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Environmentally Sustainable Transport: Implementation and Impacts for the Netherlands for 2030

Phase 3 report of the OECD project
"Environmentally Sustainable Transport"

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Preface

This report is the result of Phase 3 of the OECD project called "Environmentally Sustainable Transport" (EST) for the Netherlands. The authors wish to thank Martin Kroon (Ministry of Housing, Spatial Planning and the Environment), Jan van der Waard (Transport Research Centre of the Ministry of Transport, Public Works and Watermanagement – AVV), and members of the EST expert group for comments on earlier drafts of this report. Furthermore, the authors thank Professor John Adams (University College London) and Professor Werner Rothengatter (University of Karlsruhe) for their assistance with and comments on the economic and social implications analysis.

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Abstract

This report describes instrument packages which – if timely implemented – would result in the attainment of Environmentally Sustainable Transport (EST) in the Netherlands by 2030. Also described are the social and economic implications of EST compared to the business-as-usual (BAU) transport. EST is defined by stringent environmental criteria based on reductions of the polluting components: CO_2 by 80%, and NO_x, VOC and PM_{10} by 90% between 1990 and 2030, as well as criteria related to noise and land use in 2030.

The following main conclusions have been drawn: (1) EST criteria can only be met assuming a large increase in technological developments and/or very stringent behavioural adaptations and changes in spatial and economic structures at international level; (2) the implementation of the tradeable CO_2 emission permit system for passenger and freight transport is crucial if EST is to be realised; (3) if EST is to be realised, measures will have to be taken and new instruments developed in the short term; (4) the current policy life cycle must radically change to bring about a timely implementation of instruments; (5) the level of material wealth (expressed in GDP) and employment will be attained somewhat slower with EST scenario than with BAU, but several social factors will improve. Firstly, differences between societal groups in (a) travel behaviour, (b) the level of accessibility of economic and social opportunities and (c) (perceived) environmental quality will decrease. Secondly, the level of motorised transport will be strongly reduced, which will improve traffic safety and reduce health problems caused by local air pollution and noise nuisance from road traffic and aviation.

Contents

Summary and conclusions

In 1995 the OECD started a project called “Environmentally Sustainable Transport” (EST). This report is the result of Phase 3 of the project for the Netherlands. Earlier project phases consisted of the definition and criteria construction for EST, and the development of transport scenarios for the period 1990-2030. Six other scenario studies – besides the Netherlands – were conducted within the framework of the OECD project, with as participants, Germany, Switzerland-Austria-France, Norway, Canada, Sweden, and the Central and Eastern European countries (CEI countries). At the moment, a scenario study for Japan is also underway.

Four transport scenarios were constructed for the Netherlands: a business-as-usual scenario (BAU) and three “backcasting” EST scenarios containing measures to meet the EST criteria. The three EST scenarios are given below:
(i) a “high-technology” scenario containing only technological changes (EST1);
(ii) a “mobility-management” scenario containing only mobility changes (EST2);
(iii) a “combination” scenario containing one scenario with a combination of technological and mobility changes (EST3).

The EST criteria for the Netherlands are as follows, with the first three criteria common to all the pilot studies:
- CO_2 emissions: 80% reduction between 1990 and 2030;
- NO_x emissions: 90% reduction between 1990 and 2030;
- VOC emissions: 90% reduction between 1990 and 2030;
- PM_{10} emissions: 90% reduction of between 1990 and 2030;
- noise: a negligible level of serious noise nuisance in 2030;
- land use: stabilisation of direct land use for transport outside urban areas between 1990 and 2030; a good living climate inside urban areas in 2030 and indirect land use in 2030 representing half the 1990 level.

This report describes instrument packages for passenger and freight transport which – if timely implemented – will result in the realisation of the combination scenario (EST3) by 2030. Furthermore, the social and economic impacts of the combination scenario – compared to the business-as-usual scenario - were analysed. The social implications of the business-as-usual scenario and the combination scenario have been analysed qualitatively using existing data and empirical studies to support the analysis. The economic impacts have been assessed quantitatively using a simplified cybernetic model (called Impact Path Analysis), developed for the OECD project and aimed at assessing the order of magnitude of the macro-economic effects (in terms of GDP, employment and value added).

The main conclusions follow:

- EST criteria can only be met assuming a large increase in technological developments and/or very stringent behavioural adaptations, and changes in spatial and economic structures at the national and international level;
- If the EST criteria are to be realised through only technical changes, a very large increase in technological research will be needed. Expensive techniques will also have to be developed and implemented. Fleets of durable vehicle types (e.g. ships, aeroplanes) will have to be replaced before their technical/economic optimum ages are reached. Reducing emissions (mainly) by technical measures will likely mean a shift towards electrical traction and sustainable energy (e.g. sustainably produced hydrogen);
- If the EST criteria are to be realised through only mobility changes, mobility patterns will have to change radically. Most people will have to work in the location/region were they live. They will commute by slow modes. Motorised transport will consist mainly of public transport. Train traffic will cause noise nuisance in 2030 since no technical measures are assumed. The role of the car in the society has to change radically, e.g. only 8% of the car passenger kilometres in 1990 may be driven in 2030. The mobility changes will have major impacts on the agricultural sector: food will have to be produced and consumed within the region;
- By combining the technical and mobility measures, less radical changes will need to be made in the transport sector, with less impact on the energy and agricultural sectors. However, a trend breach in both technological development and behaviour is still necessary if the EST criteria are to be realised: (i) future technological progress will have to be much greater than in the past, (ii) mobility patterns must change greatly, i.e. shorter distances per trip and less reliance on motorised transport and (iii) freight transport must be different, i.e. fewer goods transported shorter distances with less reliance on road transport;
- Existing policy instruments will probably not be sufficient to realise the large emission reductions envisaged by EST; innovative transport policy instruments will have to be developed and introduced;
- The implementation of the tradeable CO_2 emission permit system for passenger and freight transport is crucial for realising EST. Other pricing instruments, regulations, land-use instruments, infrastructure policy, instruments for education and information, and instruments outside the transport sector, are important for support or facilitation of EST and for an increase in social, political and economic feasibility;
- If environmentally sustainable transport is to be realised, measures will have to be taken and new instruments developed in the short term. This is mainly because of the long pre-implementation phase of transport policies, technologies which still have to be developed, and the long planning and implementation phase for land-use and infrastructure policies;

- A timely implementation of the instruments to attain the combination scenario's features will mean a radical change in the current policy life cycle;
- Implementation of EST will have significant macro-economic impacts, but it will not mean a total collapse of the economy: the average yearly GDP growth in the EST scenario will be some tenths of percentage points lower than the business-as-usual scenario, the total Dutch level of employment will be a few percentage points lower in 2030. If external costs are used as an indicator for non-material welfare, the total loss of material welfare for the year 2030 will be largely – but probably not fully – compensated by gains in non-material welfare (i.e. reductions of external costs);
- EST will probably mean improvement of several social factors. Firstly, differences between societal groups in (a) travel behaviour, (b) the accessibility level of economic and social opportunities, and (c) (perceived) environmental quality will be smaller in EST than in BAU. Secondly, the level of motorised transport will be strongly reduced in EST compared to the present, which will improve traffic safety and decrease health problems caused by local air pollution and noise nuisance from road traffic and aviation.

Samenvatting

In 1995 is het OECD-project 'Environmentally Sustainable Transport' (EST) opgestart. Het onderhavige rapport maakt deel uit van de derde fase van het OECD-project. In eerdere fasen van het project is duurzaam verkeer en vervoer gedefinieerd en geoperationaliseerd, en zijn verkeers- en vervoerscenario's ontwikkeld voor de 1990-2030. Behalve de scenariostudie voor Nederland zijn in het kader van het OECD-project nog zes scenariostudies uitgevoerd, namelijk door: Duitsland, Zwitserland-Oostenrijk-Frankrijk, Zweden, Noorwegen, Canada en voor de Centraal- en Oost-Europese landen. Een scenariostudie voor Japan wordt – ten tijde van het schrijven van dit rapport – nog ontwikkeld.

In het OECD-project zijn vier scenario's onderscheiden: een referentiescenario ('business-as-usual scenario') en drie EST-scenario's die voldoen aan de gestelde criteria: (1) een scenario met alleen technische maatregelen ('high-technology' scenario), (2) een scenario met alleen mobiliteitsmaatregelen ('mobility-management' scenario) en (3) een scenario met een combinatie van technische en mobiliteitsmaatregelen ('combination' scenario).

De EST scenario's zijn geconstrueerd volgens de 'backcasting' methode. Voor deze studie betekent het, dat eerst de EST-criteria zijn vastgesteld, en vervolgens gekeken is welke maatregelen noodzakelijk zijn om de gestelde criteria te kunnen bereiken. In het OECD-project zijn gezamenlijke criteria voor CO_2, NO_x en VOS vastgesteld, terwijl criteria voor fijn stof, geluid en ruimtegebruik per studie kunnen verschillen. De EST-criteria voor Nederland zijn:

- CO_2-emissies -80% tussen 1990 en 2030;
- NO_x-emissies -90% tussen 1990 en 2030;
- VOS-emissies - 90% tussen 1990 en 2030;
- fijn stof: PM_{10}-emissies - 90% tussen 1990 en 2030;
- geluid: een verwaarloosbaar niveau van ernstige geluidhinder in 2030;
- ruimtegebruik: stabilisatie van het directe ruimtegebruik van verkeer en vervoer buiten de bebouwde kom tussen 1990 en 2030, een goed leefklimaat binnen de bebouwde kom in 2030, en een halvering van het indirecte ruimtegebruik van verkeer en vervoer tussen 1990 en 2030.

Dit rapport beschrijft de instrumentenpakketten die, wanneer deze tijdig zouden worden geïmplementeerd, kunnen leiden tot het bereiken van de maatregelen zoals die zijn verondersteld in het 'combination scenario' in 2030. Het rapport beschrijft verder de mogelijke economische en sociale gevolgen van het 'combination scenario' – ten opzichte van het referentiescenario.

De belangrijkste conclusies zijn:

- Alleen als een sterke verbetering in de technologische ontwikkeling en/of grote gedragsveranderingen en veranderingen in ruimtelijke en economische structuren optreden, kan aan de EST criteria worden voldaan.
- Indien alleen technische maatregelen worden genomen, dan is een sterke toename van technologisch onderzoek noodzakelijk, en moeten kostbare technische maatregelen worden geïmplementeerd. In het *'high-technology' scenario* wordt het grootste deel van de gewenste emissiereducties gehaald door de veronderstelling dat een zeer hoog aandeel van de elektriciteit duurzaam wordt opgewekt (80% elektriciteit uit wind- en zonne-energie, waterkracht en biomassa) en het overige deel in zeer energie-efficiënte elektriciteitscentrales. Een zeer hoog aandeel van de personenauto's, bestelauto's, bussen wordt elektrisch aangedreven, het overige aandeel bestaat uit hybride voertuigen die zeer brandstofefficiënt en schoon zijn. Voor verplaatsingen over langere afstanden kunnen elektrische auto's aan elkaar worden gekoppeld en zich op het hoofdwegennet als 'treintjes' verplaatsen. Vrachtauto's rijden voor het grootste deel op duurzaam geproduceerde waterstof, en het overige deel heeft hybride tractie. Lange-afstands luchtverkeer gebruikt duurzaam geproduceerde waterstof als energiebron, korte-afstands luchtverkeer wordt per luchtschip of trein afgewikkeld;
- Indien alleen mobiliteitsmaatregelen worden genomen, dan zullen deze waarschijnlijk een impact hebben op macro-economische ontwikkelingen en grote sociale, culturele en ruimtelijke gevolgen voor de samenleving hebben. In het '*mobility management' scenario* zullen de activiteitenpatronen radicaal wijzigen. Activiteiten (bijvoorbeeld wonen, werken, winkelen) liggen dicht bij elkaar, en het autogebruik wordt beperkt tot de hoogst noodzakelijke verplaatsingen, zoals bijvoorbeeld brandweer, politie en gehandicaptenvervoer. Ook vliegverkeer wordt beperkt tot de hoogst noodzakelijke verplaatsingen, en wordt vervangen door telematica. Korte afstands internationaal vervoer wordt per trein afgewikkeld. In het goederenvervoer vindt een sterke verschuiving van wegvervoer naar binnenvaart en railvervoer plaats. In het goederenwegvervoer zorgen bestelauto's of kleine vrachtauto's voor het voor- en natransport van/naar distributiecentra, en zorgen grote vrachtauto's met een hoge beladingsgraad voor het vervoer tussen de distributiecentra. De locaties van productie en consumptie wijzigen zodanig dat de omvang en de gemiddelde transportafstand van het goederenvervoer sterk wordt gereduceerd: goederen en diensten worden op een meer regionale schaal geproduceerd en geconsumeerd;
- Een combinatie van technische en mobiliteitsmaatregelen resulteert in relatief minder stringente maatregelen, en zal vermoedelijk een groter draagvlak in de samenleving hebben. Het *'combination' scenario* betekent een trendbreuk in zowel de technologische ontwikkeling als de mobiliteitspatronen: de technologische ontwikkeling moet sterker zijn dan in het verleden en de mobiliteitspatronen zullen radicaal moeten veranderen (kortere afstanden, minder

gemotoriseerd transport). In het ‘combination’ scenario wordt een hoog aandeel duurzaam geproduceerde energie verondersteld (40%). Verondersteld wordt dat het gehele personenautopark bestaat uit hybride voertuigen die zeer energie-efficiënt en schoon zijn, met een gemiddelde bezettingsgraad van twee personen. De gemiddelde verplaatsingsafstand per auto wordt gereduceerd, vanwege het dicht bij elkaar liggen van activiteiten. Het lange-afstands vliegverkeer gebruikt waterstof als energiebron, het korte-afstands vliegverkeer wordt afgewikkeld per luchtschip of trein. In het goederenvervoer is een sterke verschuiving van wegvervoer naar rail en binnenvaart noodzakelijk. In het wegvervoer zorgen hybride bestelauto’s voor het voor- en natransport van/naar distributiecentra, grote en volle vrachtauto’s (met een hoog aandeel duurzaam geproduceerde waterstof) zorgen voor het vervoer tussen de distributiecentra. De gemiddelde vervoersafstand en omvang van goederenvervoer verminderen significant;

- Bestaande beleidsinstrumenten zijn waarschijnlijk niet voldoende om de EST-criteria in 2030 te kunnen halen. Innovatieve beleidsinstrumenten moeten derhalve worden ontwikkeld en geïntroduceerd;
- Bij de implementatie van beleidsinstrumenten wordt op de langere termijn een systeem van verhandelbare CO_2 rechten van cruciaal belang geacht. Andere beleidsinstrumenten (prijsbeleid, ruimtelijk- en infrastructuurbeleid, educatie- en informatie, instrumenten buiten de sector verkeer) zijn belangrijk op de korte of middellange termijn, ter ondersteuning van het systeem, en/of ter vergroting van het sociale, politieke en economische draagvlak.
- Om de EST criteria te kunnen halen in 2030 zijn op de korte termijn maatregelen nodig en moeten beleidsinstrumenten worden ontwikkeld, voornamelijk vanwege de lange pre-implementatie periode van maatregelen, de ontwikkelingstijd van nieuwe technologieën, en de lange tijd benodigd voor de planning en implementatie van ruimtelijke- en infrastructurele beleidsmaatregelen;
- Het implementeren van EST heeft significante effecten op de Nederlandse economie. Zo zal de *groei* van de materiële welvaart en werkgelegenheid in EST lager liggen dan in het referentiescenario: de jaarlijkse economische groei zal naar verwachting maximaal enkele tienden van procenten lager liggen, en de nationale werkgelegenheid ligt in 2030 enkele procenten lager ten opzichte van het referentiescenario. Indien externe kosten worden gebruikt als indicator voor de niet-materiële welvaart, dan kan het verlies in materiële welvaart (BBP) niet volledig worden gecompenseerd door niet-materiële welvaart (reductie externe kosten).
- Het implementeren van EST zal de sociale kant verbeteringen opleveren. In de eerste plaats zullen de verschillen tussen bevolkingsgroepen in termen van verplaatsingsgedrag, bereikbaarheid van opportuniteiten en (gepercipieerde) milieukwaliteit kleiner zijn. In de tweede plaats zal het gemotoriseerde verkeer sterk afnemen, waardoor de verkeersveiligheid kan toenemen en

gezondheidsproblemen veroorzaakt door lokale luchtverontreiniging en geluidhinder door het wegverkeer en de luchtvaart zullen afnemen.

