisation of rules and on the possible creation of a single European authority for air safety.¹⁶⁸ Regarding road pricing, steps will be taken to secure convergence in regimes applicable to different modes.¹⁶⁹

The Fifth Environmental Action Plan contains three additional measures or proposed measures of note: (i) the launching of environmental impact assessments of Trans-European Networks; (ii) a legislative initiative concerning the transport of dangerous goods by inland waterway; and (iii) two legislative initiatives concerning the pricing of road use and airport use to take account of environmental costs. The 1994 Progress Report on the Fifth Environmental Action programme singles out transportation as a particularly problematic sector from an environmental perspective. A Green Paper on external costs was adopted by the Commission in December 1995.

The Council considers that inspection and maintenance programmes will play an important role in reducing pollution from vehicles. It calls on Member states to accelerate implementation of programmes for the inspection of vehicles, as laid down in directive 92/55/EEC.¹⁷⁰

The Council has suggested that the Commission investigate the possibility of requiring by 2005 substantially lower fuel consumption and emissions for newly registered cars.¹⁷¹ In this respect, the Commission adopted in December 1995 a communication outlining a strategy to reduce CO₂ emissions from passenger cars and improve fuel economy. The strategy sets targets of 5 litres/100 kilometres for gasoline-fuelled vehicles and 4.5 litres/100 kilometres for diesel-fuelled vehicles, each corresponding to emission of about 120 grams of CO₂ per kilometre. Policy instruments to achieve these targets by 2005 (or beyond) are evaluated in terms of cost-effectiveness and equity considerations. Fiscal and non-fiscal options are discussed and proposed.

Goals for air emissions

The Community has set clear targets for CO₂ stabilisation; the transport sector is believed to be a key actor in the efforts necessary to achieve the stabilisation target of 1990 levels by 2000.¹⁷²

The transport sector accounts for 30 per cent of all energy consumption and for 25 per cent of transport-related CO₂ emissions within the EU. Road transport in particular consumes over 80 per cent of transport-related energy and is responsible for 75 per cent of all transport-related CO₂ emissions.¹⁷³ Calculations for CO₂ show that even with a 40 per cent increase in fuel efficiency in passenger cars by 2005, stabilisation of CO₂ would not be achieved by 2010.¹⁷⁴

Regarding vehicle air emission standards, the next step in the reduction of these standards will come into force for all new passenger cars in 1997. A further tightening is seen for 2000, for which proposals may well be made by the Commission in 1996. New EURO II limit values for new heavy-duty vehicles apply in 1996. Community legislation on regular in-service emission testing is being gradually implemented for different vehicle categories, a process that will continue until 1996. The maximum allowed sulphur content of diesel fuel will be lowered to 0.05 per cent in 1996. Some details are given in Table 4.

Table 4. EU Emission Limits for Cars (grams/kilometre).¹⁷⁵

Standard	CO	VOCs and NO_x	Particulates
Stage I (1993) gasoline and diesel	3.16	1.13	0.18
Stage II (1997) gasoline	2.20	0.50	—
diesel, indirect injection	1.00	0.70	0.08
diesel, direct injection	1.00	0.90	0.10

Other goals

Community action in the area of noise pollution around airports will focus on the establishment of a standard method of calculation of noise exposure levels and standard noise exposure indices, and on the introduction of noise monitoring, land-use rules, and noise zoning around airports. EU action will take account of the work of the relevant international organisations such as ICAO and ECAC.¹⁷⁶

Best thinking about EST

The EU's objective is to achieve sustainable *mobility* which, as defined by the 1992 *Green Paper on the Impact of Transport on the Environment*, refers to mobility or traffic movement that enables transport to fulfil its important economic and social functions while at the same time limiting its detrimental effect on the environment.¹⁷⁷

5. TOWARDS A CHARACTERISATION OF ENVIRONMENTALLY SUSTAINABLE TRANSPORT (EST)

In moving towards a characterisation of environmentally sustainable transport, consideration was given to the approaches noted in the material submitted by and from Member countries and to some of the academic and professional literature. This material is noted in Sections 5.1 and 5.2. Consideration was also given to input from the meeting of experts convened by the OECD in December 1994, in part to discuss the matter of defining EST. Some of this input is presented in Section 5.3. The most important input has

been the advice of the OECD's Task Force on Transport. This advice appears in Section 5.4. It sets the framework for the development of the definition and quantitative characterisation of EST that is described in Section 6.

5.1. Ideas about EST appearing in Member country material

Approaches to definitions of EST appear in several of the Member country reviews presented in Section 4. Some of these are as follows:

Austria: The National Environmental Plan outlined the following as what should be qualitative elements of sustainable transportation systems: (i) minimisation of ecological and health risks; (ii) minimisation of hazardous potentials and accident risks; (iii) precaution before repair; (iv) optimal energy efficiency and resource management; (v) employment of the most resource- and environmentally-friendly transportation technology and means of transportation; (vi) economic efficiency to reach the best possible economic use at the least possible damage; (vii) enhanced mobility for all; and (viii) support of transport systems which enhance the above principles in the most environmentally-friendly, resource-friendly and energy-efficient way.¹⁷⁸

Germany: The discussion of EST includes the following comments: "Individual transport is only appropriate when both its social and environmental effects adhere to the definitions of sustainability."¹⁷⁹ and "Mobility must be capable of being measured according to sustainability criteria. ... Accordingly, the following (in no particular order) must be addressed in any long-term EST strategy: air pollutants, climate protection, noise abatement, land and nature conservation, quality of residential surroundings and urban liveability, waste management/reduction, and enhanced mobility. ... Indicators or targets for such elements as land and nature conservation, the quality of urban life and enhanced mobility are not readily quantifiable."¹⁸⁰

Sweden: A project proposed by the Swedish Environmental Protection Agency is designed to answer three questions: what is meant by EST? what might EST look like? and how can EST be brought about? In discussing the first question, the project proposal makes the following points: (i) the overall long-range environmental goal—which is not negotiable—is that transport activities shall be made compatible with what man and nature can tolerate; (ii) consensus about what must be done to achieve EST is essential and will not be achieved without operationally useful goal formulations; (iii) initially it may be sufficient to show the main changes in current attitudes that are required and the magnitude of the measures needed to achieve the long-term goals; (iv) concrete, short-range (5-10 years) goals must be formulated that are consistent with the achievement of the long-term goals and are supported at a high political level; and (v) the formulation of operational and consistent goals in all necessary respects may not be possible without further conceptual development and further work on the impacts of transportation systems.¹⁸¹

United Kingdom: In the UK's *Sustainable Development Strategy*, a "sustainable framework" for transportation is outlined. It has the following objectives: (i) to strike the right balance between the ability of transport to serve economic development and the ability to protect the environment and sustain future quality of life; (ii) to provide for the economic and social needs for access with less need for travel; (iii) to take measures that reduce the environmental impact of transport and influence the rate of traffic growth; and (iv) to ensure that users pay the full social and environmental cost of their transport decisions, so improving the overall efficiency of those decisions for the economy as a whole and bringing environmental benefits.¹⁸²

European Union: In the Commission's 1992 *Green Paper on the Impact of Transport on the Environment*, sustainable *mobility* refers to mobility or traffic movement that enables transport to fulfil its important economic and social functions whilst at the same time limiting its detrimental effect on the environment.¹⁸³

5.2. Discussions in the academic and professional literature

Per Kågeson has provided what may be the most comprehensive approach to a definition in a paper entitled "The concept of sustainable transport,"¹⁸⁴ which has been relied on heavily in the present report. Kågeson, following both the Brundtland Commission and Herman Daly (see Sections 2.2 and 2.3), argued that the "objectives of sustainable transport ... must be to offer basic mobility to all citizens without damaging nature and the environment." He continued by suggesting that "formulating a policy for sustainable transport can in practice hardly be done without addressing all three issues: the basic needs for mobility today, the environment and the resources of the future, and the health hazards of today."¹⁸⁵ Several "threats" were examined in detail—e.g. emissions from vehicles of NO_x, SO_x, and CO₂—with a view to establishing limit values that could be part of an operational definition of EST. No formal definition was provided, but a process for arriving at EST was outlined, a process that spoke to the provision of clear intermediate and final objectives and a time-table for action.

Lee Schipper and **Daniel Sperling**, in a paper submitted for the present exercise entitled "Sustainable transportation: the future of the automobile in an environmentally constrained world,"¹⁸⁶ raised the following "challenges of sustainable transportation":

"Can growth in mobility from cars (and, increasingly, air travel) continue as long as fuel is relatively inexpensive and the carbon dioxide emissions of present-day fuels unimportant? Or will energy/environment problems hinder this expansion? Even if these fuel and environmental problems are solved by switching to nearly benign fuels or electricity, might not other transportation problems, notably congestion, sprawl, and noise, lead to a situation where an increment in transportation activity will cost society more than it brings in private and public benefits? Will changing perceptions of the 'sins' of transportation, the many externalities (such as congestion, noise, recycling of automobiles, etc.) lead to new transportation policies that restrain or even reduce mobility and thereby restrain energy use and emissions from transportation?"