1. Introduction

In 1995 the OECD started a project called “Environmental Sustainable Transport”. The aims of the project are threefold: (i) “to examine and refine the concept of environmentally sustainable transport (EST), (ii) to determine the kind of actions required to achieve EST and (iii) to develop guidelines for the attachment of EST that could be of use to Member Countries in formulating policies and measures whose implementation would result in EST” (OECD, 1998).

The EST project has four phases:
1. A review of the OECD Member Country programmes and plans on transportation and the environment. Furthermore, this phase, completed in 1995, saw the determination of the characterisation criteria, including quantitative EST criteria;
2. Conducting of EST pilot studies for the Netherlands, Austria-France-Switzerland, Canada, Germany, Norway and Sweden. The pilot studies consist of three scenarios containing measures to meet the EST criteria. The criteria and scenarios are defined as agreed in Phase 1 of the EST project. The result of this phase for the Netherlands is described in detail in Van Wee *et al.* (1996), and will be summarised in this report. The results of other pilot studies are summarised in OECD (1998);
3. Phase 3 comprises the identification of packages of policy instruments whose implementation would result in the attainment of EST, and a description of a possible implementation time-path of these packages of policy instruments. Furthermore, this phase comprises a deeper consideration of the social and economic implications of implementing the EST-scenario features. This report is the result of this phase for the Netherlands;
4. Refinement and extension of the EST definition and establishment of guidelines for policies and measures consistent with the EST achievement. Phase 4 is planned for completion in 2000, and will be described in an OECD report.

It must be stressed that the scenario exercise in this report should be seen as an example of such an approach and not an expression of the official view of the Dutch government.

All figures relate to the territory in the Netherlands: for example, car use figures include the use of foreign-registered cars in the Netherlands but exclude the use of Dutch-registered cars abroad. For the transport of goods this means that figures will include both inland and international transport (by Dutch or foreign vehicles) as far as the use of vehicles in the Netherlands is concerned.

The rest of the report is structured as follows. Chapter 2 describes the scenario construction falling under Phase 2 of the EST project. The chapter is a summary of the Phase 2 report published earlier (Van Wee *et al.*, 1996), elaborated with a discussion of the technology assumptions. Chapter 3 describes the assessment of individual instruments used as input for the construction of scenario packages. Chapter 4 describes the identification of instrument packages for the attainment of EST. Chapter 5 outlines a possible instrument implementation time path. Chapter 6 describes the analysis of the social impacts of the business-as-usual and EST scenarios. Finally, Chapter 7 describes the economic impacts of EST relative to the business-as-usual scenario.

2. Scenario construction

2.1 Introduction

This chapter gives a summary of the Phase 2 report for the Netherlands (including some elaborations) and is mainly based on Geurs & Van Wee (1997a; 1998). For a complete description of the Phase 2 report please refer to Van Wee *et al.* (1996).

Five countries, Germany, Switzerland-Austria-France, Norway and Canada and the Netherlands, have conducted pilot studies falling under Phase 2 of the four-phase OECD project on Environmentally Sustainable Transport (EST).

The OECD concluded from the project preceding Phase 1 that for transportation to be sustainable, transportation should not result in exceedances of generally accepted international objectives for environmental quality, it should not reduce the integrity of ecosystems, and it should not contribute to potentially adverse global phenomena such as climate change and stratospheric ozone depletion. There are international guidelines (WHO, IPPC, UNECE, etc.) for all of these ecological targets. The OECD has defined EST as: transportation that does not endanger public health or ecosystems and meets needs for access consistent with (a) use of renewable sources below their rates of regeneration, and (b) use of non-renewable resources at below the rates of development of renewable substitutes (OECD, 1996). During Phase 2, six quantitative criteria for EST were derived from the ecological targets, three criteria common to all the pilot studies and three criteria for which the specification is left to the participating countries. The common EST criteria are as follows:

- CO_2 emissions: 80% reduction between 1990 and 2030
- NO_x emissions: 90% reduction between 1990 and 2030
- VOC emissions: 90% reduction between 1990 and 2030.

The three additional criteria for the Netherlands:

- particulate matter: 90% less PM10 emissions between 1990 and 2030
- noise: a negligible level of serious noise nuisance in 2030
- land use: stabilisation of direct land use for transport outside urban areas between 1990 and 2030; a good living climate inside urban areas in 2030 and indirect land use in 2030 represents half the 1990 level.

The pilot studies were conducted as a “backcasting” exercise, meaning in this study that, first, criteria have been set and, second, that measures have been assumed to meet the criteria. See section 2.2 for a more elaborate discussion. The EST criteria are met Besides a business-as-usual scenario (BAU), three EST scenarios were developed containing different approaches to meet the EST criteria. The three EST scenarios are:

(i) a “high-technology” scenario containing only technological changes (EST1);
(ii) a “mobility-management” scenario containing only mobility changes (EST2);
(iii) a “combination” scenario containing one scenario with a combination of technological and mobility changes (EST3).

The relationship of the three EST scenarios to the BAU scenario is summarised in Table 2.1.1.

Table 2.1.1: Relationship between the EST scenarios to the BAU scenario

	High-technology (EST1)	Mobility-management (EST2)	Combination (EST3)
Technological progress	>> BAU	= BAU	> BAU
Transport activity	= BAU	<< BAU	< BAU

Table 2.1.1 shows - for example - that technological progress is assumed to be much higher in the high-technology scenario than for the business-as-usual scenario, while transport activity (transport distances and volumes of passenger and goods transport) is to remain as for the BAU scenario.

These scenarios must be seen as images of what transportation might be like in 2030. The effects of developments and measures are no more than rough indications for illustrating the scenarios. Furthermore, the implementation of technological and societal changes can result in a different image of EST than is assumed here. For example, a breakthrough in new emission-reducing technology will lessen the need for behavioural changes in meeting the EST criteria, e.g. if fuel cells - using sustainable energy - for aircraft are technically feasible, there is less need for a heavy reduction of air transport.

The rest of the chapter is as follows. Section 2.2 defines the difference between “backcasting” and “forecasting” scenarios. Section 2.3 describes the main results of the business-as-usual scenario. Section 2.4 describes the high-technology scenario, section 2.5 the mobility-management scenario and section 2.6 the combination scenario. The description of the scenarios is focused on the attainment of the emission-related EST criteria for CO_2, NO_x, VOC and PM_{10}. Section 2.7 comprises the conclusions of the pilot studies. Finally, Section 2.8 discusses the technology assumptions in the EST scenarios.

Section 2.2 (differences between backcasting and forecasting), Section 2.6.3 (balance-of-effort analysis) and Section 2.8 (discussion of technology assumptions) are supplementary to the Phase 2 report (Van Wee *et al.*, 1996).

2.2 Scenarios: backcasting vs. forecasting[1]

Many scenario studies have been performed since the Rand Corporation's scenario study - mainly for military purposes - in the 1950s. A customary definition of a scenario in the Netherlands is from Becker *et al.* (1982): "*a scenario is a description of society's current situation (or a part of it) of possible and desirable future societal situations and series of events between current and future situations*". In general, two kinds of scenarios can be distinguished: projective and prospective. A projective scenario's starting point is the current situation; extrapolation of current trends results in likely future images. Recent examples of projective scenario studies are the long-term transport scenarios from the Dutch Central Planning Bureau (CPB, 1997) and the National Environmental Outlook 4 from the National Institute of Public Health and the Environment (RIVM, 1997)[2]. A prospective scenario's starting point is a desirable future situation, usually described by a set of goals or targets established by assumed events between the current and future situations. Examples of prospective scenarios are the so-called trend-breach scenarios for passenger transport (Peeters, 1988) and freight transport (Peeters, 1993). Constructing projective scenarios is also called *forecasting*; constructing prospective scenarios is called *backcasting*.

According to Dreborg (1996), backcasting was introduced by Robinson (1982). Robinson (1990) describes backcasting as a normative method and states "The major distinguishing characteristic of backcasting is a concern not with what futures are likely to happen, but with how desirable futures can be attained. It is thus explicitly normative, involving working backwards from a particular desired future end-point to the present in order to determine the physical feasibility of that future and what policy measures would be required to reach that point. In order to permit time for futures significantly different than the present to come about end points are usually chosen for a time quite far into the future ". Van Doorn and Van Vught (1978) state that the difference between projective and prospective scenarios is the place and function of fantasy. Besides empirical research and plausible future situations, imagination and formulating choices to meet desirable situations is an essential part of prospective scenarios. Dreborg (1996) distinguishes differences between forecasting and backcasting studies at different levels (see box 2.2.1) and states that to backcasting studies must reflect solutions to a specified social problem.

1 This section is based on Geurs, Van Wee and Ramjerdi (1997)

2 These studies from the CPB and RIVM also contain prospective elements: besides reference scenarios the studies also contain scenarios with measures to meet the national environmental targets.

Box 2.2.1: differences between forecasting and backcasting studies (Dreborg, 1996)

	Forecasting	**Backcasting**
1. Philosophical view	Causality; determinism; context of justification	causality & technology partial indeterminacy context of discovery
2. Perspective	dominant trends; likely futures possible marginal adjustments how to adopt to trends	societal problem in need of solution desirable futures scope of human choice strategic decisions retain freedom of action
3. Approach	extrapolate trends into the future sensitivity analysis	define interesting futures analyse consequences, and conditions for these futures to materialise
4. Method	various econometric models	partial & conditional extrapolations highlighting interesting polarities and technological limits
5. Techniques	various mathematical algorithms	--------

The EST project also provides an example of a backcasting approach. There are several arguments for choosing a backcasting approach. A backcasting approach - in contrast to forecasting - highlights discrepancies between the current and desirable future and is capable of incorporating large and even disruptive changes. As current transportation policies and measures have not reduced the overall environmental impact of transportation to a desirable (or: sustainable) level, transportation may well be a sector for which a backcasting approach is especially valuable. Further, an approach based on backcasting may be capable of generating the fresh policy directions needed if transportation is to become environmentally sustainable (see also OECD, 1998)

2.3 The Business-as-usual scenario (BAU)

2.3.1 Methodology and main assumptions

The business-as-usual scenario (BAU) is a reference scenario that reflects the continuation of present trends in transportation, moderated by likely changes in legislation and technology. This scenario does not necessarily conform to current governmental policies in the Netherlands.

In general, future transport emissions are the result of changes in (a) transport volumes, (b) behaviour, and (c) technology. Here, the most important categories of determinants are described below as a basis for the business-as-usual scenario.

Figure 2.3.1: "the business-as-usual scenario reflects the continuation of present trends"
Photo: AVV (1996a)

Transport growth depends - given the overall population size and demographic characteristics - on changes in the following main determinant categories: (i) the needs and desires of people and companies, which are related to socio-economic and cultural factors e.g. income and economic growth, individualisation, the women's labour participation (see for example AVV, 1997a) (ii) locations of human activities like those for living, working, shopping, production and distribution, and (iii) transport resistance or 'generalised costs', i.e. monetary costs, travel times, comfort and reliability of all travel modes. For a description of these trends and driving forces, see, for example, Van Veen-Groot *et al.* (1998). For the period up to 2015, the BAU scenario is based on transport forecasts using Dutch national transport models and carried out for the Dutch National Environmental Outlook 3 (RIVM, 1993) and the evaluation of the Second Transport Structure Plan (SVV-II) (AVV, 1993). These forecasts calculate the effects of two policy packages in the context of two economic scenarios (European Renaissance (ER) and Global Shift (GS)). The national transport models for passenger and freight transport used incorporate the determinants described above implicitly or explicitly (for an overview see Van Wee, 1993). For the period of 2015 to 2030, non-linear or exponential trend extrapolations and corrections to them are made on the basis of the driving forces described above, assumptions and general expectations.

Behavioural change has a potentially large influence on future transport emissions. However, in the BAU scenario preferences, attitudes and travel behaviour in given circumstances are assumed to be constant.

Technology improvements to reduce emissions are mainly influenced by new legislation; i.e. emissions from cars have been effectively reduced by (EU) emission standards (e.g. the introduction of the three-way catalyst). In the past, the Dutch car stock has become more fuel efficient due to technological improvements, e.g. a 1% average yearly fuel efficiency improvement between 1980 and 1990. However, the Dutch car stock has not become any more fuel-efficient since 1990 due to an increasing average vehicle weight and engine power, and a lack of fuel-efficiency legislation (RIVM, 1998a). Under the current policy, technology improvement will probably be modest (i.e. EURO3 and EURO4 standards are assumed in the business-as-usual scenario).

The main assumptions regarding macro-economic developments, volume growth and emission factors are:

Macro-economic assumptions

- A constant economic growth of about 2-2.5% per year, about halfway between the European Renaissance and Global Shift scenario;
- Population growth of roughly 14% between 1995 and 2030. The annual rate is assumed to decline because of fewer young (i.e. the percentage of the population under 20 years decreases from 24.3 to 21.9% in the period 1995-2020) and more old people (i.e. the percentage of people 65 and older increases from 13.1 to 24.4% in the period 1995-2020).

Volume growth

- Car use growth is assumed to be 40% between 1990 and 2010, assuming a less strict transport policy than described in the Second Transport Policy Plan due to implementation problems of several policy measures. In the longer term, we assume a growth in car use of 75% between 1990 and 2030. The assumed saturation level of car ownership of 550-600 cars per 1000 inhabitants (1992: 370 cars per 1000 inhabitants) will not be reached in 2030. This level of car ownership is about the current level in the United States[3] where the saturation level has not yet been reached. According to Gilbert (1998) North America is entering the (fourth) phase of ownership where each adult has several cars, perhaps one for commuting, one for weekend trips and one for nostalgic reasons[4]. Here, we (implicitly) assume that by 2030 the Dutch ownership level is still in the (third)

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3 The level of car ownership in the U.S. strongly depends on the definition of automobiles and trucks. Almost 95% of all trucks are light trucks (e.g. pickups, minivans and sport utility vehicles) which are mainly used for personal purposes (70% of all trucks). Without trucks used for personal use, car ownership is 480 cars per 1000 inhabitants, including personal trucks, car ownership is about 675 cars per 100 inhabitants (See U.S. Dep. of Transportation, FHA, Highway Statistics 1997, Washington (http://www.fhwa.dot.gov); U.S. Census Bureau (1999), Vehicle Inventory and Use Survey 1997, Washington, D.C. (http://www.census.gov)

4 The first phase of ownership is the car as a luxury item, available to the rich, the second phase is the car as a household item (i.e. one car per household), the third phase is the car as a individual item (i.e. one car per adult in a household), and the fourth phase is the single purpose vehicle (i.e. more than one cars per individual) (Gilbert, 1998).

phase where each adult in a household possesses a car. The saturation level in the Netherlands is probably lower than in the United States (see Figure 2.3.2) because of better public transport and cycling facilities and a different geographical/ infrastructural constellation.

- The yearly growth factors for van and lorry use are expected to decrease for the period 2010-2030; growth in van use is assumed to be 225% between 1990 and 2030 and growth in lorry use, 175%.
- No large changes in the modal split of passenger transport are expected, whereas in goods transport some changes are expected, i.e. the share of road transport increases from roughly 50% to 60% between 1990 and 2030, decreasing the share of inland shipping.

Figure 2.3.2: "The United States drive-in society extends to every phase of life, and even beyond, as Americans eat, bank, watch movies, and worship from their automobiles - modern centaurs with steel bodies and human heads and hands" (Source: National Geographic, February 1981).

Emission factors

- The emission factors are based on the ER scenario of the Third National Environmental Outlook, e.g. car-fuel efficiency improves by 25% between 1990 and 2030.
- All cars, vans, lorries and buses comply with the EURO4 VOC and NO_x standard in 2030;
- Efficiency of electricity plants increases from 40% in 1990 to 50% in 2030; we assumed no additional use of sustainable energy sources.

2.3.2 Results

Table 2.3.1 shows the passenger and freight transport and emission levels for the business-as-usual scenario for 2030; Table 2.3.2 gives 1990 emission levels and 2030 emissions as an index of 1990 emissions.

Table 2.3.1: Passenger and freight transport, emission factors and total CO_2, NO_x, VOC and PM_{10} emissions for the business-as-usual scenario for 2030

	unit	volume	emission factors				total emissions			
			CO_2	NO_x	VOC	PM_{10}	CO_2	NO_x	VOC	PM_{10}
passengers		(billions)	(g/pass.km)				(ktonnes)			
car	pass.km	181.9	108	0.202	0.230	0.007	19725	36.8	41.8	1.3
rail passenger	pass.km	15.5	34	0.024	0.000	0.000	532	0.4	0.0	0.0
bus.	pass.km	13.3	61	0.413	0.035	0.038	814	5.5	0.5	0.5
mopeds	pass.km	1.7	139	0.270	6.030	0.120	229	0.4	9.9	0.2
motorbikes	pass.km	1.7	50	0.050	7.034	0.040	85	0.1	12.0	0.1
bicycle	pass.km	12.8	0	0.000	0.000	0.000	0	0.0	0.0	0.0
freight		(billions)	(g/tonne km)				(ktonnes)			
lorry	tonne km	97.2	130	0.843	0.075	0.063	12651	81.9	7.3	6.2
inland shipping	tonne km	62.5	36	0.675	0.069	0.048	2226	42.2	4.3	3.0
rail freight	tonne km	6.1	20	0.014	0.000	0.000	120	0.1	0.0	0.0
other		(millions)	(g/pass.;g/veh.km; kg/index point)				(ktonnes)			
aviation	passengers	56.9	24	0.129	0.035	0.005	1356	7.4	2.0	0.3
special vehicles	veh. km	710	712	4.238	0.511	0.409	505	3.0	0.4	0.3
other mobile sources	hours (index)	175	13	0.155	0.041	0.006	2193	27.0	7.2	1.0
total										
Total transport emissions							40435	204.7	85.4	12.8
EST-criteria							5836	35.2	20.1	2.2

Table 2.3.2: Total CO_2, NO_x, VOC and PM_{10} emissions for 1990 and business-as-usual emissions for 2030 as an index of 1990 emissions

	1990				2030			
	CO_2	NO_x	VOC	PM_{10}	CO_2	NO_x	VOC	PM_{10}
	kton				index 1990=100			
cars	15081	148.0	141.0	5.5	131	25	30	23
vans	2073	12.0	10.0	1.8	253	108	79	191
lorries	3257	50.0	8.2	3.8	230	99	53	82
heavy lorries	2244	48.0	8.2	3.5	230	68	36	89
special verhicles	282	4.1	1.7	0.5	179	73	21	59
buses	552	10.0	2.6	1.0	100	37	12	36
motorcycles	141	0.3	5.7	0.1	140	128	150	150
mopeds	102	0.1	13.0	0.1	83	86	93	100
inland shipping	1623	30.1	3.1	2.1	137	140	137	140
marine transport	727	16.1	0.6	1.1	120	120	120	120
rail passengers-diesel	53	0.3	0.1	0.0	95	105	95	266
rail goods-diesel	38	1.3	0.0	0.0	135	150	135	234
aircraft	538	2.1	0.8	0.1	252	350	252	198
other mobile sources	1759	28.1	5.8	2.8	125	96	125	37
rail passengers-electr.	639	1.6	0.0	0.0	77	21	n.a.	n.a.
rail goods - electr.	71	0.2	0.0	0.0	110	30	n.a.	n.a.
TOTAL	29180	352.3	200.9	22.3	159	67	46	78
EST criteria					20	10	10	10

n.a. = not applicable

Table 2.3.2 shows a high increase in CO_2 emissions. NO_x emissions are reduced by about one-third, VOC emissions by more than 50% and PM_{10} emissions by more than 20%. The table also shows the BAU emissions to be much higher than the EST criteria: the BAU scenario is far from being sustainable according to the emission-related EST criteria. If the EST criteria are to be met, CO_2 and PM_{10} emissions have to be reduced by 87% of the BAU scenario emissions, NO_x emissions by 85% and VOC emissions by 78%.

Regarding the noise and land use criteria, the BAU scenario is far from being sustainable. Table 2.3.3 shows that a negligible level of serious noise nuisance is far from being attained.

Table 2.3.3: Noise nuisance and serious noise nuisance by road traffic, rail traffic and civil aviation; 1990 and projections for 2010[a] and 2030

		1990	2010	2030
		index 1990=100		
Road traffic	noise nuisance	100	95	95
	serious noise nuisance	100	75	75
Rail traffic	noise nuisance	100	95	95
	serious noise nuisance	100	97	97
Civil aviation	noise nuisance	100	144	200
	serious noise nuisance	100	170	250

[a] 2010 projections from the ER scenario (Van Wee *et al.*, 1993)

Further, the direct land use for motorised transport is expected to increase inside and outside urban areas, i.e. total (metalled) road length in the Netherlands (which accounts for about 1.6% of the total Dutch surface area) is expected to increase by about 30 % between 1990 and 2030, outside urban areas by about 25%. The increase is roughly the same as for the period 1970-1990. Indirect land use caused by noise pollution - the most important issue related to indirect land use - will slightly increase up to 2030.

2.4 The high-technology scenario (EST1)

2.4.1 Methodology and main assumptions

In the high-technology scenario, technological progress is assumed to satisfy the EST criteria. The high-technology scenario has two key categories of change:

- Changes in “existing” vehicle categories and technology; the vehicle categories from the business-as-usual scenario are assumed to use best technical means;
- Introduction of new technologies, e.g. hybrid vehicles.

This section describes the main technology assumptions and specific assumptions for car use, road freight transport and other vehicle categories (non-road transport). For a more elaborate description please refer to Van Wee *et al.* (1996).

Main assumptions

- The introduction of new technologies is strongly related to a much greater use of electrical traction, especially for passenger transport but also for goods transport;
- A large share of sustainably produced energy is technically feasible. We assume 80% of electricity produced to be sustainable, i.e. water power, biomass, wind and solar energy;
- Fossil fuel electricity production (20% share) is highly efficient (80% compared to 50% in the BAU scenario), combining heat and power.

Car use assumptions

- A high market share of electric cars (80% of all car use), mainly making use of sustainably produced energy. For short distances they run on batteries, for longer distances they are driven to a place where they can be connected to each other, using externally supplied energy;
- A modest share of hybrid cars (20% of all car use) with a conventional combustion engine (only LPG or other gases). These ultra-light hybrid cars (also called hyper cars) are very fuel-efficient, using 80% less energy than the cars in the business-as-usual scenario in 2030 (see Lovins *et al.*, 1996). To reduce NO_x and VOC emissions, hybrid cars use de-NOx catalysts, evaporation control measures and exhaust-treatment facilities.

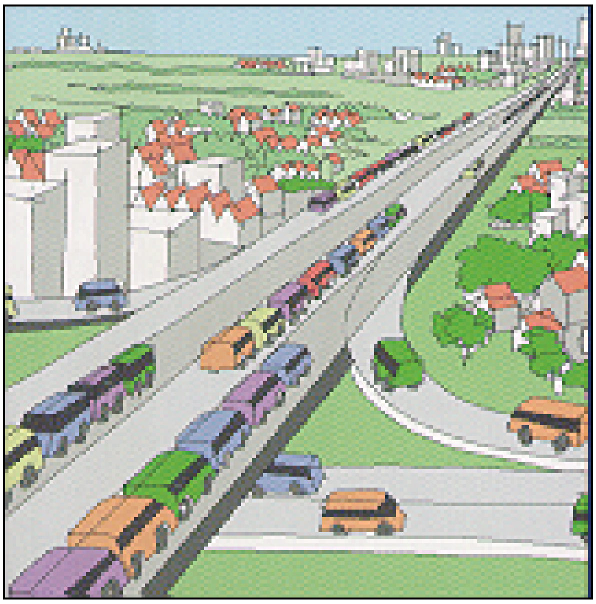

Figure 2.4.1: "Cars drive to a place where they can be connected"
Drawing: RPD (1997)

Road haulage assumptions

- ♦ Electric vans are used for short and inter-urban trips (70% of all van use). Hybrid vans - running on LPG or other gases - are used for longer trips (30% of all use). These hybrid vans are very fuel-efficient, using 60% less energy than the BAU vans thanks to re-use of brake energy, better engines, light materials, lower air resistance and use of the same end-of-pipe techniques as hybrid cars to reduce NO_x and VOC emissions.
- ♦ Fuel cells in combination with sustainably produced hydrogen become the mayor energy source for heavy lorries (80% of all lorry use). Small lorries use hybrid traction running on LPG or other gases (20% of all lorry use). Energy use of hybrid lorries is reduced by 50% due to light materials and a lower air resistance. End-of-pipe measures reduce NO_x and VOC emission from hybrid lorries, i.e. de-NOx catalysts, evaporation control measures and exhaust treatment facilities.

Other freight transport assumptions

- ♦ For inland shipping, marine transport and aircraft, fuel cells using sustainably produced hydrogen will be used. For short distance air transport, rigid airships will be used. Special vehicles and other mobile sources use the same technology as the vans and lorries they are based upon.
- ♦ All passenger and freight trains will operate with electrical traction and benefit from the sustainably generated electricity. Besides, light materials are used, and rolling resistance and aerodynamics are improved. Energy "lost" while braking is regenerated. Technical improvements allow trains to be easily shortened or lengthened, so that supply almost equals demand. An average occupancy rate of 80% (twice the BAU-level) is assumed for both passenger and freight transport. Longer trains in peak hours do not result in "empty" trains during the off-peak hours.

Figure 2.4.2: "For short distance air transport, rigid airships will be used"
Photo: Peeters *et al.* (1997)

2.4.2 Results

Table 2.4.1 gives the result of assumed technological progress in the high-technology scenario: total CO_2, NO_x, VOC and PM_{10} emissions in 2030 and as an index of business-as-usual emissions in 2030.

Table 2.4.1: Total CO_2, NO_x, VOC and PM_{10} emissions for the high-technology scenario in 2030 and as an index of the business-as-usual emissions

	volume	CO_2	NO_x	VOC	PM_{10}	CO_2	NO_x	VOC	PM_{10}
		ktonne				index BAU=100			
cars	175	1973	0.74	0.84	0.11	10	2	2	9
vans	325	1048	0.39	0.95	0.61	20	3	12	18
lorries	275	749	0.49	0.22	0.28	10	1	5	9
heavy lorries	275	516	0.33	0.15	0.28	10	1	5	9
special vehicles	200	126	0.30	0.04	0.07	25	10	10	22.5
buses	120	138	0.11	0.08	0.08	25	3	24	22.5
motorcycles	150	12	0.00	0.00	0.00	6	0	0	0
mopeds	100	6	0.00	0.00	0.00	7	0	0	0
inland shipping	175	0	0.00	0.00	0.00	0	0	0	0
see going ships	150	0	0.00	0.00	0.00	0	0	0	0
rail passengers - diesel	0	0	0.00	0.00	0.00	0	0	0	0
rail goods - diesel	0	0	0.00	0.00	0.00	0	0	0	0
aircraft	350	176	0.00	0.00	0.00	13	0	0	0
other mobile sources	175	548	2.70	0.72	0.23	25	10	10	22.5
rail passengers - electr.	152	21	0.00	0.00	0.00	4	1	n.a.	n.a.
rail goods - electr.	308	5	0.00	0.00	0.00	6	9	n.a.	n.a.
Total transport emissions		5319	5.1	3.0	1.65	13.7	3.7	3.8	14.1
EST-criteria		5836	35.2	20.1	2.23	13	15	22	13

Table 2.4.1 shows that in the EST criteria for CO_2, NO_X, VOC and PM_{10} emissions can be met with changes in existing vehicle technologies and the introduction of new technologies: total CO_2 emissions are well below the EST criterion; total NO_x and VOC emissions fall approximately 85% below the EST criterion; PM_{10} emissions fall 25% below the EST criterion.

The noise and land-use criteria seem attainable with technical measures only. In short, noise emissions from road traffic are strongly reduced by the shift to electric vehicles (which also improves the living climate in urban areas), decreased travel speeds (e.g. maximum speed of 30 km/hr on urban roads) by on-board technical measures and using porous asphalt on urban roads. Rail noise emissions are reduced by taking technical measures to insulate the rolling noise and by insulating dwellings and constructing noise barriers. Noise emissions from aircraft are reduced by technical improvements to engines, insulating dwellings, and a shift from aircraft to rigid airships.