Schipper and Sperling then suggested that if sustainable development means increasing the wealth of present-day generations without making future generations worse off, then a definition of sustainable transportation could be: "providing transportation services as long as those using the system pay the full social costs of their access, without leaving the unpaid costs for others (including future generations) to bear."¹⁸⁷

Tom Hart, in a paper entitled "Transport choices and sustainability: a review of changing trends and policies,"¹⁸⁸ did not offer a definition of sustainable transportation but in a section headed "The meaning of sustainability" distinguished between *ecological sustainability* and *subjective sustainability*. About the former Hart wrote, "[it] remains a fragile concept having a lesser impact on transport than many green writers advocate." This, he said, is because "The abstract needs of future generations and current equitable arguments for redistribution to the South face down-grading in the search for maintained growth and increased employment in the advanced world."¹⁸⁹ Subjective sustainability, wrote Hart, refers to the growth in "political and economic demand ... for less stressful, more qualitative and more cost-effective lifestyles which lead to greater moderation in resource use and cuts in CO₂ emissions."¹⁹⁰ He was building

towards the argument that actions towards achieving ecological sustainability might be successful only if they are compatible with how people want to live their lives, in which case “policy nudges and revised transport frameworks” may be effective.

Peter Nijkamp, in a paper entitled “Roads towards environmentally sustainable transport,”¹⁹¹ also stopped short of defining EST. He made some observations about *sustainable development* in the context of discussing EST:

“The concept of sustainable development is often narrowed down to environmental concerns, but it has to be recognised that a broader interpretation in terms of balanced (co-evolutionary) industrial, social, ecological, and economic development is more adequate. ... In general, sustainability refers to long-term availability of proper means that are necessary for a long-term achievement of pre-specified goals. ... Development is—ecologically—sustainable when long-run (per capita) social welfare improvement is not impeded by environmental deterioration, either through environmental amenities or through environmental productivity or through a combination of the two. The condition for sustainable development is that production and consumption patterns do not cause such environmental degradation, i.e., remain within boundaries set by the environment. These boundaries are expressed in terms of critical levels, quality standards, maximum sustainable yield or carrying capacity, resilience, vulnerability, fragility, etc.”¹⁹²

Nijkamp concluded his paper by arguing that “paving the road toward an ecologically sustainable transport solution” will require a phase of deregulation (to remove conventional government intervention) followed by a phase of environmentally sustainable regulation.

David Throsby, chair of the Australian government’s Transport Working Group established to recommend policy measures consistent with the achievement of ecologically sustainable development, set out some relevant principles in a paper entitled “Ecologically sustainable development and the transport sector.”¹⁹³ The six principles were: (i) advancement of material and non-material well-being; (ii) inter-generational equity; (iii) intra-generational equity; (iv) protection of biodiversity and the maintenance of ecological processes and systems; (v) dealing cautiously with risk and uncertainty; and (vi) recognition of global dimensions. He argued that the concept of an ecologically sustainable transport sector is intimately bound up with the broader question of what makes a sustainable city, and that ecologically sustainable cities will be characterised by: (a) better designed and more efficient public transit systems for passenger and small freight movement; (b) more efficient energy use within the transport sector; (c) more efficient resource use through waste management and recycling; and (d) better urban design in both aesthetic and functional terms. Also outlined were some ways in which long-distance passenger and freight transportation might be developed. No formal definition of EST was advanced. The comment was made that the translation of sustainability concepts into operational terms is difficult.

The OECD and the European Conference of Ministers of Transport (ECMT) set out a general strategy for approaching sustainable development with respect to urban travel in a report entitled “Urban travel and sustainable development.”¹⁹⁴ Sustainable development was discussed primarily in terms of the need to reduce emissions through setting targets: “... logic suggests that policy-makers should begin with world targets and work down through national targets to ones appropriate to the city or regional level. Targets need to be sectoral as well as global and need to cover not only CO₂ but all other types of emissions also. This will require international negotiation for which OECD and ECMT are well placed to take a lead.”

5.3. Advice given at the expert meeting

Material submitted by the Ministry of Environment, Forests, and Landscape for Switzerland in connection with the activities of the meeting of experts arranged for this project in December 1994 provides a comprehensive array of quantitative targets that might be used to characterise environmentally sustainable transportation. The specific targets are set out in Appendix 1. They are organised according to four domains: urban, suburban/residential, rural/remote, and global.

Extracts from the discussion at the meeting of experts follow. Each paragraph is based on the remarks of a member of the Expert Group. (The contributions of about a quarter of the members are represented here.)

“All relevant environmental threats must be reflected, as well the production, use, and disposal of transportation and infrastructure. The most important environmental problems related to the transport system are: (i) climate change and depletion of the ozone layer; (ii) spread of acidifying, eutrophication, and oxidant-forming substances; (iii) spread of metals and persistent organic compounds; (iv) local noise and pollution; (v) changes in the function and structure of the landscape; and (vi) damage to soil and other natural resources.”

“An abstract portrayal of sustainable transport should be developed; later, realistic region-related portrayals should be achieved. Concrete criteria for sustainable transport have to be defined, preferably numerical, e.g. emission reduction targets for different substances within a given time frame or intended environmental standards. The role played by the transportation sector in sustainable development has to be discussed. Freight and passenger transport must be treated separately.”

“Reflection and work are required in the articulation of numerical goals, which will not have the same expression from place to place. We need clarity and agreement on the goals/criteria for defining EST: about parameters, the ranges of values, the way to assess and measure the importance of given values in given areas and about how these numerical values are and can be built into the specific mechanisms that national, regional, and local officials use to make transport decisions.”

“A comprehensive definition of EST should address the negative side effects of transportation on different geographic and time scales that in the end are all caused at the local scale. Subgoals should be established for local (accidents, air quality, noise, public space), regional (air quality), and global (greenhouse gases, ozone layer, resource use) scales. ... It should not be forgotten that growing congestion in urban areas, and megacities in particular, is becoming one of the most severe causes of adverse effects on people and on the environment.”

“Where possible, requirements should be quantified—otherwise they should be described qualitatively—in global, regional, and local terms. Where possible, define criteria in positive terms, especially at the local level, to give them popular appeal; examples are: health standards, air quality standards, noise standards, ratio of undisturbed space for human activities to traffic-dominated space; ratio of walking space to driving and parking space, and avoided costs due to avoided environmental damage. The earliest possible attainment of EST must be considered; a concrete schedule and agenda for attaining EST must be established, with short-term and long-term components. A combined approach to local, regional, national, and international levels should be considered.”

5.4 Direction given by the Task Force on Transport

The Task Force on Transport held an informal workshop in July 1995 in connection with the present study to guide preparation of this report. Several points were made at the workshop in connection with the development of a definition and characterisation of EST, including the following:

- Sustainability has three aspects: environmental, social, and economic. The characterisation should be chiefly concerned with the environmental aspect, but may make reference to social and economic aspects, notably fairness and practicality.
- The characterisation of EST should be expressed in two ways: (i) a short qualitative definition that may have an explanatory preamble; and (ii) a definition in terms of quantitative criteria, which should be few in number and selected in a clearly articulated manner
- The characterisation and definition should be such as to allow that EST systems can vary according to circumstances and to provide that they must (i) not endanger public health or ecosystems; (ii) be compatible with sustainable development, including sustainable resource use; and (iii) meet mobility needs to the greatest extent possible within the foregoing.

The Task Force endorsed the use of the matrix in Table 5 as an overall expression of the scope and organisation of a characterisation of EST. The matrix arranges possible objectives by type (whether they concern public health, ecosystem quality or resource management) and domain (global, regional or local). Criteria developed with respect to some or all of the objectives would provide an operational definition of EST.

The Task Force considered adding a column for mobility objectives. However, after reviewing the purpose and scope of its work on EST, the Task Force decided that the focus should be on formulating the *environmental* criteria for sustainable transport, while recognising that countries developing and implementing sustainable transport policies and strategies would need to formulate mobility objectives (presumably leading to measurable criteria) as well as environmental objectives and criteria.

The Task Force also considered including in the table a column of what were described as “environmental threats.” In the global domain the threats were stated as climate change, ozone depletion, and natural resource depletion; in the regional domain the threats were photochemical oxidants, eutrophication, metals and toxic organic pollutants, and exploitation of land and water (including urban sprawl); in the local domain the threats were urban air pollution and noise, and urban sprawl.

The Task Force noted that whereas the global domain might be clearly distinguishable from the regional and local domains, the difference between regional and local is less clear and requires attention.

At its meeting in November 1995, the Task Force reviewed a draft of the present report. It decided that the four criteria for EST developed in the draft—concerning fossil fuel use, nitrogen oxides, volatile organic compounds, and land use in urbanised areas—should be amended and expanded. Specifically, it asked that criteria be added concerning noise and particulate matter, that some attention be given to the effects of inter-city transportation corridors on landscape, ecosystems, and biodiversity, and that health impacts be given more emphasis in the specification of the criteria. After considering the proposal to use fossil fuel consumption as a surrogate for carbon dioxide emissions, the Task Force decided that this criterion should be expressed more directly in terms of CO₂ emissions from non-renewable sources. It also suggested that the criterion concerning emissions of volatile organic compounds

be more stringent for carcinogenic substances than for other VOCs. These various proposals, except the concern about inter-city corridors, have been incorporated into the quantitative characterisation of EST developed in Section 6. (A criterion concerning inter-city corridors has been left undeveloped on account of the complexity of the matter and the time available to complete this report. The topic should be revisited during a later phase of the study.)

Table 5. Potentially measurable transportation impacts arranged by domain and type of objective.