2.5 The Mobility-Management scenario (EST2)

2.5.1 Methodology and main assumptions

In the mobility-management scenario, mobility changes satisfy the EST criteria. This scenario has two main characteristics:

- Overall motorised mobility has to be reduced significantly;
- The remaining demand for mobility has to be met with vehicle categories having the lowest unit impact.

Further, the same techniques as in the BAU scenario are assumed.

Passenger transport assumptions

- People's activity patterns change significantly; the locations for these activities will be close to each other, thus reducing the need to travel over long distances;
- Car use is restricted to special services such as transport of the disabled and ambulance services;
- Non-motorised modes and public transport meet remaining mobility demands; the train will meet long-distance mobility demands. More flexible train and bus systems result in a doubling of the occupancy rates, e.g. provided buses are a more flexible mixture of individual and collective transport;
- Mopeds and motorcycles will disappear.
- Long-distance passenger transport by aircraft will be restricted to highly necessary trips, for instance, diplomatic purposes or family visits to emigrants. Long-distance business trips will be replaced by telematics, over shorter distances by train.

Freight transport assumptions

- A shift towards larger vehicles and fewer empty trips is the result of a logistical optimisation (e.g. fewer empty trips) for road transport, inland shipping and rail. The effects are more-or-less the same as in the so-called *trend-breach scenario for freight transport* (Peeters, 1993); Figure 2.5.1 illustrates the logistical optimisation for road transport. Small lorries (vans) transport the goods to a distribution centre (DC). In the distribution centre the goods are reloaded to a smaller number of large lorries. The large lorries transport the goods to the next distribution centre, where the goods are reloaded to small lorries. The trend-breach scenario shows that a logistical optimisation (including fewer empty trips) results in a decrease of 56% in 2015 in road-traffic vehicle kilometres. The use of vans decreases the most, by almost 80% in 2015. Vans are only used for the "before" and "after" transport to the distribution centre.
- A strong shift from road transport to inland shipping and rail transport, i.e. the share of road transport in the total number of tonne kilometres is reduced from 56% (BAU) to 25% in 2030. The share of inland shipping increases from 41% to 46%;

rail transport increases from 6% to 30%. The effects are more-or-less the same as in the trend-breach scenario;

- There is more regional production and consumption of food, resulting in a reduction of average food-related transport distances of 71%. A shift in the pattern of origin and destination of non-food goods results in a reduction of average non-food-related transport distances of 50%;
- There is less consumption of goods and consumed goods last longer, reducing non-food goods transport volumes by 42%;
- Long-distance freight transport by aircraft will disappear to a large extent.

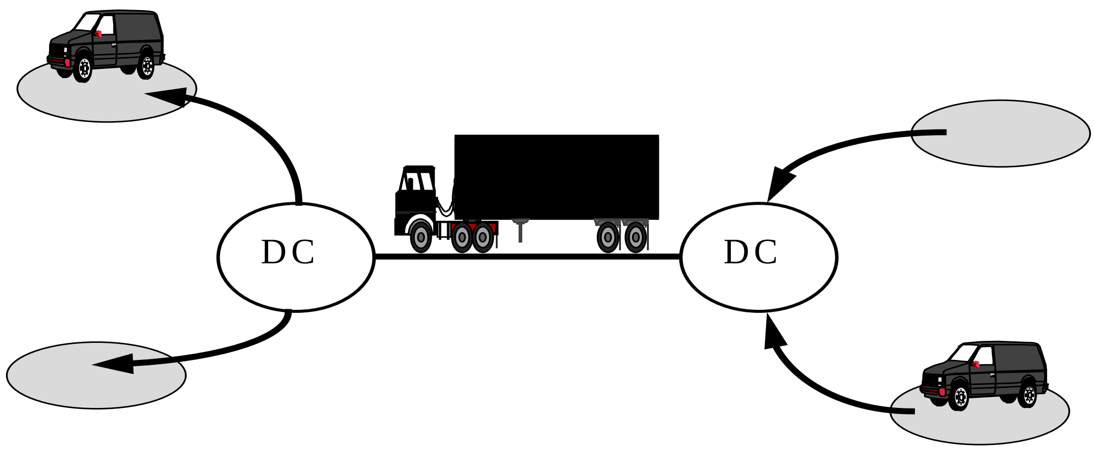

Figure 2.5.1: Logistical optimisation of road freight transport

2.5.2 Results

Table 2.5.1 gives the results of assumed mobility changes in the mobility-management scenario: total CO_2, NO_x, VOC and PM_{10} emissions in 2030 as an index of BAU emissions in 2030. The shows that total CO_2, NO_x, VOC and PM_{10} emissions in the mobility-management scenario are below the EST criterion, and also that emissions from public transport are expected to increase, however, less than the volume growth due to higher load factors.

The noise and land-use criteria can probably be attained by mobility changes only. In short, noise emissions (and indirect land-use caused by noise) are strongly reduced by the strong reduction of motorised transport and a restriction of lorry use in residential areas to daytime. Rail noise emissions will increase due to the tripling of the rail passenger kilometres. However, the increased noise nuisance caused by rail will be more than compensated by decreased noise nuisance by road traffic and civil aviation. Traffic-related land use will be reduced by at least one-third and used for other purposes, e.g. recreation, woodlands, public gardens.

Table 2.5.1: Vehicle use and total CO_2, NO_x, VOC and PM_{10} emissions for the mobility-management scenario in 2030 and as an index of business-as-usual emissions

	unit	volume	total emissions				index BAU2030=100			
			CO_2	NO_x	VOC	PM_{10}	CO_2	NO_x	VOC	PM_{10}
passengers		(billions)	(ktonnes)							
car	pass.km	11.3	1230	2.3	2.6	0.008	6	6	6	1
train	pass.km	56.7	1294	0.9	0.0	0.000	243	243	0	0
bus-publ.tr.	pass.km	11.3	347	2.3	0.2	0.021	86	86	86	9
bus-other	pass.km	0.0	0	0.0	0.0	0.000	0	0	0	0
mopeds	pass.km	0.0	0	0.0	0.0	0.000	0	0	0	0
motorbikes	pass.km	0.0	0	0.0	0.0	0.000	0	0	0	0
bicycle	pass.km	34.0	0	0.0	0.0	0.000				
goods		(billions)	(ktonnes)							
lorry	tonne km	12	992	6.4	0.6	0.48	8	8	8	8
inland shipping	tonne km	22	630	11.9	1.2	0.85	28	28	28	28
train-electricity	tonne km	14	222	0.2	0.0	0.00	186	186	0	0
passengers + goods										
TOTAL			4716	24.0	4.6	1.4	13	14	6	12
EST-criteria			5257	26.6	11.1	1.7				

2.6 The Combination scenario (EST3)

2.6.1 Methodology and main assumptions

The combination scenario uses several assumptions from both the high-technology and the mobility-management scenarios. In general, we assume that the changes in the two scenarios mentioned - having the greatest implications in terms of changes in society - can be omitted.

Main assumptions

- ♦ We assume a modest share of sustainable energy (40%);
- ♦ Fossil-fuel electricity production (60% share) is highly efficient, i.e. 80% in the EST3 and 50% in BAU, like in the high-technology scenario.

Passenger transport assumptions

- ♦ The activities are closely located to each other, thus reducing the need to travel over long distances;
- ♦ Car use is reduced by 50% compared to the BAU level in 2030 due to carpooling, shorter trips and a shift to rail. Due to a high vehicle occupancies (2.0 compared to 1.3 in BAU) car passenger kilometres are reduced by roughly half the reduction of

car use (25% reduction)[5]. All cars are hybrid, using a fuel-efficient engine (using LPG or other gases) and end-of-pipe techniques to reduce NO_x and VOC emissions;

- The level of rail-passenger kilometres is the same as in the BAU scenario: a decreased number of passenger kilometres due to shorter trips is assumed to compensate for the shift from car to rail. Rail emissions are reduced due to the technical improvements in the high-technology scenario (50% energy use, only electrical traction), higher occupancy rates (60% compared to 40% in BAU) and the logistical optimisation (goods transport) of the mobility-management scenario;
- Non-motorised transport (bicycles, walking) will be more than double the BAU level;
- All buses are hybrid (with diesel engines), using end-of-pipe techniques to reduce NO_x and VOC emissions. Energy use is reduced by 65% due to technical improvements and a doubling of occupancy rates.

Freight transport assumptions

- We assume the same logistical optimisation and modal-shift change for road haulage, rail freight transport and inland shipping as in the mobility-management scenario.
- We assume half the reduction in average transport distances for both food (40% reduction) and non-food (25% reduction) of the mobility-management scenario due to more regional production and consumption.
- Less consumption of goods and goods last longer, reducing non-food goods transport volumes by 20% (half the mobility-management level).

Road haulage assumptions

- Small lorries (20% market share) are hybrid vehicles with 50% lower CO_2 emissions than in the BAU scenario. For bigger lorries (80%) we assume a market share of sustainably produced hydrogen of 50%. This is valid for 40% of all lorries and for this 40% there are no CO_2 emissions; the other bigger lorries have 25% lower CO_2 emissions due to technical improvements (e.g. hybrid traction, light materials). NO_x emission is reduced by 50% as a result of the efficiency improvement of both the hybrid and conventional lorries. The assumption here is that the NO_x gain is as half as big as the reduction in energy use. This is because of the typical trade-off between energy use and NO_x emission of engines. Further, NO_x emission reductions are accomplished by using de-NO_x catalysts with a lower efficiency than in the high-technology scenario, i.e. 50% efficiency compared to 80% in the high-technology scenario.

[5] This assumption differs from the Phase 2 report (Van Wee *et al.*, 1996), where the vehicle occupancies in the combination scenario in 2030 are assumed to be the same as in the business-as-usual scenario. Here, we assume a reduction of the number of passenger kilometres by 25%, whereas in the Phase 2 report a reduction of 50% was assumed. Energy and emission figures remain the same.

Non-road freight transport assumptions

- For rail we assume the same technical improvements as in the high technology scenario (-50% energy use; only electrical trains).
- For inland shipping and marine transport we assume a 50% share of hydrogen ships, which is lower than in the high-technology scenario to prevent recently built ships from being scrapped or altered.
- Long-distance air transport (of both passengers and goods) will be strongly reduced, as new technologies to reduce emissions (i.e. hydrogen aeroplanes) will probably mean a relatively expensive “solution” compared to other (transport and non-transport) technical solutions. Improved engine technology, aircraft design optimisation (e.g. larger wingspans, lower optimum speeds) and higher load factors are assumed to reduce energy use per passenger kilometre by 45% compared to the BAU level (see Dings et al., 1997). Long-distance business transport will be largely replaced by telematics; long-distance leisure trips will be made less frequently. Short-distance air passenger and goods transport will be replaced by (high-speed) rail transport and rigid airships travelling at speeds of 100-300 km/h and designed for 100-400 passengers. The total number of air passengers is reduced by about 75% in 2030 (this is roughly a 15% reduction compared to the 1990 level). Overall energy use and CO_2 emission reduction from aircraft in 2030 is assumed to equal the average reduction percentage for CO_2 emissions from the transport sector in the combination scenario compared to BAU, i.e. a 87% reduction.

2.6.2 Results

Table 2.6.1 shows the result of the mobility-management scenario: total CO_2, NO_x, VOC and PM_{10} emissions in 2030 as an index of BAU emissions in 2030. Total CO_2, NO_x, VOC and PM_{10} emissions in the mobility-management scenario are found below the EST criterion.

A combination of the technical measures and reductions of motorised transport can also meet the noise and land-use criteria. In short, noise emissions from road traffic are reduced by a reduction of car use and lorry use (by 50% and 25%, respectively, of the BAU level), decreasing speed to 30 km/hr in urban areas using on-board technical measures. Noise from rail traffic and civil aviation is reduced by technical measures (i.e. insulating rolling noise of trains and improvements of aircraft engines), insulating outer walls of houses and construction of noise barriers along rail tracks. In urban areas, the reduction of motorised traffic and the shift towards hybrid vehicles running in electric mode will improve the living climate.

Table 2.6.1: Passenger and freight transport, emission factors and total CO_2, NO_x, VOC and PM_{10} emissions for the combination scenario for 2030

	unit	volume	emission factors				total emissions			
			CO_2	NO_x	VOC	PM_{10}	CO_2	NO_x	VOC	PM_{10}
passengers		(billions)	(g/pass.km)				(ktonnes)			
car	pass.km	140.0	14	0.014	0.016	0.001	1974	2.0	2.3	0.11
train	pass.km	15.5	3	0.004	0.000	0.000	53	0.1	0.0	0.00
bus-publ.tr.	pass.km	13.3	21	0.033	0.006	0.012	285	0.4	0.1	0.16
bus-other	pass.km	0.0	21	0.000	0.000	0.011	0	0.0	0.0	0.00
mopeds	pass.km	0.4	30	0.030	4.220	0.022	13	0.0	1.8	0.01
motorbikes	pass.km	0.4	83	0.162	3.618	0.065	34	0.1	1.5	0.03
bicycle	pass.km	25.6	0	0.000	0.000	0.000	0	0.0	0.0	0.00
goods		(billions)	(g/tonne km)				(ktonnes)			
lorry	tonne km	23.9	34	0.139	0.020	0.015	821	3.3	0.5	0.36
inland shipping	tonne km	45.8	14	0.135	0.028	0.017	652	6.2	1.3	0.79
rail	tonne km	29.8	3	0.003	0.000	0.000	92	0.1	0.0	0.00
other		(millions)	(g/pass.;g/veh.km; kg/index point)				(ktonnes)			
aviation	passengers	14	13	0.071	0.019	0.003	179	0.3	0.1	0.0
special vehicles	veh. km	140	214	1.271	0.153	0.123	106	0.6	0.1	0.1
other mobile sources	hours (index)	122.5	4	0.046	0.012	0.001	461	5.7	1.5	0.2
total										
Total transport emissions							4669	18.8	9.1	1.74
EST-criteria							5257	26.6	11.1	1.66

2.6.3 Balance-of-effort analysis

To assess the relative contributions of assumed technological and non-technological changes in the combined scenario for the attainment of the EST criteria, a “balance-of-effort” analysis was conducted. The OECD has provided a framework for the “balance-of-effort” analysis of the contribution of four factors to the attainment of the CO_2 reductions required for the combined scenario, compared to the BAU scenario (see OECD, 2000):

1. reduced emissions per unit of transport activity from the same vehicle type through technological change or vehicle downsizing;
2. reduced transport activity, i.e. fewer passenger- or tonne kilometres through less trips or shorter distances;
3. reduced emissions per unit of transport activity through the use of more efficient vehicle types, i.e. through mode shifts;
4. reduced emissions per unit of transport activity through using the same vehicle type more efficiently, i.e. higher occupancies.