Domains	Types of objective		
	Public Health	Ecosystem Quality	Resource Management
Global	Stratospheric O ₃ Persistent compounds	Greenhouse gases Stratospheric O ₃ Biodiversity	Energy use Materials use Recyclability
Regional	Tropospheric O ₃ Persistent compounds	Tropospheric O ₃ Acidification (NO _x , SO _x) Persistent compounds Nitrogen deposition	Land use Energy use Waste
Local	O ₃ , VOCs, PM Carcinogens Individual health and quality of life Noise Safety	Impacts on the urban ecosystem, including landscape and separation of functions by transport and its infrastructure	Damage to buildings Energy use Land use Waste

6. CHARACTERISATION OF EST

Most of this section comprises elaboration of *quantitative* criteria for EST. Section 6.1 provides a brief *qualitative* definition.

6.1. A brief qualitative definition of EST

The brief qualitative definition of EST proposed below takes its cue from Herman Daly's thinking¹⁹⁵ and from the discussion of the Task Force on the topic in July 1995. The proposed brief definition of EST is this:

Transportation that does not endanger public health or ecosystems and meets mobility needs consistent with (a) use of renewable resources at below their rates of regeneration and (b) use of non-renewable resources at below the rates of development of renewable substitutes.

An expanded qualitative definition would likely include recognition that EST is a concept for the longer term to be achieved through the attainment of several intermediate steps.

6.2. Selecting quantitative criteria

The Task Force proposed that the quantitative characterisation of EST involve *few* criteria and invited choice among a range of criteria of the kind indicated in Table 5 and Appendix 1. The point was made that a few strong, simple signals are needed in order to penetrate the way an economy works. When the decentralised actions of millions of different actors are required, the simpler and clearer the signals the better, even if there is risk of “not getting it completely right.” Thus what may be required is a set of no more than, say, six environmental criteria concerning the impacts of transportation systems. The criteria should be such that progress consistent with meeting the criteria should provide comfort that transportation systems are moving towards sustainability.

In order to attain the long-term protection of human health ecosystems and precious resources, the primary concerns associated with the transport sector are to achieve air quality objectives, prevent climate change, reduce noise levels, preserve arable land, and protect sensitive ecosystems.

Given these protection objectives, motor-vehicle-related criteria may be derived. The six criteria proposed here concern: (i) emissions of nitrogen oxides (NO_x), (ii) emissions of volatile organic compounds (VOCs), (iii) emissions of suspended particulates, (iv) carbon dioxide emissions from fossil fuel use, (v) use of land for motorised transport in urban areas, and (vi) noise. They were selected so as to touch as many as possible of the cells in Table 5 and the specific items in the cells. The six chosen here address the widest range of domains (global, regional, and local) and the widest range of types of objective for EST (public health, ecosystem protection, and resource management). The logic for the selection of the six criteria is as follows:

- The need for a criterion concerning reductions in emissions of **nitrogen oxides** is based on the supposition that heat engines of one form or another, on-board or remote, might continue to be used to provide energy or traction for transportation. Nitrogen oxides are produced whenever air is involved in high-temperature combustion processes. NO_x are major contributors to ozone formation and acid deposition.
- The need for a criterion concerning emissions of **volatile organic compounds** is based on the supposition that carbon compounds, whether renewable or not, might continue to be used as fuels. Emissions of VOCs can occur whenever there is combustion of carbon compounds, the result of incomplete combustion spillage or evaporative emissions. VOCs contribute significantly to formation of excess ground-level ozone.
- The need for a criterion concerning **suspended particulate matter** is also based on the supposition that carbon-based fuels might continue to be used. (Particulate matter from motor vehicles usually consists of numerous compounds absorbed on a solid carbonaceous core, but sulphates, nitrates and other compounds can be implicated; secondary particulate matter can result from the transformation in the atmosphere of gaseous combustion products.) Such a criterion reflects, furthermore, the progressive substitution of diesel fuel

for gasoline noted in Section 3.1, the much higher rate of emission of particulate matter from diesel engines, and the observation by the United Nations that suspended particulate matter is the most severe air pollution problem affecting the world's largest cities.¹⁹⁶

- To prevent climate change, greenhouse gas emissions need to be reduced. The criterion concerning emissions of **carbon dioxide** from fossil fuel use reflects concern about the contribution of such emissions to potential climate change, discussed in Section 3.2.
- The criterion concerning **use of urban land for motorised transport** is the most novel criterion among the six proposed here. It was chosen to capture a range of adverse impacts including those arising from inhospitality towards pedestrians and bicycle users, excessive paving, and urban sprawl (see Section 3.3).
- The proposed criterion concerning **noise** reflects the potential for any mechanised system to cause adverse impacts through noise, affecting health of humans and possibly that of other organisms. As noted in Section 3.3, in Europe noise is often felt to be a greater concern than transport-related air pollution. Noise may become especially important with the application of the criterion concerning land use, which could bring mechanised transport systems and everyday human activity into closer proximity.

The criteria were selected to be comprehensive as to type of fuel and type of transportation system, bearing in mind present concerns. In particular, the criterion concerning NO_x would be relevant whatever kind of heat engine might be employed for transportation, on-board vehicles or remotely. The criteria concerning VOCs and particulate matter would be relevant whatever organically-based fuels might be used, whether or not they were derived from fossil fuels. The criteria concerning land use and noise would be relevant whatever kind of mechanised transportation system might be used, collective or individual, remotely or locally powered.

It should be stressed that the selection of only six criteria, and the particular selection proposed here, are preliminary; critical review and comment are invited. A notable omission from the six is a criterion concerning ambient ozone levels, an omission that is addressed below in Section 6.3. Other notable omissions concern accidents and waste. The development of criteria for EST should be a process that evolves in the light of accumulated knowledge and analysis and will undoubtedly evolve during the course of the present study.

Where appropriate, the criteria should be applied within the context of a full life-cycle analysis of kind the noted above in the presentation of the Finnish approach to sustainable transportation (see Section 4.6) and endorsed by the Nordic Council of Ministers.¹⁹⁷ A life-cycle approach means for transport that the impacts of production, use, and disposal are considered for all vehicles, infrastructure, and fuels. In one example of the application of a life-cycle analysis, North American gasoline-fuel passenger cars were found to emit 73 per cent of their greenhouse gas emissions (in carbon dioxide equivalents) during operation, 18 per cent in connection with the production and distribution of fuel, and 10 per cent in connection with vehicle manufacture.¹⁹⁸ (Infrastructure components of life-cycle impacts were not included in this application.)

A final point concerns the time frame for achievement of EST. The year 2030 was selected here as a compromise between earlier and later dates mentioned during the discussions at the Expert Group and Task Force meetings. Part of the reasoning is that current problems have been generated within one generation or two and probably could be solved within the same kind of time period. A later year could be used as the target for achievement of EST, but if this is done the challenge could become somewhat

greater, at least in non-OECD countries, because of the growth in population and consequent demand for transportation. If an earlier year is used the challenge is greater, especially for OECD countries, because the rate at which change must occur is greater.

The present preliminary establishment of criteria concerns this target year only. Development of guidelines for the achievement of EST, whether internationally or as part of a national strategy, will almost certainly involve not only the refinement of the criteria but also the setting of intermediate criteria in the form of five- or ten-year milestones.

6.3. Criteria concerning air quality

Overview

Transportation emissions of local and regional concern include nitrogen, carbon monoxide, sulphur oxides, particulate matter, and various metals. They also comprise volatile organic compounds (VOCs) including 1,3-butadiene, acetaldehyde, formaldehyde, benzene, polycyclic aromatic hydrocarbons, and other carcinogens arising for the most part from incomplete fuel combustion (some of which are technically VOCs but are often treated separately because of their different health and ecological effects). The impact of most concern is ground-level ozone (also known as smog), which is not an emission but rather the result of the action of sunlight on emissions.

Other things being equal, emissions or ambient levels of all of these substances vary with fossil fuel use. Thus adherence to the global criterion for carbon dioxide set out in Section 6.4 could result in comparable reductions in many other pollutants. However, there are two reasons for selecting one or more criteria in the regional or local domains.

The first is that the criterion concerning CO₂ elaborated in Section 6.4 can be met without reducing the amount of combustion of carbon-based fuels. This could happen, at least in theory, through the use of renewable carbon-based fuels such as ethanol from sugar cane and methanol from wood waste (although in practice the market may be quite unable to provide sufficient quantities of such fuels). In this event, emissions and ambient levels of some of the pollutants discussed here may not decline significantly; in some cases, levels may increase. Thus at least one additional criterion may be needed to ensure pollution control consistent with sustainability.

The second reason for going beyond a CO₂ criterion is that, generally speaking, it is practicable to secure large reductions in emissions to achieve acceptable ambient air quality levels of substances other than CO₂ at an early date; and, indeed, such large reductions are being sought. The last point is evident from Table 3 on Page 25, where it can be seen, for example, that Austria is seeking 70 per cent reductions in total emissions of both nitrogen oxides (NO_x) and volatile organic compounds (VOCs) by 2005, but only a 20 per cent reduction in overall CO₂ emissions by 2005; likewise Denmark is seeking 60 per cent reductions in emissions of both NO_x and VOCs by 2030, but only a 25 per cent reduction in CO₂ emissions by the same year.