The balance of effort is calculated by estimating the relative contributions to the total CO_2 reduction of each of the four separate contributions (assuming independence between the four factors), calculating their total, and then calculate each estimate's percentage of the total[6]. The method is different for passenger transport and freight transport. For passenger transport, the balance-of-effort calculation is based on the total number of passenger and vehicle kilometres per mode (cars, rail passenger, bus, motorcycles and moped) and CO_2 emission factors (gram of CO_2 per vehicle kilometre) per mode for the business-as-usual and combination scenario. For freight transport, the calculation is based on the number of tonne kilometres and CO_2 emission factors (gram of CO_2 per tonne kilometre) per mode (lorry, inland shipping and rail), estimations of the relative change of emission intensity (CO_2 per vehicle kilometre) and load factor improvements for the combined scenario compared to the BAU scenario.

Figure 2.6.2 gives the results of the balance-of-effort analysis. Totally, the balance-of-effort of technology and non-technology changes is equally divided, i.e. technology and non-technology changes account for 50% of the CO_2 emission reduction. For passenger transport, more emphasis lies on technology changes, i.e. technology changes contribute 58% to the total CO_2 emission reduction, activity changes, 15%, mode shifts, 1%, and higher occupancies, 26%. Note that the contribution of mode shifts negligible, because the additional passenger kilometres due to a shift from car to rail are assumed to be compensated by shorter average public transport trip distances.

For freight transport, more emphasis lies on non-technology changes, i.e. technology changes contribute 40% to the total CO_2 emission reduction, activity changes, 27%, mode shifts, 17%, and higher occupancies, 16%.

6 The sum of emission reduction as a result of technology and non-technology changes is therefore higher than the total CO_2 emission reduction.

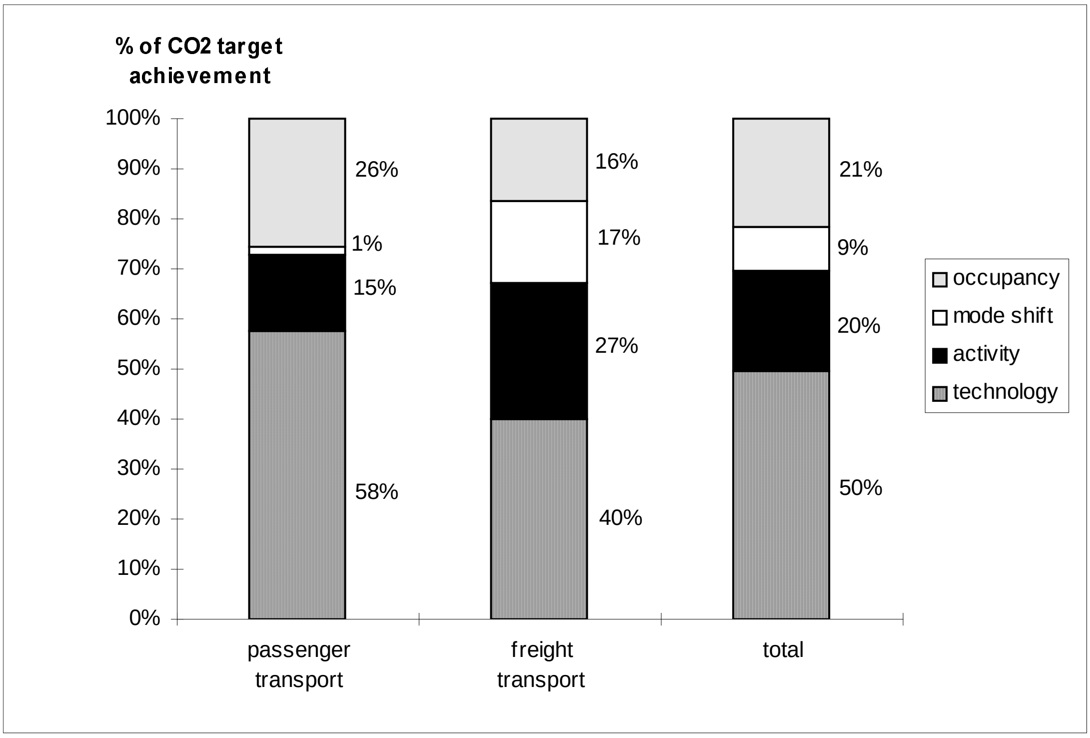

Figure 2.6.2: Estimate of the relative contribution of changes in technology, activities, mode shifts and occupancy to the total CO_2 emission reduction for the combination scenario

2.7 Conclusions

This chapter described transport scenarios that meet stringent criteria for Environmentally Sustainable Transport (EST), based on reductions (%) of the polluting components: CO_2 by 80% and NO_x, VOC and PM_{10} by 90% between 1990 and 2030, and criteria related to noise and land use in 2030. Conclusions are as follows:

- Only if a high increase in technological developments and/or very stringent behaviour adaptations and changes in spatial and economic structures at an international level are assumed, the EST criteria can be met with (i) only technological changes, (ii) only mobility changes, or (iii) the combination of both technological and mobility changes,
- If the EST criteria are to be realised through only technical changes, a very high increase in technological research and progress is needed. Expensive techniques will also have to be developed and implemented. Reducing emissions (mainly) by technical measures will likely mean a shift towards electrical traction and sustainable energy (e.g. sustainably produced hydrogen);
- If the EST criteria are to be realised through only mobility changes, mobility patterns will have to change significantly. Most people will have to work in the location/region were they live and commute by non-motorised modes. Motorised

transport will be mainly public transport. The role of the car in the society has to change radically. The mobility changes will have major impacts on the agricultural sector: food has to be produced and consumed more on a regional scale. Train traffic will cause noise nuisance in 2030 because no technical measures are assumed;

- As a result of the combination of some technical measures from the high-technology scenario and some mobility measures from the mobility-management scenario, the NO_x, VOC and PM_{10} emissions are found below the EST criterion for NO_x, VOC and PM_{10} so as to reduce the CO_2 emissions. By combining the technical and mobility measures, less stringent changes need to be made in the transport sector, with less impact on the energy, agricultural and other sectors. These measures also may have the best potential societal support;
- The mobility and technical measures needed to meet the CO_2 criterion contribute to a large extend to meeting the NO_x, VOC and PM_{10} criteria and almost fully satisfy the noise and land-use criteria in the EST scenarios. In other words: the CO_2-criterion is the most difficult criterion to attain. To meet the noise and land-use criteria, some additional measures are necessary (e.g. noise barriers, insulating outer walls of houses, restricting lorry use to daytime in residential areas) but these measures do not interfere with the other measures.

2.8 Discussion of technology assumptions

The assumptions on the vehicle technologies in the high-technology and combination scenario in this report are based on the available knowledge and information in 1996. In short, in the high-technology scenario, a shift towards electrical traction is assumed for passenger transport and a shift to fuel cells using hydrogen in freight transport. The electricity and hydrogen in this scenario are to be (largely or fully) produced from a range of renewable sources, i.e. waterpower, biomass, wind and solar energy. In the combination scenario, a heavy reliance on hybrid vehicles is assumed and less reliance on electric and hydrogen traction, e.g. all cars are hybrid, 60% of all lorries.

In the last few years several technologies have been discussed for emissions reductions in the future. Table 2.8.1 gives an overview of technological options for emission reductions, split by:

(a) vehicle type, i.e. vehicles with a conventional combustion engine (i.e. (ultra) low emission vehicles or vehicles running on alternative fuels), hybrid traction, fuel cell vehicles and electric vehicles;
(b) fuel type, i.e. gasoline, diesel, LPG, natural gas, ethanol, methanol, hydrogen;
(c) type of energy production, i.e. fossil fuel (with or without CO_2 sequestration and storage), biomass, solar/wind/water power.

The CO_2 and NO_x emission reduction potential for each technology presented in Table 2.8.1 is relative to the current generation of gasoline vehicles with a catalytic converter (complying with EURO2 standards). Note that in the business-as-usual scenario, a car fuel-efficiency improvement of 25% is assumed between 1990-2030.

Table 2.8.1 Technological options for emission reductions (relative to a 1996-gasoline vehicle)

vehicle type	fuel type	fuel production	emission reduction potential	
			CO_2	NO_x
			index 1996 gasoline vehicle = 100	
(ultra) low emission vehicle	gasoline	fossil	20 - 40	20 - 40
	diesel	fossil	20	100
	LPG	fossil	20	30
alternative fuels	natural gas	fossil	80	25
	ethanol	fossil	20 - 100	110
	methanol	fossil	30 - 90	90
	diesel	biomass	0	100 - 200
	ethanol	biomass	0	100 - 200
	methanol	biomass	0	100 - 200
hybrid traction	gasoline/diesel/LPG + other traction	fossil	10 - 35	10 - 25
fuel cell	methanol/natural gas	fossil	40	10
	hydrogen	fossil	10 - 30	0 - 10
	hydrogen	biomass	0	0
	hydrogen	solar/wind/water	0	0
electric traction	battery	fossil	50 - 90	30 - 60
	battery	biomass	10	0
	battery	solar/wind/water	10	0

Source: Elzen *et al*. (1996); Thijssen *et al.* (1999)

Table 2.8.1 shows that further development of cars with a conventional combustion engine can reduce emissions strongly, i.e. an (*ultra) low emission vehicle* with an fuel efficient combustion engine can have up to 50% lower CO_2 emissions and 80% lower NO_x emissions compared to current vehicles. Improving conventional vehicles is very cost-efficient: according to Kolke & Friedrich, the development and production costs of (ultra) low emission vehicles can be more than compensated by lower vehicle and fuel costs. A further reduction (up to 100%) of CO_2 emissions can be achieved if biomass is used to produce diesel, ethanol or methanol. Biomass can probably be used at relatively low costs: according to Thijssen *et al* (1999), the avoidance costs for CO_2 (for the entire fuel chain from production to enduse) are about 20 Euro per tonne for cellulose ethanol (to replace gasoline vehicles) and about 140 Euro per tonne for biomass diesel (based on Fischer-Tropsch (FT) synthesis). Disadvantages of biomass fuels are the availability of biomass (e.g. large-scale introduction of these fuels imply a large production of biomass outside the Netherlands), and that NO_x emissions are not automatically reduced.

Hybrid vehicles are another option for heavy emission reductions. Hybrid vehicles combine two different propulsion systems, e.g. a conventional combustion engine with an electric engine. The hybrid vehicles which are currently being developed in the United States have a 65% lower CO_2 emissions than current Dutch gasoline cars and are very cost-efficient, i.e. the additional production and development costs for a hybrid car (about 4500 Euro) will - during the life time of the vehicle - be more than compensated by reduced fuel costs (Elzen *et al.*, 1996). A hyper car – a very low weight and aerodynamic hybrid car – such as suggested by Lovins *et al*. (1996) can (further) reduce CO_2 and other emissions (up to 90%) at probably low cost for the user.

The use of *fuel cells* as an alternative propulsion system has a very large potential for reducing transport emissions. Fuel cell vehicles could run on gasoline, methanol (produced from natural gas) reducing CO_2 emissions up to 60% and other emissions up to 100% at the costs of about 180 Euro per tonne CO_2 (Kolke & Friedrich, 1997). The use of hydrogen in fuel cells has a higher potential to reduce CO_2 emissions, especially if renewable sources (biomass, wind and solar energy) are used to produce the hydrogen, but at a much higher cost because of high costs of infrastructure and end use. Thijssen *et al.* (1999) estimate the avoidance cost for hydrogen (for the entire fuel chain) produced from natural gas (including CO_2 sequestration and storage), biomass or wind and solar energy at 550 Euro or more per tonne CO_2. Although Kolke & Friedrich give a lower avoidance cost estimate for hydrogen from natural gas (about 150 Euro per tonne CO_2), they conclude that the use of hydrogen in road transport is not to be supported because of the high energy losses in production en processing of the energy source. The availability of renewable energy (biomass or wind and solar energy) may also be a problem if a large-scale shift to fuel cells using sustainably produced hydrogen is to be achieved.

Electric vehicles are another option for heavy emission reductions. If the electricity is produced conventionally (i.e. oil, coal, natural gas) than CO_2 emissions can be reduced up to 50%, with solar or wind energy up to 90%. According to Elzen *et al.* (1996), electric vehicles are currently 50-100% more expensive than conventional vehicles, although small manufacturers already offer electric vehicles which are only 15 to 25% more expensive. Disadvantages of electric vehicles are the limited driving range, the size and weight of the batteries (which is a problem for heavy-duty vehicles) and the costs of a new energy infrastructure system. A (probably expensive) solution for the limited driving range – which is assumed in the high-technology scenario - is to supply the electricity externally on vehicles on the main road network.

In conclusion, in the high-technology scenario a heavy reliance on renewable energy is necessary if CO_2 and other emissions are to be reduced by almost 90% through technology alone. In the high-technology scenario, fuel cell vehicles running on hydrogen and electric vehicles are plausible but expensive options because of the need for a new energy infrastructure and the high cost of producing carbon free energy. More cost-efficient vehicle technologies (improved conventional vehicles and hybrid vehicles) may be used on the medium term, but these technologies will probably not be able to attain the necessary emission reductions envisioned by EST.

In the combination scenario, the reliance on renewable energy is less, and more cost-efficient vehicle technologies (compared to the high-technology scenario) can be used. Both improved conventional vehicles (e.g. ultra low emission vehicles) and hybrid vehicles seem plausible vehicle technologies, where the hybrid vehicle has a higher potential for emission reductions.

3. Assessment of individual instruments

3.1 Introduction

This chapter describes the results of the assessment of instruments for the combination scenario (EST3) for the Netherlands. The assessment of individual instruments formed the input for the construction of packages of instruments which – if implemented – would result in the attainment of EST by 2030 (see Section 4). The method used to identify instruments and instrument packages can be described as *structured brainstorming*, i.e. a method based on collective expert judgement (in multiple interations) organised around a prescribed form. The aim of the assessment of individual instruments is only to construct a feasible package of instruments for the attainment of EST, taking into account the interactions between instruments. In a next step, the instrument packages are more thoroughly assessed in terms of social and economic impacts (see Section 5 and 6).

The assessment consisted of the following steps:

(1) identification of features in the *combination scenario* for the Netherlands,
(2) identification of the most promising instruments, which if implemented in a timely manner would result in the feature being put into operation by 2030,
(3) a "brainstorming" exercise to assess the individual instruments in terms of (a) effects, (b) cost-effectiveness, (c) impacts inside and outside the transport system, and (d) advantages and disadvantages of implementing the instrument. The format of the table presented in Appendix 2 was used as a framework in the brainstorming exercise.

This section does not explain the assessment of instruments in detail, only the assessment of the macro-economic impacts of implementing the instruments to realise reductions in car and lorry use. The macro-economic impacts of instruments for the attainment of EST are assessed using existing information from scenario studies for the Netherlands. A more thorough analysis of the economic impacts of EST is described in Section 7.