Nitrogen Oxides (NO_x)

There are several reasons for considering a criterion based on NO_x emissions: (i) ambient NO_x causes respiratory problems in humans and damage to plants; (ii) NO_x is an important contributor to acid rain, acid deposition, and eutrophication, which can alter the ecosystems of water bodies, forests, and meadowlands; and (iii) NO_x is a precursor to the formation of ground-level ozone, discussed in Section

6.3. In many parts of Europe, critical loads for acidification and eutrophication are exceeded by a factor of two to four, indicating that ecosystems are at risk of being damaged and their sustainability endangered.¹⁹⁹ In addition to its local and regional effects, NO_x can have global effects in that it can contribute to global warming, directly and indirectly.²⁰⁰ In the United States, transportation accounts for 43 per cent of NO_x emissions; in Europe it accounts for 60 per cent.²⁰¹

NO_x is produced whenever atmospheric nitrogen is involved in a combustion process at high temperatures such as occur in internal combustion engines. NO_x emissions can be reduced by lowering the combustion temperature, but at the risk of increasing emissions of carbon monoxide and VOCs. NO_x emissions can also be reduced by passing exhaust gases through three-way catalytic converters. When functioning (i.e., when the engine is properly tuned, and the exhaust system is hot and not contaminated with lead or other substances), three-way catalytic converters are capable of removing 75-95 per cent of NO_x from exhaust gases (and similar proportions of VOCs and carbon monoxide). Diesel engines, which operate at higher temperatures and whose exhaust gases cannot be cleaned with present three-way catalytic converters, are responsible for a relatively large proportion of atmospheric NO_x.²⁰²

Notwithstanding the potential for removing NO_x, emissions of NO_x from vehicles are expected to increase during the early part of the next century and be more than 40 per cent higher worldwide in 2030 than in 1990, largely on account of increases in non-OECD countries. However, even in OECD countries, transportation-related NO_x emissions are expected to fall during the same period by only 20 per cent.²⁰³ This is far short of the 90 per cent reduction in ambient NO_x levels claimed necessary for Europe by Per Kågeson.²⁰⁴

The just-mentioned 90 per cent reduction claimed necessary in ambient NO_x levels can be compared with the difference between what is estimated to be the critical level for NO_x, stated to be an annual mean of 30 µg/m³,²⁰⁵ and the estimated average levels of 120, 40-50, and 10 µg/m³ due to transport in urban main streets, urban residential areas, and rural areas, respectively, in Germany.²⁰⁶ In urban areas of other countries, NO_x levels due to transport can be much higher.²⁰⁷

Standards for NO_x can be stated as vehicle emissions (grams/kilometre or grams/kilowatt-hour) and as ambient air levels (parts/billion or micrograms/cubic metre, averaged by the hour, day or year). The objective of pollution control is to reduce ambient air levels, but vehicle emissions can be specified and controlled more directly. Thus, although the overall objective might be to reduce ambient NO_x levels by 90 per cent, the transportation-related objective might be better expressed in terms of reductions in emissions from the use of vehicles, either at the vehicle or remotely (as in the case of electric vehicles).

Current emissions controls result in emissions of NO_x from light-duty road vehicles of 0.62 grams/ kilometre. Advanced controls are already capable of reducing that level to 0.12 g/km,²⁰⁸ i.e., a reduction of just over 80 per cent. Available advanced control technology can reduce NO_x emissions from heavy-duty road vehicles by about 70 per cent.²⁰⁹ Thus, a reduction by 90 per cent from transport over the next 35 years may well be possible, although the overall reduction might comprise a greater contribution from light-duty than from heavy duty vehicles. To sustain a 90-per-cent reduction in ambient NO_x levels resulting from transport in spite of traffic growth, the average reduction per vehicle-kilometre would have to be greater than 90 per cent. A reduction in vehicle-kilometres travelled or, more precisely, fuel use, would likely contribute to abatement of NO_x emissions.

Volatile organic compounds (VOCs)

There are several reasons for considering a criterion based on emissions of VOCs: (i) many VOCs have direct toxic effects on humans and animals, including carcinogenesis and neurotoxicity, and

are harmful to plants; and (ii) many VOCs are photochemically reactive, i.e., in the presence of sunlight they contribute to the formation of ozone. Moreover, some VOCs (e.g. methane) are radiatively active and thus contribute to potential climate change. In the United States, transportation accounts for 48 per cent of emissions of VOCs; in Europe it accounts for 50 per cent.²¹⁰

A difference between emissions of NO_x and VOCs is that NO_x emissions are more likely to result from the operation of heavy-duty (diesel) engines, whereas the emissions of VOCs are more likely to result from the operation of light-duty (gasoline) engines. Indeed, gasoline-fuelled vehicles account for about 90 per cent of the VOCs generated by road transport. Of the gasoline-vehicle portion of road-transport VOCs, 30-50 per cent arises from fuel evaporation during vehicle use or during refuelling and the remainder from tailpipe emissions of unburned fuel. VOCs from diesels are almost entirely composed of unburned fuel in tailpipe emissions.²¹¹

For similar reasons to those given for NO_x, the criterion for VOCs should be set in terms of total emissions rather than ambient levels. Technically, by improvements to engine design, fuels, fuel systems, and exhaust systems, it should be possible to virtually eliminate emissions of VOCs due to transportation. This argues for very low emission limits. Estimates of reductions possible with existing advanced control technology support this option.²¹²

However, a very stringent criterion may be justified on health and other grounds only in respect of VOCs that are known or suspected carcinogens, notably 1,3-butadiene, benzene and PAH associated with particulate matter and products of incomplete combustion. Motor vehicle exhaust is the source of 94 per cent of current emissions of 1,3-butadiene in the U.S, a compound which the U.S. Environmental Protection Agency considers to be, by a wide margin, the most dangerous (in terms of cancer risk) air toxicant emitted by motor vehicles. This VOC is also believed to be genotoxic and possibly responsible for other adverse health effects including heart, lung, and blood disease.²¹³ Another VOC of concern is benzene, which has been identified as a carcinogen causing leukaemia in humans. Motor vehicles are the source of 85 per cent of benzene emissions in the U.S.²¹⁴ There is considered to be no safe level for airborne 1-3-butadiene, benzene, and carcinogenic PAHs as they present a cancer risk for humans.

Accordingly, the criterion for VOC involves consideration of carcinogenic VOCs, as well as stringent VOC controls to prevent photochemical smog formation.

Ozone

A critical factor to consider when reviewing criteria concerning emissions of NO_x and VOCs is ambient ozone levels. In temperate climates, high ambient levels of ozone (smog) comprise the most pervasive air pollution problem associated with transportation. Smog episodes can result in the immediate hospitalisation of vulnerable people.²¹⁵ Ozone is known to be formed by the action of sunlight on vehicle emissions, notably NO_x and VOCs. The recent assessment made under the UN ECE Convention on Long-Range Transboundary Air Pollution showed that “critical levels” for ozone, i.e., “the concentrations above which adverse effects on plants, ecosystems or materials may occur”, were exceeded by a factor of four.²¹⁶ A challenge concerning ozone is that ambient levels appear to have *increased* in some countries in spite of impressive improvements in the ability of pollution control technology to reduce unit emissions of NO_x and VOCs.

Part of the response to this challenge may be that the relationship between ozone formation and NO_x levels in particular is complex, and that high NO_x levels can be associated with *low* levels of ozone production. This may happen because of scavenging of ozone during the production of NO_x from the nitric oxide created during combustion. Catalytic converters that remove NO_x may thus, under certain

circumstances, contribute to *increased* ozone levels. Other emissions that scavenge ozone may also be removed by pollution control systems.²¹⁷ The relation between ozone formation and levels of VOCs is also complex.

The most effective control strategy to reduce peak ozone levels involves reducing emissions of both NO_x and VOCs. As long as the internationally accepted air quality guideline for ozone (70 parts per billion, one-hour average) is exceeded by a factor of two to four in many OECD countries, considerable reductions in emissions of precursors will be necessary to meet currently acceptable ozone levels. If critical levels of ozone as defined by UN ECE experts as necessary to protect agricultural crops and trees (40 parts per billion, accumulated exposure) are to be attained, reduction in precursor emissions of 70-80 per cent or more will be needed. Meeting the ozone air quality level is the most powerful driving force for achieving emission improvements and to protect human health and vegetation in the long-term.

Meeting WHO air quality guidelines and critical levels of the UN ECE for ozone would call for a very large reduction of present and future motor vehicle emissions of NO_x and VOCs (and other emissions implicated in the formation of ozone).

Particulate matter

Suspended particulate matter has been noted in Section 6.2 as the most severe pollution problem affecting the world's largest cities, although only a part of the amount in the atmosphere in any particular location can be attributed to motor vehicles, chiefly heavy diesel vehicles. Suspended particulate matter penetrates the pulmonary system to a degree depending on the size of the particle. Particles with a diameter of less than 2.5 µm are small enough to penetrate to the deep lung and stay there. Most particulates from diesel exhaust are in this category arise primarily through incomplete combustion of fuel. They contain unburned hydrocarbons, oxygenated hydrocarbons, known carcinogens such as benzo(a)pyrene and other polycyclic aromatic hydrocarbons (PAH), inorganic species such as sulphur dioxide, nitrogen dioxide, and sulphuric acid and sulphates.²¹⁸ These and larger particles can be a cause of or contribute to cancer and various respiratory disorders. For London, England, the suggestion has been made that a 10 per cent reduction in atmospheric particulates would result in several hundred fewer early deaths.²¹⁹ While it is generally only in urban areas that these pollutants are present in amounts exceeding current WHO air quality guideline values and national standards, they also contribute to several forms of environmental degradation on the regional and global levels, including photochemical smog, visibility impairments, and arctic haze.