Section 3.2 explains the terms used in the assessment of instruments. Section 3.3 deals with the assessment of macro-economic impacts of instrument implementation that would result in the necessary reductions in car and lorry use in the EST3 scenario. Finally, Section 3.3 presents the conclusions from the assessment of individual instruments.

3.2 The terms explained

Appendix 2 shows the results of the assessment of the features and instruments used in the combination scenario (EST3) in terms of (1) effects, (2) cost-effectiveness, (3) impacts inside and outside the transportation system, (4) macro-economic impacts, (5) links with other instruments, and (5) advantages and disadvantages of implementing the instrument.

The appendix lists the *features* (or characteristics) of the EST3 scenario. For example, 100% of the car stock in the EST3 scenario is hybrid. An *instrument (or strategies)* is the term given to the means of realising the scenarios. Examples include pricing instruments, regulations, infrastructure policies, education and information.

The *effects* the instruments have are split into:

- effect on transport activity, e.g. the number of vehicle, passenger or tonne kilometres;
- effect on unit impact, i.e. the emission per vehicle, passenger or tonne kilometre.

The *cost-effectiveness* can be described as the unit price (Dutch guilder Euro, dollar, etc.) per kilogram emission avoided.

The effects and cost-effectiveness are assessed on a five-point scale as follows: -- = very negative, - = negative, 0 = neutral, + = positive, ++ = very positive.

Impacts inside the transportation system are split into:

- impact on vehicles, e.g. a shift from conventional to hybrid cars;
- impact on fuels, e.g. a shift from conventional fuels to CNG;
- impact on infrastructure, e.g. a shift from road to public transport infrastructure.

Impacts outside the transportation system are split into:

- impact on land use, e.g. changes in land-use functions to accommodate short recreational distances and distances travelled for commercial purposes;
- impact on people's organisation of social and other activities, e.g. more local social activities to shorten distances travelled for social purposes (visiting friends, family, etc.);
- psychological impact, e.g. breaking down the image of the car as status symbol.

The impacts inside and outside the transportation system are assessed on a three-point scale as follows: 0 = no impact, + = some impact, ++ = a large impact.

Macro-economic impacts are split into:

- impact on employment, e.g. less employment in car-related sectors of the economy;
- other macro-economic impacts, e.g. impact on production sectors, GDP (total added value), household incomes and external costs.

The macro-economic impacts are assessed on a five-point scale as follows: -- = strong negative impact, - = small negative impact, 0 = no impact, + = small positive impact, ++ = a strong positive impact.

The *links* with other instruments describes whether the instrument is linked to other features or instruments involving activity reductions (A), impacts per passenger or tonne kilometre (I), or both (A/I).

The *advantages/disadvantages* of the instruments can be related to their effect (e.g. only short term), the political/social/technical feasibility of implementing the instrument or other relevant issues.

3.3 Macro-economic impacts of reductions of road transport volumes

Macro-economic impact of heavy reductions in car use

The study called *The Netherlands travelling clean* (Peeters, 1988) qualitatively analyses the macro-economic impacts of a heavy reduction in car use and a shift from car use to public transport. Peeters concludes:

- Reductions in car (ownership and) use will lead to a reduction in employment in transport-related sectors. Decreased employment in car-related sectors of the economy cannot be fully compensated by increased employment in public-transport-related sectors. However, secondary employment is thought to increase, e.g. scaling-down of activities will increase employment in the retail industry;
- Necessary investments in the public transport infrastructure in the “Trend Breach” scenario equal the investments in car infrastructure in the “Trend” scenario;
- A heavy decrease in car use will lead to a reduction in government revenues. Reduced car ownership and car use cannot be compensated by drastic increases in car taxes;
- Added value (GDP) *growth* will be less;
- External costs will be strongly reduced.

Therefore, instruments to reduce car volumes are assumed to have a negative to neutral effect on employment (score: -/0) and will have both positive (less external costs) and negative impacts (lower GDP growth) on “other” macro-economic developments (scored -/+). The employment effect of a shift from car infrastructure to rail infrastructure is assumed to be neutral (score: 0).

Macro-economic impact of heavy reductions in lorry use

The study called *A new course in freight transport* (Peeters, 1993) quantifies the macro-economic impacts of a heavy reduction in road transport and a shift from road transport to rail and inland shipping. Peeters concludes the following:

- A logistical optimisation will result in a small reduction in employment in the sectors of the economy related to freight transport. This is the result of increased transport costs, which represent the combined effect of (a) fewer vehicle kilometres with empty vehicles and thus reduce costs, (b) more waiting time and thus increase costs;
- A shift from road transport to rail and inland shipping results in a small reduction of employment in freight transport related sectors. This is the result of increased transport costs, which is the combined effect of (a) cost savings because of lower costs per tonne kilometre, i.e. rail and inland shipping per tonne kilometre is cheaper than road transport and (b) increased transport time, thus increasing costs;
- The logistical optimisation and the modal shift change will lead to a reduction in added value *growth* (GDP) because of higher transport costs;
- The external costs of freight transport will be strongly reduced.

Therefore, the instruments related to logistical optimisations are therefore assumed to have a small negative impact on employment (score: -); the instruments related to a shift from road transport to rail and inland shipping are assumed to have a small negative impact on employment (score: -); the instruments related to activity reductions in road transport are assumed to have both positive and negative impacts on “other” macro-economic developments (score: -/+).

3.4 Conclusions from the assessment of instruments

From the qualitative assessment of individual instruments, the following conclusions can be drawn which are relevant for the construction of instrument packages for the attainment of EST:

- A combination of pricing policies and regulations is probably the most effective and cost-efficient way to attain EST;
- An instrument package including only existing policy instruments (e.g. fuel tax increases, improving public transport infrastructure) will probably not be sufficient to meet the EST criteria. Innovative instruments - such as a system of tradeable CO_2 emission permits - need to be developed and implemented as part of a instrument package. This conclusion is in line with an advice from the Dutch Council for Housing, Spatial Planning and the Environment (1998) to the Minister

of Housing, Spatial Planning and the Environment, in which they conclude that (i) attaining long-term climate policy targets (beyond the 2010 Kyoto targets) will be very difficult with the current set of policy instruments (e.g. energy taxes, energy efficiency regulations) and (ii) a national system of tradeable carbon emission permits is to be preferred as a policy instrument - for attaining long-term CO_2 emission reduction targets - instead of regulatory energy taxes because of its self-regulating potential and its possibly larger social feasibility;

- An instrument package containing only instruments related to the transport sector will probably not be sufficient to attain the emission reductions envisioned by EST. Sustainable transport according to the EST criteria can probably not be met without changes in other sectors, i.e. agriculture, energy, industry. Sustainable transport implies a sustainable society. Moreover, if other sectors - for example, industry - are to become (more) sustainable, realising EST will be less difficult and the impact on society also less;
- An instrument package containing only measures on the national and regional/local level will probably not be sufficient to meet the EST criteria. International co-operation and measures are also needed, for example, in the framework of the EU or OECD;
- EST is likely to have an impact on society, i.e. both transport and the society as a whole will be fundamentally different compared to the business-as-usual scenario. EST will have large impacts outside the transportation system, i.e. the impact on land use, people’s organisation of social and other activities, and psychological impact;
- Impacts of an environmentally sustainable transport system are likely to differ between countries because of country-specific characteristics. The Netherlands can be characterised as a country with: (a) a relatively large share in the international freight transport, i.e. the transport of goods through the Rotterdam harbour and Amsterdam Airport, (b) an open economy, (c) no car industry to speak of and (d) a spatial infrastructural constellation with relatively short distances between the major cities, a relatively high-density rail network and a relatively high number of cyclists. Thus, we can expect a large impact of EST on freight transport -long-distance freight transport will decrease significantly because of the changes in production and consumption - and contrarily a small impact on the car industry and on Dutch society, which will function reasonably well without so many private cars.

4. Instrument packages

4.1 Introduction

This chapter describes possible instrument packages for passenger and freight transport which if implemented in a timely manner would result in *combination scenario* (EST3) features and hence the achievement of sustainable transport according to the EST criteria. The implementation of the instruments will not be easy or comfortable. There will be innumerable difficulties and strains in the process of transition from business-as-usual to EST; there will be hard cases, unexpected consequences, and pressure to weaken or abandon the attempt to face up to the environmental consequences of transport.

Implementation of the instrument package implies a fundamentally different society in 2030 compared to the current and the "business-as-usual" society of 2030. It implies that many changes outside the transport sector have taken place: changes in the political, societal, economic and spatial context. For example, people in an EST world have a more ecologically sound lifestyle (i.e. they buy more durable and regionally produced goods, and use renewable energy); the international orientation of the Dutch economy has also changed. Here, we focus more on the instruments within the transport sector, and less on the instruments outside the transport sector.

Section 4.2 describes the instrument package for passenger transport, while section 4.3 is devoted to freight transport. Section 4.4 gives an overview and characterisation of the instruments.

4.2 Passenger transport

4.2.1 Introduction

The instrument package to allow passenger transport to meet the EST criteria comprises:

- Tradeable CO_2 emission permits per capita;
- Other pricing instruments, e.g. road pricing, fuel prices;
- Land-use/spatial-planning instruments, e.g. regulations for closer proximity of locations to activities (housing, work, retail outlets, recreation sites);
- Infrastructure policy, e.g. expansion of rail infrastructure;
- Regulations, e.g. prohibiting cars with conventional combustion engines in central urban areas;

- Speed control measures, e.g. lower speed limits on highways;
- Education and information instruments;
- Instruments outside the transport sector, i.e. instruments to promote flexible housing and employment markets.

The assessment of individual instruments in terms of (a) effect on activities, (b) effect on unit impact and (c) cost-effectiveness showed that a combination of regulations and pricing policies is probably the best way to attain sustainable transport according to the EST criteria. Furthermore, innovative instruments will need to be developed and implemented if the EST criteria are to by met by 2030. *A system of tradeable CO_2 emission permits for passenger transport is assumed to be the main element in an instrument package striving for EST. Other instruments are important for supporting or facilitating EST and increasing the (social) feasibility of the implementation of EST.* In other words, tradeable CO_2 permits can only be implemented as a part of an instrument package with flanking/supporting instruments.

4.2.2 An instrument package for passenger transport

Tradeable CO_2 emission permits

The main ideas underlying the theory of tradeable permits were already described in the early 1960's (see Verhoef *et al* (1996) for a literature overview). Probably the most promising direction for applying tradeable permits in the regulation of environmental externalities of transport, is through a system of tradeable fuel permits (Verhoef *et al.*, 1996).

In the EST Combination scenario, the implementation of a "system of tradeable CO_2 emission permits is assumed for the transport sector. Alternatively, it can be envisaged that CO_2 emission targets are set for the entire economy, in which case permits should also be tradeable between sectors. This opens up the possibility of achieving the CO_2 targets in a cost-effective way within and between economic sectors. The CO_2 permits are directly related to fuel use: the starting point of the system is a rating system calculating the number of carbon units embodied in each fuel type. Fleming (1997) describes an example of a tradeable carbon emission quota system for all sectors of the economy (see box 4.2.1 for a description).

A system of tradeable CO_2 permits for passenger transport potentially has several advantages:

1. *Effectiveness:* the system will have several effects on passenger transport, as people will try to optimise their travel patterns within their CO_2 budget. Firstly, the total volume of passenger kilometres is influenced by CO_2 permits, depending on the total CO_2 budget for passenger transport and the price of buying extra CO_2

permits. Secondly, energy use per vehicle kilometre is influenced by CO_2 regulations, e.g. the higher the energy efficiency of the car the more vehicle kilometres can be driven with the same CO_2 permit. Thirdly, the modal split of passenger transport is influenced, e.g. the use of non-motorised transport will increase;

2. *Equity*: the unconditional allocation of quota to inhabitants gives them free access to the baseline quantity of fuel (and thus motorised mobility), and the option of selling part of their allocation opens up the possibility of earning revenues from the system. Compared to increasing fuel taxes as a pricing instrument to meet the EST criteria, a system of tradeable emission permits will be better from an equity point of view, i.e. the increase in transport expenditures for maintaining their current mobility patterns will be higher for high-income groups than for low-income groups (see also Section 6.2.1).
3. *Lower costs:* Fleming (op. cit.) states two reasons why in practice a fuel price resulting from tradeable permits would be substantially lower than the prices that would have to be set by carbon taxes to deliver the same emission reduction, although in an equilibrium world of economic theory the price which delivers a given quantity would be the same, i.e. (i) the price of allocation to consumers is zero and would make a very large contribution towards keeping to a minimum rise in prices developing as a result of the permit system, and (ii) the permit system would be able to make full use of "false expectations" of price, i.e. a forecast for a price for an emission permit for example in 10 years time would be the incentive for the market to respond by accelerating its energy efficiency programme and reducing its CO_2 emissions, so that the price that developed at the end of the 10 year period may turn out to be substantially less than expected;
4. *Flexibility:* the necessary emission reduction for EST implies long-term policies which should be able to respond to profound societal changes, e.g. periods of economic growth and recession, and shifts in intensity of concerns of climate change. A tradeable permit system can adapt to such changes, e.g. falling consumer demand caused by a recession probably means a reduced equilibrium permit price; the CO_2 budgets could also be moved to a steeper reduction trajectory if global warming were to intensify (Fleming, op. cit.);
5. *Simple monitoring and enforcement:* Gasoline stations are allowed to sell fuel only to purchasers handing in a sufficient number of permits. For those road users who do not possess permits, such as foreigners or people who forget to take them with them, permits could be offered for sale at the station (Verhoef *et al*, 1996).

A disadvantage of the system is that it may suffer from border problems caused by trans-border fuel purchases. The obvious 'solution' to this problem is to implement the policy on an international scale, for example the European Union. This implies a high level of international co-operation if the tradeable permit system is to be implemented.

Box 4.2.1: A tradeable permit system to reduce national carbon emissions

Fleming (1997) proposes tradeable quotas as an economic instrument for shifting national economies away from their dependencies on fossil fuels. This box describes how this system works. Tradable quotas would specify the permissible quantity of carbon emissions from all sources within a national economy, allowing the prices to adjust around it, and using information technology to distribute the quota units through the market. The starting point of Fleming's system is a rating system calculating the number of carbon units (other greenhouse gases converted this standard) embodied in fuel.

Issuing and using quota

The quota, measured in carbon units, is issued to the market in two ways, i.e. through allocation and tender. The proportion of carbon emissions used by the household sector (mainly from domestic heating, lighting and power and car use) is distributed *free and in equal quantity* to all adults (aged 17 or older, not to the entire population because this would be an incentive to have children) free and in equal quantity to all adults. Carbon units can be bought and sold by anyone. Low users, who do not use their whole allocation, can sell the excess, earning revenue from their quota sales. The transfer of carbon units backs fuel purchases from buyers to sellers. In most cases, the transaction is carried out electronically, with no requirement for administration and paperwork. There is no change in the way in which a customer pays a gas bill: quotas are automatically deducted from the customer's quota account on the model of a direct debit. Alternatively, the gas supplier buys quota on the customers behalf, and charges the cost onto their bill, credit cards can be used at petrol filling stations to transfer the money required to cover the quota cost, or to surrender quota, or both.

The proportion of carbon emissions used by firms, government, public transport and all other sectors of the economy is issued through a tender, a bid by banks and other institutions on the present model of the market for Treasury bills. The carbon units are distributed into the economy through electronic direct-credit systems, and traded daily in the market.

Registration

A complete register of the ownership of quota is stored electronically by a central agency, which Fleming called QuotaCo. Every quota-holder's account is held in this system, and all transfers of quota are registered there. Banks do not have to set up and maintain accounts for quota. The location of the quota remains at all times within the central QuotaCo computer, just as the location of consumer's debt remains within the computer of a credit-card company.

Carbon budget

Fleming proposes a 10-year 'carbon budget' which is set and published by the government. A rolling 10-year time-horizon, with the added implication of continued reductions in carbon emissions, provides the framework in which fundamental changes in economic structures and technologies can be achieved. The 10 year carbon budget is divided into two periods: a one year *Commitment* which is binding for the government with the same force as the obligation underpinning government debt, and the 9 year *Intention*, which is to remain unchanged though the whole of the period. The Intention will largely determine the price of the quota.

A system of tradeable CO_2 permits that achieves 100% of the emission reduction needed to achieve the *combination scenario* would mean a total CO_2 budget of 160 kg per Dutch inhabitant (older than 12 years) for passenger transport in 2030. People are free to spend this budget on available travel modes, and can buy or sell CO_2 permits on - for example - a “permit market”. This means that if an individual wants to spend his/her entire CO_2 passenger travel budget on car use - and does not buy extra permits - the number of car passenger kilometres will be limited to 8000 car vehicle kilometres in 2030 using a fuel efficient hybrid car (as assumed in the combination scenario). If a conventional “business-as-usual” car is used, roughly 1400 car vehicle kilometres can be travelled within the CO_2 budget in the year 2030. If the train is the only chosen motorised travel mode, more than 45,000 kilometres can be travelled in 2030. The implementation time path will be announced in advance to promote anticipate behaviour.

Other pricing instruments

Contrast to tradeable CO_2 permits, pricing policy instruments like increasing fuel taxes and road pricing are seen as short-term/medium-term instruments. These pricing instruments will eventually be replaced by the system of tradeable CO_2 emission permits by 2030.

Spatial-planning/land-use instruments

A sharp reduction in the total volume of motorised passenger transport can only be achieved if the spatial infrastructural constellation promotes and facilitates short-distance trips and non-motorised transport (walking, cycling). This means that locations for work, recreation and shopping must in the proximity of residential areas. Land use policies will be aimed at an efficient use of the available land.

New urban areas are built so as to realise “compact cities”, i.e. new housing and working locations are – as much as possible - realised within or connected with existing urban areas. However, not the entire demand for housing (more than 1.5 million houses between 1995 and 2030) can be realised within existing urban areas. A small number of new urban towns will be developed close to existing metropolitan areas along public transport infrastructure between existing towns. These new towns, probably about 25,000 to 50,000 inhabitants, are fairly self-supporting; a large share of activities is employed within these towns. Working and living are closely related to each other, the structure of services is of high quality and the living climate will be good. The new towns are linked with existing towns with high-quality public transport, and within these towns non-motorised transport is given a higher priority than car traffic. The spatial structure of these new towns may be very similar to the Dutch city Houten (see box 4.2.2).

Box 4.2.2: The city of Houten

Houten (23,000 inhabitants) is a city in the Netherlands where the spatial infrastructural constellation promotes cycling and public transport. The city center is directly accessible by train and bicycle, a “star shaped” network of walking and cycling lanes connect residential areas directly with the city center, whereas the road network for motorised transport does not connect the residential areas with the city center directly. Cars are “forced” to the outside of the residential areas.

Empirical research shows that Houten has a lower share of car use for shopping purposes (19%) than average Dutch cities with 20,000 - 50,000 inhabitants (28%), whereas the share of walking and cycling is higher (Brükx et al., 1993). However, the average number of car kilometres per 100 inhabitants in Houten is higher than a comparable city (Raalte), because of demographic differences, i.e. Houten has a larger number of higher educated who use the car for working or business purposes (Janse et al., 1997). Without demographic differences car use would probably be lower in Houten.

The demand for new working locations will also primarily be met within existing urban areas. Large office locations will only be developed near public transport interchanges of national or regional importance. A more multi-functional use of existing working locations will largely satisfy the land use demand for these working locations. Furthermore, the new towns will also create space for smaller office locations and mixed working locations. As a policy instrument, the Dutch employment location policy for new employment locations “the right business in the right place” (see box 4.2.3), combined with pricing measures, will be expanded to re-location of existing businesses and will comprise supporting and regulatory instruments. The main aim of the location policy - as a part of the instrument package for the attainment of EST - is to increase the accessibility of working locations for public transport and non-motorised modes.

The land-use instruments must be seen as part of the instrument package for attaining EST; they are effective as a flanking policy to increase the social feasibility of implementing the tradeable CO_2 emission permit system for passenger transport. EST land use policies increase the number of opportunities reachable within certain travel distance or time by bringing activities closer to each other. As a result, the reduction of average travel distances assumed in EST does not necessarily mean a lower level of accessibility to social and economic opportunities. Furthermore, it must be noted that the largest changes in the spatial distribution of activities are not the result of land use policies aimed at future housing and working locations, but the result of changes in the *use* of the existing buildings as a result of the restrictions in motorised mobility.

Box 4.2.3: Principles and effects of the Dutch ABC location policy

The Dutch employment location policy comes in essence down to "the right business in the right location" "Accessibility profiles" of locations are matched with "mobility profiles". The "accessibility profile" of a employment location describes its accessibility by public transport and car, including parking facilities. There are three location types:

- location type A: employment locations are situated close to public transport interchanges of national or regional importance. There are few parking facilities allowed, i.e. 10-20 parking spaces per 100 employees;
- location type B: employment locations are situated close to public transport connections of local or regional importance, and near a major local road or motorway. There are more parking facilities allowed;
- location type C: employment locations situated to a motorway connection, in or on the periphery of urban areas. There is no upper limit to parking facilities.

The "mobility profile" of a firm or public service is defined as the potential use of public transport by employees and visitors. Main characteristics are (i) labour intensity, i.e. the number of employees per unit area, (ii) car-dependence, (iii) visitor intensity, i.e. the number of visitors per unit area, (iv) dependence upon freight transport by road. (Van Wee and Van der Hoorn, 1996).

Studies have been conducted into the relationship between modal split and work location according to the ABC criteria. Results from various studies show that a reduction of car kilometres on the national level (all purposes together) of grossly 5-8% may be expected (Van Wee and Van der Hoorn, 1996).

Infrastructure policy

Infrastructural improvements in the rail network are necessary to facilitate a 40% growth in the number of rail passenger kilometres between 1990 and 2030. The use of buses also increases by 140% between 1990 and 2030. A light rail system will have to be implemented to improve regional rail transport. Furthermore, infrastructural improvements are necessary to supply a more "door-to-door" and flexible collective transport. Investments in public transport will mainly be necessary at the local level; large additional rail infrastructure investments at the national level will probably not be necessary as the assumed passenger growth in the *combination scenario* is the same as in the *business-as-usual scenario.*

To facilitate and promote the assumed non-motorised transport growth in the combination scenario, in which bicycle use is expected to be twice the *business-as-usual* level, road infrastructure policy must radically change. Passenger car infrastructure in cities and towns with 40,000 to 100,000 inhabitants will be largely converted to non-motorised infrastructure (see box 4.2.4).

Box 4.2.4: The "Mobilopolis" Concept: A Bicycle City

By 2030, middle-sized cities have changed into bicycle cities according to the "Mobilopolis concept", developed in the late 1990s. The concept radically changed the spatial-infrastructural constellation. The last three decades saw large investments in bicycle infrastructure were made: a main network of twice four meter wide cycle lanes has replaced car infrastructure, connecting urban areas to the city centre, and is complemented with direct connecting lanes to locations of activities outside the city centre. The main network of cycle lanes is used by different kinds of bicycles, high-speed bicycles - used for trips up to 15 km - as well as the traditional low-speed bicycle from the 20th century. The network is well connected to public transport nodes. All locations and areas are accessible by bicycle and cycle shelter facilities are close to all activities. Most of the urban trips are shorter than the conventional maximum cycle distance of 7.5 km (5 km as the crow flies), because of the changes in locations of activities. The Mobilopolis concept - combined with the tradeable permit system for CO_2 emissions - has reduced urban car vehicle kilometres by 65%, mainly because most of the trips shorter than 7.5 km are made by bicycle.

Source: based on Jansen *et al.* (1997).

Regulations

Because of health and "quality of life" reasons, transport in urban areas will have to be almost completely electrical i.e. to achieve the EST criteria for NO_x, VOC, noise and PM_{10}. Central parts of all cities with more than 40,000 inhabitants in the Netherlands will not be accessible for cars with a conventional combustion engine, whereas access for electric or hybrid vehicles operating in the "electric mode" in urban areas will not be restricted. This instrument supports the effects of the tradeable CO_2 permit system, because it will result in an increase in the use of hybrid vehicles.

Furthermore, NO_x and VOC emission regulations are introduced to implement end-of-pipe emission reduction techniques for cars and buses, i.e. de-NO_x catalysts and VOC evaporation control measures.

Speed-control instruments

Speed limits on highways and other road types will be lowered. Vehicles will be equipped with on-board speed adaptation systems for a full maintenance of the lower speed. There are several reasons for implementing these instruments. Firstly, lower vehicle speeds reduce fuel-use, emissions, noise levels and accident risks and thus external costs of emission, noise and accidents (see Peeters *et al*., 1996). Secondly, overall lower car speeds promote shorter distances and a shift to public transport and non-motorised modes. Thirdly, lower car speeds reduce the attractiveness of car use, i.e. lower speeds influence the psychological factors of car use: feelings of "individual freedom of movement" and "addiction to (high) speed" are reduced (see Diekstra and Kroon, 1996).

Education and information

Education and information are necessary instruments to achieving public acceptability of a system of tradeable CO_2 permits. Furthermore, education/ information is an instrument to promote the advantages of sustainable transport, e.g. it contributes to clean cities, prevents a possible climate change, does not contribute to acidification, prevents health problems/costs, creates transportation systems without congestion and leads to better public transport. Education and information instruments should be addressed to these rational arguments but also to emotional aspects of motorised transport. For example, people have instrumental or rational motives for car use (e.g. time, money, flexibility) but also emotional motives (e.g. status, thrill, macho driving behaviour, pleasure), which differ between groups of car users in the relative importance (Steg *et al.*, 1998; Steg & Tertoolen, 1999). Steg *et al.* (1998) state that effective policies aimed to reduce car use should be based on what the different groups of car users literally and figuratively moves, e.g. alternatives for car use should be cheap and funny.

Instruments outside the transport sector

Flexible housing and employment markets form a necessity for shorter home-work trips. Fiscal instruments stimulate moving to houses closer to working locations. Demand and supply of housing are regionally balanced in 2030. Local or regional multi-company buildings with telecommunication facilities - to the main offices - are introduced at town peripheries.

The *combination scenario* assumes a 40% share of renewable energy and a very efficient conventional energy production, i.e. an efficiency level of 80% compared to 50% in the *business-as-usual scenario*. Instruments to implement these features comprise investments in renewable energy production and highly efficient conventional plants combining heat and power, combined with voluntary agreements with the energy sector. Furthermore, pricing instruments are used to stimulate renewable energy use and production to achieve a lower energy price for renewable energy than for conventional energy in 2030, e.g. houses produce their own solar energy.

4.3 Freight transport

4.3.1 Introduction

The instrument package necessary to meet the EST criteria for freight transport comprises:

- Tradeable CO_2 emission permits;
- Other pricing instruments, e.g. road pricing, fuel prices;

- Land-use/spatial planning instruments, e.g. production and distribution locations situated close to rail and inland shipping infrastructure;
- Infrastructure policy, e.g. expansion of rail infrastructure;
- Regulations, e.g. prohibiting lorries with conventional combustion engines in central urban areas;
- Education and information instruments; e.g. information on consuming locally produced goods;
- Instruments outside the transport sector, e.g. instruments to reduce emissions in other sectors of the economy.

A system of tradeable CO_2 emission permits for freight transport - as for passenger transport - is assumed to be the main element in an instrument package to attain EST. The highest potential effect takes place on activities and unit impact and cost-effectiveness are high. Other instruments are necessary to support or facilitate EST and to increase the economic, political and social feasibility of its implementation.

4.3.2 An instrument package for freight transport

Tradeable CO_2 emission permits

In contrast to the tradeable CO_2 permit system for passenger transport, freight transport companies do not receive a CO_2 budget, mainly because of practical reasons. CO_2 emission permits can be bought at a “permit market” for a market price. Such a permit system will have several effects, as transport companies will try to optimise their travel patterns using as few CO_2 permits as possible. Firstly, the total volume of vehicle kilometres is influenced by CO_2 permits, depending on the total number of CO_2 permits for freight transport and the price of buying extra CO_2 permits. The greatest effect on the number of vehicle kilometres will be changes in the logistical organisation: (i) changes in the origins and destination pattern of transport within the production column, i.e. the spatial differentiation of raw materials and semimanufactured articles, (ii) more storage of goods, instead of “just-in-time” deliveries, (iii) changes in production and distribution locations, i.e. more local production and consumption of goods, and (iv) an optimisation of vehicle load factors, e.g. more return loads. Secondly, energy use per vehicle kilometre is influenced by CO_2 regulations, e.g. the higher the energy efficiency of a lorry, the more vehicles kilometres can be driven with the same CO_2 permit. Thirdly, the modal split of freight transport will be influenced, i.e. rail transport and inland shipping are more energy efficient than road haulage. The system promotes multi-modal freight transport. The system will be gradually implemented so that the CO_2 budget per transport company will be gradually reduced to the desirable CO_2 emission level in 2030. The time path will be announced in advance to promote anticipate behaviour.