Reduction in emissions of particulates from diesel vehicles can be achieved through use of trap-oxidisers, cleaner fuels, low sulphur fuels and also by running engines at higher temperatures (which can raise NO_x emissions). Reductions in the order of 90 per cent in per-kilometre emissions of particulates from 1993 levels are anticipated in actual and proposed European Union emission limits.²²⁰ Furthermore, because potential carcinogens are involved, more stringent reductions may be needed.

6.4. Criterion concerning CO₂ emissions from fossil fuel use

At the global level, the predominant transportation-related concern is climate change resulting from anthropogenic emissions of greenhouse gases. The greatest contribution in this respect comes from emissions of carbon dioxide resulting from combustion of fossil fuels. In 1990, the transport sector (including passenger travel and freight movement by road, rail, air and water) accounted for about 22% of CO₂ emissions from energy use. Moreover, for a given vehicle technology—e.g. using or not using a

catalyst—the other air pollutant emissions will also be roughly proportional to the volume of fuel consumed. One of the criteria for EST should therefore address CO₂ emissions.

The Second Assessment Report of the Intergovernmental Panel on Climate Change maintains that, in order to stabilise atmospheric CO₂ concentrations at near current levels, worldwide CO₂ emissions would need to be reduced immediately by 50-70 per cent, with further reductions thereafter.²²¹ Several authors have argued that reductions of 80 per cent or more per capita should be achieved in industrialised countries in order to allow for increases in emissions in countries that are presently responsible for very low levels of emissions.²²²

Few of the impacts of transportation are unique to transportation. As noted in Section 3.2, the proportion of anthropogenic CO₂ emissions from transportation is rising. A case could be made that the importance of transportation warrants some exemption or relaxation in an approach to sustainability, especially where it can be demonstrated that CO₂ reductions in other sectors can be achieved more cost effectively. But it appears that the contrary applies. Important progress has already been achieved in the industrial sector although it is possible to go further. In the residential and commercial sectors, progress has been necessarily slow. For automotive fuel efficiency, progress could be both technically significant and rapid.

Although countries will want to assess their most cost-effective measures for CO₂ reduction across sectors, several factors argue against exempting transportation emissions in any way. The first is the agreement among most of the world's nations at UNCED in Rio de Janeiro in 1992 that sustainable development should be sought in all sectors of human activity (see Section 2). This means that the transport sector should respect the same environmental limits as apply to other human endeavours. The second factor is that most current projections in respect of transportation, particularly in respect of fossil fuel use, may be so evidently in the wrong direction as to warrant the kind of drastic activity that can be achieved only if ambitious goals are set. The third factor is that, in principle at least, application of *effective* measures could produce rapid and significant results. The fourth—and most important—factor is that it is hard to see how greenhouse gas reduction could be achieved at all without reducing transport emissions significantly.

The criterion for CO₂ can be specified in terms of emissions of the gas from fossil fuel use or in terms of the actual consumption of fossil fuel. The two are essentially equivalent, although allowance has to be made for differences in carbon:energy ratios among fuels. Fuel use is presently easier to measure than CO₂ emissions and may therefore for the moment be more practicable as the basis for a criterion. Moreover, a criterion in terms of fuel use has the advantage of directly addressing concerns about resource use, which may become at least as strong as concerns about CO₂ emissions, a point noted in Section 3.1. However, a criterion expressed in actual CO₂ emissions would more precisely address the emissions-reduction objective and may allow for more flexible responses to certain regulations.

Per Kågeson has provided a table showing prescriptive linear reduction of CO₂ emissions from transportation per person for Western Europe for the period 1992 to 2050.²²³ The table provides for an 80 per cent reduction over the period, from 2.20 to 0.44 tonnes of carbon per capita. Given the possible urgency to reduce CO₂ emissions and the large needs of non-OECD countries—driven by ongoing population growth and economic development—the criterion for OECD countries might well be set for 2030 rather than by 2050.

The criterion does not specify the levels from which the reduction is to occur. The problem here is the wide variation among OECD countries, as is shown in Table 6. For the moment, the amounts to be

reduced could be stated in terms of initial country values, but there might also have to be a process of harmonisation towards a criterion expressed in absolute values.

Table 6. Transportation-related CO₂ emissions in 1991 for selected OECD Member countries (tonnes per inhabitant).²²⁴

United States	5.8	Sweden	2.5	Greece	1.9
Canada	4.7	U.K.	2.4	Italy	1.9
Australia	4.1	France	2.3	Ireland	1.9
Norway	3.2	Germany	2.3	Portugal	1.3
Switzerland	2.6	Netherlands	2.3	Turkey	0.5

The criterion should concern CO₂ emissions arising from transport-related fossil fuel combustion only. That does not mean, however, that treating fuels on a life-cycle basis should be ignored. Emissions of CO₂ from the combustion of renewable organic materials become part of the recycling of carbon between the atmosphere and the planet's surface and make no contribution to potential climate change.

Concern has been expressed by some members of the Task Force as to whether the criterion for a significant reduction in CO₂ emissions from fossil fuel use is realistic, and thus worth proposing. For the moment, it can be noted that the transportation chapter of the new IPCC report²²⁵ includes the following:

“If users were prepared to accept changes in vehicle size and performance, transport energy intensity could be reduced by 60 to 80 per cent in 2025. With energy-intensity reductions, the use of alternative energy sources could, in theory, almost eliminate greenhouse-gas emissions from the transport sector after 2025. A complete transition to zero-greenhouse-gas emission surface transport is conceivable, but would depend on eliminating emissions throughout the vehicle and fuel-supply chain.”

The CO₂ criterion should be examined regularly and adjusted in the light of new information. One cause for examination will be advancement of national plans for implementing the Framework Convention on Climate Change.

6.5. Criterion concerning land use

The use of land for transportation purposes, particularly in and near urban areas, has numerous adverse effects including direct impacts on liveability and on ecosystems. Moreover, as noted in Section 3.3, urban sprawl magnifies the need for transportation; it is associated with high levels of automobile ownership and use and resulting emissions. As also noted there, proportions of urban land devoted to transportation are often in the range 25-35 per cent and in some cities may be much higher.

A criterion that addresses the set of problems associated with the use of land might speak to limiting the proportion of land surface set aside for the operation, maintenance, and storage of motorised vehicles of all kinds (e.g. to 10 per cent). Identification of the actual proportion consistent with sustainability requires further work; the proportion is likely to be much less than what currently applies, even in long-established urban areas where priority is given to collective transport. What is offered here is an extremely preliminary formulation of an EST criterion for land use in urban areas—one that may

facilitate the preservation of ecosystems and the enhancement of equity and conviviality. It should be stressed that the kind of criterion proposed here refers to land for *motorised* vehicles, which in some parts of some cities is already less than half of the land devoted to transportation (including pedestrian movement).

Urban regions differ widely in the amount of land devoted to motorised transportation and may well encounter widely differing difficulties with respect to reaching a fixed criterion of this kind. An alternative formulation of a land-use criterion that is more sensitive to such differences will likely be developed during subsequent phases of the present study.

6.6. Criterion concerning noise

Noise finds a place among these criteria on account of the high level of concern about noise from motorised transport and the possible adverse impacts of noise on human health and quality of life. The U.K. Royal Commission on Environmental Pollution in its 1994 report entitled *Transport and the Environment*, concluded for these reasons that “present exposure to noise is environmentally unsustainable.”²²⁶

Excessive noise is known to cause hearing loss and may contribute to stress-related health problems including raised blood pressure and minor psychiatric illness. Noise can interfere with sleep and thus may contribute to accident proneness and reduced immunity to disease. Foetal growth may be inhibited and birth weights reduced as a result of exposure to high noise levels. In animals, exposure to noise has caused still births, birth defects, and reduced birth weights.²²⁷

What may not be available is clear evidence that ordinary loud noise from road traffic is harmful in any of these ways, as opposed to merely being irritating. Ordinary loud noise from road traffic on busy streets results in nearby sound level meter readings of some 65 dB.^{228†} The World Health Organisation has recognised noise as a health hazard and has suggested that day-time outdoor noise levels should be less than 55 dB (57 dB for aircraft noise) and that they should not exceed 65 dB. A report for the German government has suggested that night-time noise levels of 40 dB can lead to disturbed sleep, inability to concentrate, and an increase in noise-related illnesses such as cardiovascular disease.²²⁹ Thus day-time and night-time levels of 55 and 40 dB respectively (as perceived by the non-motoring public) may be those at which no harm results from noise.

6.7. The proposed criteria for EST

Quantitative criteria of environmental quality have been adopted in many OECD countries. Air quality standards are an example. Where such standards do not exist, WHO air quality guidelines provide quantified objectives. From these air quality objectives most countries have derived emission reductions needed to meet the objectives. What is proposed here is that transportation will be able to be characterised as environmentally sustainable in OECD countries in the target year of 2030 to the extent that the following conditions are met:

† Measures of noise are expressed in various kinds of decibels (dB), which refer to logarithmic scales of physical noise intensity. Decibels here mostly refer to what is known as dB (A) or dBA, assessed using sound meters adjusted to correspond to the frequency range detectable by the normal human hearing system. Subjectively, a reduction by 10 dB corresponds approximately to a halving of noise intensity.

- 1. Transport-related NO_x emissions have been reduced to the extent that the objectives for ambient NO₂ and for ozone levels as well as for nitrogen deposition are achieved.**
- 2. Emissions of VOCs have been reduced to the extent that excessive ozone levels are avoided, and emissions of carcinogenic VOCs from all movement of all vehicles have been reduced to meet acceptable risk levels.**
- 3. Emissions of particulates have been reduced to the extent that harmful ambient air levels are avoided.**
- 4. Climate change is being prevented by achieving per-capita carbon dioxide emissions from fossil fuel use for transportation consistent with the global protection goals for the atmosphere.**
- 5. Land surface in urban areas is used for the movement, maintenance, and storage of motorised vehicles, including public transport vehicles such that the objectives for ecosystem protection are met.**
- 6. Noise caused by transportation should not result in outdoor noise levels that present a health concern or serious nuisance.**

Where appropriate, national ambient air quality standards—or if not available, the international Air Quality Guidelines of WHO or Critical Levels and Loads of the UN ECE—for major air pollutants will be met (i.e., no exceedances will be tolerated).

The conditions of 2030 are unknowable, or at least not more knowable than today's conditions were knowable in 1960. Much could change between now and 2030 that could make one or more of the above criteria for EST irrelevant and may impel consideration of other criteria. All that can be said is that, from the perspective of the mid-1990s, these criteria seem to be the most comprehensive and relevant. They should be reviewed frequently and adjusted accordingly, both during the present study and subsequently.

The Task Force on Transport asked that the characterisation of EST be such as to allow for the meeting of mobility needs, within environmental limits. This aspect of a definition is not readily quantifiable and thus has not been considered in selection and elaboration of the quantitative criteria. Moreover, some specifications of mobility needs might reduce the flexibility available to participating countries in the construction of scenarios during the next phase of this study (see Section 1.1). Mobility needs have been included as a factor in the proposed brief qualitative definition proposed in Section 6.1.

7. IMPLICATIONS OF THE CHARACTERISATION OF EST

This section discusses the utility of the characterisation of environmentally sustainable transport developed in Section 6 for subsequent phases of this study and for policy-makers. First, there is an account of the *relevance* to EST of the proposed six quantitative criteria.

7.1. Relation between the six quantitative criteria and EST

What has been attempted in Section 6 is a step towards an operational definition of EST. An operational definition of a thing is one that answers the question “how do I recognise the thing?” Thus an operational definition of EST based on the kind of criteria summarised in Section 6.7 would be this:

Examine the transportation system, in particular its contribution to ambient air levels of NO_x, VOCs, and particulates, its emissions of CO₂ from fossil fuel use, the amount of land it occupies in settled areas, and the noise it is responsible for. If it meets the criteria for these features then it is an EST system.

The criteria for NO_x, VOCs, particulates, and CO₂ emissions are being stated in terms of reductions relative to today’s values depending on the conditions in the various countries. However, the objectives of EST are more of an absolute condition (e.g. ambient air quality, noise levels, prevention of climate change) than a relative one that is dependent on today’s situation. Accordingly, the characteristics of EST should be expressible in absolute values. From such an expression the emissions-related criteria and the kinds of emission reductions required to meet the objectives can be formulated such as to give an indication of the *scale or order* of the changes that may be necessary to secure EST. The actual amounts needed will have to be determined by each country and will depend on the ambient levels and the improvements already made. As specific country studies will address these issues, and as work and knowledge progress, the absolute criteria can be specified with increasing precision.

Questions concerning the type of unit in which to express such absolute criteria have already been raised in consideration of the NO_x and CO₂ criteria in Sections 6.3 and 6.4; the questions apply equally to the criteria concerning VOCs and particulates. Are the limits to be stated in terms of emissions or ambient levels in the atmosphere? Are they to be stated per person (which might be fairest method), per person-kilometre or per vehicle-kilometre (or per tonne-kilometre in the case of freight)? These questions will be important questions to answer as work to characterise EST progresses.

Finally, there is the question as to the extent to which the six criteria represent EST. Is a transportation system that meets the criteria unquestionably sustainable? Also, could EST occur even though one or more of the six criteria are not met? From a present-day perspective a negative answer must be given to these two questions, but new information and analysis may well indicate otherwise. For the moment, these six criteria may together be the best practicable way of briefly quantifying EST.

7.2. Utility of the criteria for scenario construction

As noted in Section 1, the next phase of the study involves pilot work concerning the construction of several EST scenarios and identification of means and measures required to bridge the gaps between the present and these possible futures. One scenario is to involve heavy dependence on technological advances in transportation to maintain and even expand levels of mobility; the second will involve heavy dependence on non-motorised transportation and telecommunications to maintain and even expand access while reducing mobility; the third will seek an optimum combination of these general strategies.

A key question is whether the six criteria permit construction of one or more plausible EST scenarios. This can be properly assessed only by using the criteria to specify the EST scenarios and evaluating the results. In one such exercise, the *Cities without Cars* project,²³⁰ what seemed initially to be an implausible scenario became increasingly plausible as the study progressed. Participants in the study—

mostly municipal planning officials—examined aspects of what life might be like without personal automobiles in the Toronto and Vancouver regions a few decades into the 21st century. They reached the following conclusions, among others: (i) the *Cities without Cars* scenario is more consistent with sustainability objectives than the alternatives; (ii) the scenario, compared with its alternatives, would provide better conditions for most of the objective measures of the quality of life; and (iii) the scenario is desirable, possible, and even necessary.

7.3. Utility of the criteria for policy-makers

As sustainability and transportation become increasingly matters of concern for policy-makers, almost any elaboration of environmentally sustainable transport might be found to be of value. Of particular use, however, might be the indication of the *scale* of change that must occur if EST in one form or another is to be realised.

Flexible, long-term plans can be a powerful policy-making tool, especially when difficult changes must be made. It is easier to justify and usually to implement a particular increase in fuel taxes, for example, if it is part of a long-term plan that has a defined, desirable goal. Long-term plans can be better articulated if they have well-defined objectives. The preliminary quantitative criteria developed here, in conjunction with the qualitative definition, may help with the setting of such objectives within the context of transportation planning and policy-making.

There may well be disagreement with the criteria chosen and the definition advanced here, or with the manner of their development. If the present proposals do no more than provoke further discussion about what might be the long-term goals of transportation policy-making they will have served a useful purpose. It can be argued—as was done by one expert consulted for this work—that consideration of long-term goals can sometimes be a distraction from pressing immediate problems. But incremental responses to transportation issues do not seem to have worked.

Basic problems for the achievement of environmentally sustainable transportation are existing transportation infrastructures, logistics and operational practices that rely primarily on individual road vehicles for transporting people and freight. Overcoming these problems will require analytical tools and policy-making approaches that are different from those that have been used so far and aim at the full integration of environmental objectives into transportation policies. The present report is offered as a contribution to the development of such tools and innovative approaches.

APPENDIX 1

ILLUSTRATIVE OBJECTIVES FOR THE ATTAINMENT OF ENVIRONMENTALLY SUSTAINABLE TRANSPORT

OVERVIEW

1. Urban scale

- Major air pollutants: Nitrogen dioxide, particulate matter, carbon monoxide, lead
- Carcinogenic pollutants: Benzene, 1,3-butadiene, PAH (BaP)
- Noise
- Security

2. Suburban/residential scale

- Major air pollutants: Ozone, particulate matter, nitrogen dioxide, carbon monoxide
- Carcinogenic pollutants: Benzene, 1,3-butadiene, PAH (BaP)
- Noise
- Security

3. Rural/remote scale

- Major air pollutants: Ozone
Nitrogen deposition (eutrophication)
Acid deposition (S- and N-compounds)
- Noise
- Land use, physical planning

4. Global scale

- Greenhouse gases Carbon dioxide

EXAMPLES OF SPECIFIC GOALS FOR EST

1. URBAN SCALE

Major air pollutants:

- Nitrogen dioxide Concentration below 1994 WHO/EURO Air Quality Guideline (40 $\mu\text{g}/\text{m}^3$, annual mean)[†]
- Carbon monoxide Concentration below 1994 WHO/EURO Air Quality Guidelines
- PM₁₀ Risk minimisation: 15-20 $\mu\text{g}/\text{m}^3$ (annual mean)
- Lead No emissions

[†] WHO/EURO = WHO European Centre for Environment and Health, RIVM, Bilthoven, The Netherlands

Carcinogenic pollutants:

- Benzene 2.0 $\mu\text{g}/\text{m}^3$ (annual mean)
- 1,3-Butadiene 0.1 $\mu\text{g}/\text{m}^3$ (annual mean)
- PAH (as BaP) 0.5 $\mu\text{g}/\text{m}^3$ (annual mean)

Noise:

- Residential areas 55 dBA (daytime value)
45 dBA (night-time value)
- Mixed areas 60 dBA (daytime value)
50 dBA (night-time value)
- Industrial areas 65 dBA (daytime value)
55 dBA (night-time value)

Security:

- Reduction of casualties by 50 per cent

2. SUBURBAN/RESIDENTIAL SCALE

Major air pollutants:

- Ozone Concentration below 1994 WHO/EURO Air Quality Guideline (120 $\mu\text{g}/\text{m}^3$, 8-hour average)
- Carbon monoxide As for urban
- PM₁₀ As for urban
- Lead As for urban

Carcinogenic pollutants:

As for urban

Noise:

- Recreational areas 50 dBA (daytime value)
40 dBA (night-time value)
- Other areas As for urban

Security:

As for urban

3. RURAL/REMOTE SCALE

Major air pollutants:

- Ozone Concentration below 1994 WHO/EURO Air Quality Guideline (120 µg/m³, 8-hour average)
UN/ECE critical levels: †
Forests: 10,000 ppb.h (AOT40)
Crops: 5,300 ppb.h (AOT40)

- AOT40 for forests = Accumulated exposure over a threshold of 40 ppb from April to September = Sum of differences between hourly concentrations in ppb and 40 ppb for each hour when the concentration exceeds 40 ppb during 24 hours a day and six months (April-September)
- AOT40 for crops = Accumulated exposure over a threshold of 40 ppb during daylight hours and three months = Sum of differences between hourly concentrations in ppb and 40 ppb for each hour when the concentration exceeds 40 ppb during daylight hours (hours with mean global radiation > 50 Wm⁻²) and three months (May-July)

Nitrogen deposition (oxidised and reduced N-compounds)‡:

No exceedance of UN/ECE critical loads for nitrogen

Acid deposition (S- and N-compounds):*

No exceedance of UN/ECE critical loads for acidity

Noise:

- Recreational areas 50 dBA (daytime value)
40 dBA (night-time value)

Land use, physical planning:

- Protection of the integrity of ecosystems
- Creation of ecological compensation areas

4. GLOBAL SCALE

Greenhouse gas emissions:

- Carbon dioxide Global: reduction in emissions by 50%
OECD: reduction in emissions by 70-80%

† Source: Critical Levels for Ozone—a UN/ECE Workshop Report, Eds. Fuhrer J, Acherman B, FAC-Schriftenreihe No. 16, March 1994, ISSN-1-13-154X.)

‡ See: Critical Loads for Nitrogen—Report from a UN/ECE Workshop held in Lökeberg, Sweden, April 6-10, 1992, Eds. Grennfelt P, Thörnelöf E, Nord 1992:41, ISBN 92-9120-121-9.

* See: Mapping Critical Loads for Europe, CCE Technical Report No. 1, July 1991, Eds. Hettelingh J-P, Downing RJ, de Smet PAM, RIVM Report No. 259101001, ISBN 90-6960-011-0. Calculation and Mapping Critical Loads in Europe, Status Report 1993, Eds. Downing RJ, Hettelingh J-P, de Smet PAM, Co-ordination Centre for Effects, RIVM Report No. 259101003, ISBN 90-6960-047-1.

APPENDIX 2

A NOTE ON AIR TRANSPORT AND GREENHOUSE GAS EMISSIONS

Several comparisons have been made of emissions by various modes of transportation. A particularly useful one was conducted for the European Commission by the United Kingdom Atomic Energy Authority.²³¹

What is especially valuable about this analysis is that it includes (i) impacts of all emissions, expressed in carbon dioxide equivalents, and (ii) impacts during vehicle production, disposal, and operation as well as fuel production (but not infrastructure). When comparing impacts of aircraft it is especially important to consider emissions of nitrogen oxides, which have a powerful indirect greenhouse effect when injected into the troposphere at the height where they have the most impact on global warming, i.e., at the kind of heights at which commercial jet aircraft fly.²³² Ground-level emissions of nitrogen oxides and consequent greenhouse gases are largely removed before they reach this level. Emissions of nitrogen oxides account for more than half of greenhouse emissions of aircraft but well under 5 per cent of greenhouse emissions of surface modes (all expressed in carbon dioxide equivalents).

The report provides carbon dioxide equivalents per seat-kilometre for various modes. In the following table they have been converted to grams per passenger-kilometre by assuming 80 per cent occupancies for aircraft and 40 per cent occupancies for all other modes.

Mode	Grams per passenger-km
1990 average car	278
New catalyst car	197
Diesel car	161
Bus	69
Diesel train	79
Electric train	76
Local train	54
Aircraft	853

Thus the contribution to potential global warming of air travel is some 4.3 times greater per passenger-kilometre than that of travel in a new-model, gasoline-powered automobile, and more than 10 times greater than that of travel by bus or train. (Automobiles make roughly three times the contribution of buses and trains.)

The comparisons for freight transport show larger differences. The following table, adapted from the report, compares emissions in grams of carbon dioxide equivalent per tonne-kilometre.

Mode	Grams per tonne-km
7.5-tonne truck	174
40-tonne truck	56
Fast rail	39
Slow rail	14
Aircraft	3 414

Thus the impact of air freight is approximately 20 times greater per tonne-kilometre than for a medium-sized truck and more than 240 times greater than for slow rail.

The comparisons are for British vehicles. North American automobiles on average emit about 50 per cent more carbon dioxide per passenger-kilometre—the result of the use of larger vehicles on average (chiefly the higher proportion of passenger vans and small trucks) and of the lower average occupancy—which brings the aircraft/car ratio down to about 2.9 rather than 4.3.

Accordingly, it can be estimated that taking a return flight between Toronto and Paris, France—about 12,000 kilometres—has the global warming impact of travelling about 35,000 kilometres by automobile in Ontario.

APPENDIX 3

U.S. SUBMISSION: REPORT HEADINGS

- I. Mandatory schedule for air quality attainment
 - A. *Ozone non-attainment*
 - B. *Carbon monoxide*
- II. Programmes to improve the emission control design of highway vehicles
 - A. *Emission standards for light-duty vehicles, light-duty trucks, heavy-duty engines, and motorcycles*
 - B. *Vehicle manufacturer compliance programme*
 - C. *Other current vehicle design requirements*
 - 1. *Defeat devices*
 - 2. *On-board diagnostics*
 - 3. *Evaporative emissions regulations*
 - 4. *Expected emissions regulations*
 - 5. *On-board refuelling and vapour recovery systems*
 - D. *Inspection and maintenance programmes*
 - E. *Remote sensing devices*
 - F. *Vehicle scrappage programme*
- III. Future regulations affecting highway vehicle design
 - A. *Revisions to the federal test procedure for emissions from motor vehicles*
 - B. *Expected emissions reductions*
 - C. *Heavy-duty NO_x and particulate initiative*
 - D. *National low-emission vehicles*
- IV. Fuels and alternative fuel programmes
 - A. *Oxygenated fuels*
 - B. *Reformulated gasoline*
 - C. *Clean-fuel fleets*
 - D. *California pilot programme*
 - E. *California's low-emission vehicle programme*
 - F. *Urban bus low polluting fuels*
 - G. *Fuel quality regulations for highway diesel fuel*
 - H. *Fuels and fuel additives registration programme*
 - I. *Renewable fuels*

- V. Non-road mobile sources
 - A. *Non-road compression engines at or above 37 kW*
 - B. *Proposed regulations for marine engines*
 - C. *Outboard spark-ignition and personal watercraft engines—expected reductions*
 - 1. HC
 - 2. NO_x
 - 3. CO
 - D. *Gasoline spark-ignition sterndrive/inboard engines—expected reductions*
 - E. *Diesel compression-ignition marine engines—expected reductions*
 - F. *Emissions from ocean-going vessels*
 - G. *Locomotives*
 - H. *Proposed regulations for new non-road spark-ignition engines at or below 19 kW*
 - I. *Airport ground support equipment and airline operating procedures*
- VI. Efforts to reduce congestion and growth in vehicle miles travelled—transportation control measures
 - A. *Employee commute options programme*
 - B. *Enhanced traffic modelling*
 - C. *Transportation conformity*
 - D. *Inter-modal Surface Transport Efficiency Act (ISTEA)*
- VII. Efforts to reduce Greenhouse Gas emissions from the transport sector
 - A. *Mandatory programmes placed on the vehicle manufacturer*
 - B. *Fuel economy labelling*
 - C. *Gas guzzler tax*
 - D. *Policy dialogue advisory committee to assist in the development of measures to significantly reduce GG emissions from personal motor vehicles*
 - E. *President's Council on Sustainable Development*
 - F. *Partnership for a new generation of vehicles (PNGV)*
- VIII. Sustainable transportation: provisions in US laws
 - A. *Planning and project development*
 - 1. Transportation and land-use planning
 - 2. National Environmental Policy Act
 - 3. Highway and transit legislation
 - 4. Transportation and air quality planning
 - 5. Coastal zone management
 - 6. Congestion management plans
 - 7. Wetlands planning
 - 8. Endangered species
 - 9. Bicycle/pedestrian planning
 - 10. Federal Highway Administration environmental policy
 - B. *Balanced transportation systems*
 - 1. Flexible highway funding
 - 2. Transit funding
 - 3. Bicycle/pedestrian accommodation
 - 4. Transportation enhancements

- C. *Air quality*
 - 1. Transportation and air quality planning
 - 2. Air quality transportation funds
 - 3. Clean Air sanctions
 - 4. Clean Air plans
 - D. *Fuel economy and alternate fuelled vehicles*
 - 1. Fuel economy
 - 2. Alternative fuels bus test and demonstration programme
 - 3. Electric vehicles for mass transit
 - E. *Airports*
 - 1. Airport Noise and Capacity Act of 1990
 - 2. Airport Act
 - 3. Airport noise mitigation plans
 - F. *Oil and hazardous materials transportation*
 - 1. Oil Pollution Act of 1990
 - 2. Hazardous Materials Transportation Act
- IX. Other studies and activities

APPENDIX 4

SOURCES REVIEWED

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In general, these documents were submitted or produced by or for the governments of the respective Member countries. Certain documents submitted in respect of specific countries by members of OECD's Expert Group on Sustainable Transportation are also noted.

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- AU5. Protokoll No. 9. Über den Straßen- und Schienenverkehr sowie den Kombinierten Verkehr in Österreich, 1994.
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Denmark

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Germany

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END NOTES

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- ¹1. G27.
 2. G26.
 3. Backcasting, according to the Expert Group, is a reverse analogue of forecasting. Backcasting involves looking at the present from the perspective of the future. Forecasting involves looking at the future from the perspective of the present. The leading idea in backcasting is to develop scenarios of desirable futures with regard to a societal problem, and then to discuss how these future states could be attained.

Policy guidance through forecasting usually involves an assessment of future conditions in terms of current trends and accommodation to the trends or modest adjustments of them. The presuppositions adopted as well as the overall methodology often preclude major change. However, solutions to the environmental problems caused by the transport sector will probably call for more than marginal changes at many levels of society.

In the long-term, the potential for humans to influence development in desired directions is relatively large. Major obstacles to real change are perceptions of what is possible or reasonable. The scenarios of a backcasting exercise may broaden the scope of solution-finding by describing new options.

Such a methodology may be of special value for the transportation sector on account of the apparent inability of current policies and measures, many based on forecasting, to reduce the overall environmental impacts of transportation, even though such reductions are widely desired. Backcasting may be capable of generating the fresh policy directions that may be needed if transportation is to become environmentally sustainable. Moreover, because such a method highlights differences between current trends and a desirable future, it may be capable of generating the motivation needed to implement fresh policy directions.
 4. G25, p19, and G18, p33.
 5. According to G19, p1.
 6. G28, p43.
 7. G28, p89.
 8. See the discussion in G22.
 9. G22, p32.
 10. G13, p139.
 11. G5. One expert reviewer of the present report has expressed concern about the practical difficulties of defining Daly's second criterion. For example, if a non-renewable resource can be used very prudently, e.g. through recycling, is it always preferable to develop a substitute from a renewable source?
 12. G2, p5.
 13. G18, p27.
 14. G18, p27 and G25, p22.
 15. G18, p33.
 16. G11, p36-37.
 17. G16.
 18. Information in this table comes mostly from G18 (p27-33) and G26 (p24-33).
 19. G18, p30.
 20. See, for example, Table 2 in G24, p262; and footnote 26 on p10 of G9.
 21. G28, Table 4.1, p100.

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22. G12, Table 2, p711.
 23. G18, p31.
 24. Michael Walsh, *Car Lines*, Sep. 1995, p16.
 25. G26, p32, and G21, p6.
 26. *Winnipeg Free Press*, Aug. 4, 1995.
 27. G4, p3-4.
 28. GE6, p81.
 29. G20, p3.7-1; G14, p148-149.
 30. G7, p42-44.
 31. G20, p3.15-1, G17, p94.
 32. G31, p29-30.
 33. G10.
 34. G20, p3.14-7, G7, p53.
 35. UK5, p52-54.
 36. G1, p139-157.
 37. UK5, p16.
 38. G23, Table 1 (p7) reports on some surveys of how people travel in Asian and African *cities*, including Tianjin and Nairobi (90% and 15% non-motorised).
 39. G29, Figure 2. The percentages derived from this figure have been somewhat arbitrarily reduced by 5 points to allow for walking and bicycling distances. This brings the European percentages in line with G23, Table 2 (p8).
 40. G23, Table 2, p8.
 41. G12, Table 1, p707.
 42. G24, Table 1, p262.
 43. G12, Table 3, p712.
 44. G6, Table 6-2, p6-5.
 45. G6, Table 1.9.
 46. G29, Figure 2, adjusted for international flights by reference to G6, Table 6-2, p6-5.
 47. G26.
 48. G26, p121-126.
 49. G26, p121-126.
 50. GE6, p364.
 51. AU2, p13.
 52. AU2, p21-22, 195-96.
 53. GE1 and GE8.
 54. AU2, p178-80.
 55. AU2, p197.
 56. AU2, p183-89.
 57. AU2, p201.
 58. AU2, p229.

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59. AU2, p197, 229.
 60. AU2, p197.
 61. AU2, p195.
 62. AU2, p195-196.
 63. CA1, p118.
 64. CA1, p114.
 65. CA1, p123. (According to a report in the Globe & Mail on October 25, 1995, Canada's federal and provincial environment ministers have endorsed a proposal to require introduction of low-emission vehicles by 2001, or earlier if the U.S. government requires earlier introduction.)
 66. CA1, p7, 144.
 67. CA4.
 68. CA1, p12.
 69. CA2, p34-35.
 70. CA3, p1.
 71. DE3, p4.
 72. DE3, p4.
 73. DE3, p6-12.
 74. DE1, p1-3.
 75. DE1, p1.
 76. DE1, p2-5.
 77. FI2, p4-5
 78. FI2, p6-7
 79. FI2, p6
 80. FI2, p19-24
 81. FR1 and FR2.
 82. FR3.
 83. FR2, p52-57.
 84. FR2, p145-7.
 85. FR1, p63.
 86. FR1, p64.
 87. FR1, p69
 88. FR1, p69.
 89. FR2, p115.
 90. FR2, p116-117.
 91. FR2, p117.
 92. FR2, p145.
 93. FR2, p133.
 94. FR2, p118-119.
 95. FR2, p141.
 96. FR2, p155-156.

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97. FR3.
 98. FR1, p58.
 99. FR1, p67.
 100. GE6, p65.
 101. GE6, p70-71.
 102. GE5, p104.
 103. GE11, p31.
 104. GE5, p103.
 105. GE5, p106.
 106. GE11, p31.
 107. GE1, p12.
 108. GE5, p124-125.
 109. GE1, p8-9.
 110. GE10, p4-6.
 111. GE1, p13.
 112. GE1.
 113. GE9, p19 and GE1, p17-19.
 114. GE1, p19-22.
 115. GE8, p1.
 116. GE9, p1.
 117. GE9, p2.
 118. JA2, p7.
 119. JA2, p8.
 120. JA2, p13-14, 43-44.
 121. JA2, p13, 16-17.
 122. NE3, p108.
 123. NE3, p109-14.
 124. NE3, p108.
 125. NE1, p2.
 126. NE1, p5.
 127. NO4, p34.
 128. NO5(iii), p23.
 129. NO7(i), pp26-26.
 130. NO5(iii), p6.
 131. NO3(iii), p3.
 132. NO5(iv), p7.
 133. NO3(ii), p2. See also UK8.
 134. SW9, p1.
 135. SW5, p1.

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136. SW8, p2.
 137. SW8, p2-3.
 138. SW5, p21.
 139. SU9, p30.
 140. SU9, p35 and SU10, p3.
 141. SU9, p38-44.
 142. SU4(iii), p17.
 143. SU10, p2.
 144. The foregoing summary was based on information provided in a note from the Federal Office for Environment, Forests and Landscape (August 22, 1995).
 145. SU3, p34, 87.
 146. UK1, p1-2.
 147. UK2, p1 and 173.
 148. UK6, p1.
 149. UK2, p175.
 150. UK2, p169-176.
 151. UK7, p13.
 152. UK2, p14.
 153. UK5.
 154. UK8.
 155. US1, p2-3.
 156. US1, p4-7.
 157. US1, p11-12.
 158. The requirements with respect to 1998 and 1999 appear to be in the process of being removed. *Toronto Star*, December 23, 1995.
 159. US1, p25-28.
 160. US1, p33-34.
 161. US1, p2-3.
 162. US1, p29-34.
 163. EU5, p13.
 164. EU1, p2.
 165. EU6, p2.
 166. EU1, p3.
 167. EU6, p1.
 168. EU6, p4.
 169. EU6, p5.
 170. EU1, p5.
 171. EU1, p5.
 172. EU5, p13.
 173. EU5, p35.

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174. EU5, p38.
 175. UK5, p121.
 176. EU5, p66.
 177. EU2, p1
 178. AU2, ??.
 179. GE8, p53.
 180. GE9, p1-2.
 181. SW5, p21.
 182. UK2, p169.
 183. EU2, p1. (This cites the *Green Paper*.)
 184. G19.
 185. G19, p5.
 186. G29.
 187. G29, p16.
 188. G12.
 189. G12, p711.
 190. G12, p711.
 191. G24.
 192. G24, p261.
 193. G32.
 194. G34, p19-20.
 195. G5.
 196. G26, p28.
 197. G37, p9.
 198. G18, p81.
 199. G35, G36.
 200. G26, p24-32; G21, pA-85.
 201. G30, p9.
 202. G26, p54-56.
 203. G26, p121-126.
 204. G19, p10.
 205. UK5, p37.
 206. GE4, p65. The critical level of an atmospheric pollutant is the “concentration in the atmosphere above which direct adverse effects on receptors such as plants, ecosystems or materials may occur according to present knowledge.” (See UK5, p37.)
 207. G26, p25.
 208. G26, p55.
 209. G26, p56.
 210. G30, p9.
 211. G26, p26.

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212. G26, p55-56.
 213. G26, p28.
 214. G26, p29.
 215. G26, p31.
 216. G35
 217. UK5, p26-27.
 218. Michael Walsh, *Car Lines*, Nov. 1995, p24.
 219. UK5, p26,31.
 220. UK5, p121,123.
 221. G16, pxi.
 222. See, for example, G8 and G19.
 223. G19, p15.
 224. G38, Tables 2.3B and 12.1.
 225. G23, p1.
 226. UK5, p49.
 227. UK5, p48.
 228. G4, p3.
 229. GE4, p69.
 230. G9.
 231. G21, see especially Figure A.8, pA-98, and Figure A.10 on pA-99.
 232. See also GE6, p60-64.