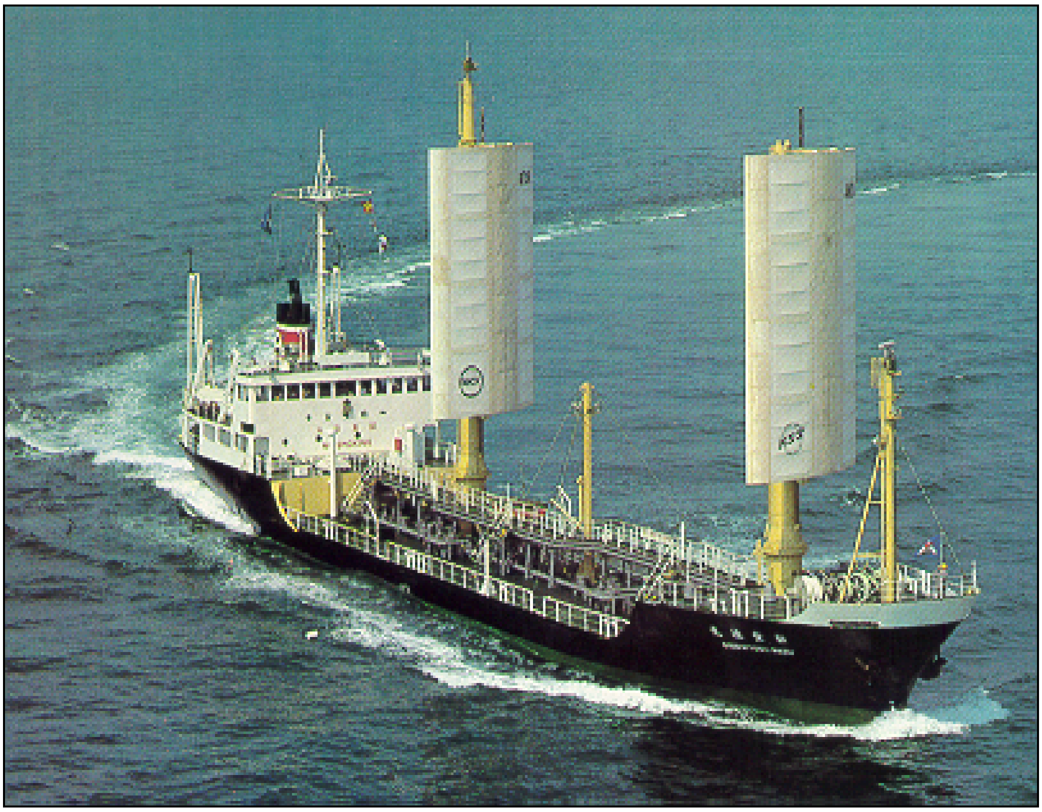

Figure 4.3.1: "A tradeable CO_2 permit system promotes technology developments such as illustrated by this Japanese ship. "The sail on the fully loaded ship can provide 53% of the power to travel 12 knots. To get the most from wind speed and points of sail, a microcomputer gives automatic commands to trim the steel-framed canvas sails by rotating the masts. With efficient equipment and design, fuel savings can be as high as 50%. The incentive: Japan's acute need to conserve imported oil" [during the oil crises] (source: National Geographic, February 1981).

Other pricing instruments

Pricing policy instruments like increasing fuel taxes and road pricing will be necessary as short-term and medium-term measures. These pricing instruments will eventually be replaced by the system of tradeable CO_2 emission permits by 2030.

Furthermore, subsidies will promote (i) transport standardisation (containers), so as to facilitate transfers, and (ii) multi-modal transport companies.

Spatial planning/land-use instruments

To promote multi-modal freight transport, production and distribution locations are to be situated within rail and inland shipping infrastructure. A location policy for road, rail and inland shipping transport companies will have to be developed and implemented.

Infrastructure policy
A network of urban distribution centres will be introduced to increase load factors and to reduce vehicle kilometres (of mainly light-duty vehicles). To promote multi modal freight transport, a combined transport system will be developed by constructing a network of road/rail, road/water and rail/water transfer terminals.

Furthermore, to increase the share of rail transport in international freight transport a better European organisation of rail transport and the rail infrastructural network is necessary, e.g. European-level multi modal transfer terminals and computer systems to facilitate transport handling will be necessary.

Regulations
In central urban areas the use of vans and lorries with a conventional combustion engine will be prohibited. Only electric or hybrid vans can be used to distribute goods to the retail industry in urban areas.

Furthermore, NO_x and VOC emission regulations are introduced to implement end-of-pipe emission reduction techniques for vans, lorries and ships, i.e. de-NO_x catalysts and VOC evaporation control measures.

Education and information
A “CO_2 permit knowledge” institute could be introduced to give companies information on the optimisation of the use of their CO_2 permits.

Instruments outside the transport sector
Several instruments will be necessary to reduce emissions in other sectors of the economy to a sustainable level. The international orientation of the agriculture sector will have to be transformed into a more local/regional orientation to food production. Further, implementing instruments to reduce emissions in the industrial sectors of the economy will contribute to a lower level of produced goods and thus to the need for freight transport.

Instruments outside the transportation sector will probably also contribute to the changes needed to reduce freight transport distances (40% reduction for food, 25% for non-food related freight transport) and total produced volumes (20% reduction of non-food volumes). For example, globally produced goods will have much higher transport costs and thus higher selling prices.

In the energy sector, instruments will have to be implemented to achieve a 40% share of renewable energy and a highly efficient energy production, thus reducing emissions in the transport sector.

4.4 Overview and characterisation of instruments

Table 4.4.1 gives an overview of the instruments within the instruments packages for passenger and freight transport. The instruments are characterised by:

1. Passenger or freight:
   - P = passenger;
   - F = freight;
2. Phasing of implementation:
   - S = short term (< 2005);
   - M = medium term (2005-2009);
   - L = long term (2010-2014);
   - V = very long term (>2015);
3. Type of effect sought:
   - A = reduce the impacts of motorised transport activity on the global environment (i.e. reduction of CO_2-emissions);
   - B = reduce the impacts of motorised transport activity on the regional and local environment (i.e. reduction of NO_x, VOC and PM_{10}-emissions);
   - C = improve the environmental performance of motorised transport activity by mode shifts;
   - D = reduce overall motorised transport activity by increasing occupancy or otherwise improving logistics;
   - E = reduce overall motorised transport activity by raising its costs or by imposing other penalties;
   - F = reduce overall motorised transport activity by favouring non-motorised alternatives;
   - G = reduce transport activity in specific locations;
   - H = make land use or economic arrangements more conducive to EST;
   - I = reduce noise
   - J = other types of effects, e.g. changing attitudes, ways of living, acceptance of measures
   - K= general actions, or specific actions not included above.
4. Responsibility for action:
   - I = international;
   - N = national;
   - L = local/regional
5. Status:
   - A = instrument already in use (but might need elaboration or intensification);
   - B = instrument is in currently under consideration;
   - C = instrument is not yet under consideration.

Table 4.4.1: Overview of instruments for the attainment of the Combination Scenario

Instruments	**Pass. Or Freight**	**Phasing**	**Type of effect**	**Responsibility**	**Status**
Car-free urban centres	P	M	G	L	A
Expansion of non-motorised infrastructure	P	S	F	L	A
Expansion of rail infrastructure	P	S	C	N	A
Fiscal instruments for flexible housing en job markets	P	S	H	N	C
Fiscal instruments for hybrid and electric cars	P	S	A	N	C
Intelligent speed adaptation systems	P	V	A/I	N	C
Land use/fiscal policies for scaling down of activities	P	S	H/E	L	C
Location policy for companies that relocate	P	S	H	N	A
Creation of network of urban distribution centres	F	S	D	N	C
Expansion of transfer terminal networks (e.g. road to rail and water)	F	S	C	N	A
Fiscal instruments for hybrid and hydrogen freight vehicles	F	S	A	N	C
Fiscal instruments of information technology (EDI)	F	S	D	N	C
Improvement of the international organisation of rail transport	F	S	K	I	C
Location policy for transport companies	F	S	H	N	C
Measures to reduce industrial emissions	F	S	K	N	A
NOx and VOC emission regulations for ships	F	S	B	I	A/C
Restriction of lorry use to daytime in residential areas	F	M	I	L	C
Subidies to promote containerisation	F	S	C	N	A
Subidies to promote multi-modal transport (companies)	F	S	C	N	A
Taxes/subsidies on non-durable/durable goods	F	M	J	N	C
Access restrictions for combustion vehicles in urban areas	B	V	G	L	C
CO2 taxation on fuels	B	M	E	I	C
Education/information (especially re. CO2 tradeable permits)	B	S	J	N	A
Energy-efficiency regulations for road vehicles	B	M	A	I	B
Information technology to reduced long-distance air transport	B	S	F	N	C
Infrastucture for rigid airships	B	M	C	N	C
Investments in renewable energy applications for transport	B	M	A	N	C
Location policy for existing companies	B	M	H	N	C
Lower motorway speeds with on-board limiters	B	M	A/I	N	C
Lower speeds on all road types with on-board limiters	B	V	A/I	N	C
NOx and VOC emission regulations for road vehicles	B	V	B	I	A
Road pricing	B	M	E/G	N	B
Taxes/subsidies in non-renewable/renewable energy use for all purposes	B	S	A	N	A
Tradeable CO2 permits (households and commercial)	B	L/V	A/E	N	C

Table 4.4.1 shows that a large number of instruments is related to both passenger and freight transport. The number of instruments related to freight transport only is larger than those for passenger transport only, this reflects the current position of freight transport in the Dutch transport sector and national economy and the policy task to move freight transportation towards EST.

Furthermore, the table shows that a large number of instruments are to be implemented on the short term, which shows that policy efforts are necessary on the short term if EST is to be attained by 2030. See also Section 5 for the implementation time-path of instruments.

In addition, the table shows a large differentiation in the type of effect sought by the instruments. The largest number of instruments seeks to find a reduction of motorised transport activity to reduce CO_2-emissions, which reflects the conclusion that the CO_2-criterion is the most difficult one to attain (see Section 2.7).

Furthermore, the table shows that the responsibility for implementation of the instruments is mainly a national one (e.g. instruments aiming to reduce emissions and transport activities), whereas international responsibility is related to energy- and emission-regulations (i.e. EU standards) and improving the international organisation of rail transport, and local responsibility is related to measures in specific locations (e.g. access restrictions), non-motorised infrastructure (e.g. bicycle lanes) and promotion of the scaling down of activities (e.g. more local shops). The focus on instruments on the national level does not mean that international or regional policies are not effective or not necessary for the attaining EST (e.g. European emission regulations are effective in reducing transport emissions), but mainly reflects the geographical scope of this study.

Finally, the table shows that a large number of instruments necessary to attain EST is not yet under consideration in current transport policy. This shows the policy gap between ‘business-as-usual’ policies and policies necessary to attain the large emission reductions envisioned by EST: innovative instruments will have to be developed and implemented if 80-90% emission reductions are to be attained by 2030.

5. Implementation time-path of instruments

5.1 Introduction

Implementing the time path of instruments, and thereby the manifestation of the combination scenario's features, depends on the extent of political and societal efforts to make society as a whole sustainable. In other words, the political and societal context will determine the implementation path. In this study, the concept of the "policy life cycle" is used to construct a possible implementation time path for the instruments. The focus here is on describing the necessary mobility changes as opposed to detailed time-path descriptions of the technical measures. Achieving the necessary mobility changes, which are politically and socially feasible, probably is the greatest challenge of the EST3 scenario.

It must be stated that the instrument package and implementation time path do not offer a blueprint for sustainable transport; instead they should be taken as an illustration of a possible and plausible path towards a more sustainable transport system.

Section 5.2 describes the methodology and section 5.3 describes the results and presents the conclusions.

5.2 Methodology

A possible implementation time-path of instruments necessary to achieve the combination scenario's features is constructed using the backcasting method: i.e. we assume the instrument to have its full effect by 2030, and calculate backwards to establish the start of the implementation.

Describing the *time-path of instruments necessary to achieve the technical features* of the combination scenario (e.g. all cars are fuel efficient hybrid cars by 2030) can be done relatively easy if it is assumed that:

- full replacement of road vehicles will take (at least) 15 years;
- full replacement of other vehicle categories (trains, ships, aircraft) will take (at least) 30 years. Vehicle engines may be replaced in a shorter time period.

The *time-path of instruments necessary to achieve the mobility features* (e.g. a 50% reduction of car vehicle kilometres compared to BAU) depends on the level of political and societal efforts to make the society as a whole sustainable. In other words: the political and societal context will determine the implementation date. The concept of the "policy life cycle" derived from Winsemius (1989) can be useful in describing this context. The "traditional" policy life cycle can be split into four phases: (1) the problem recognition phase, (2) the policy formulation (or: adjustment) phase, (3) the policy implementation phase and (4) the control phase[7]. Figure 5.2.1 illustrates a possible policy life cycle for applying the measures assumed in the EST3 scenario.

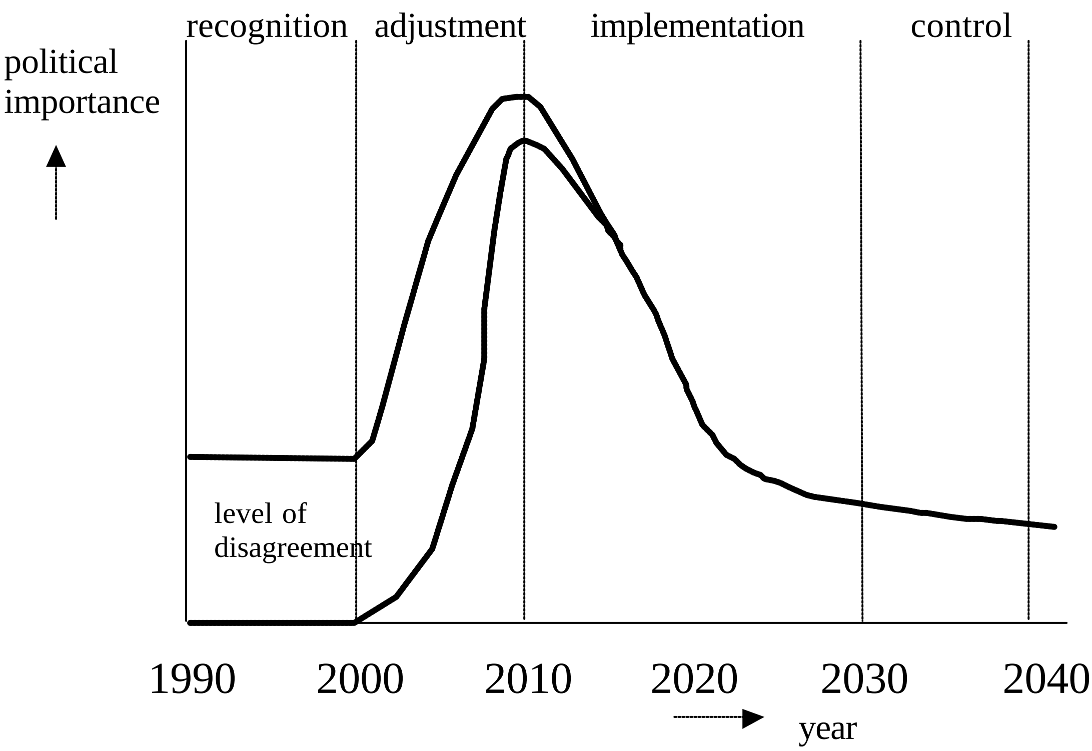

Figure 5.2.1: Possible policy life cycle for applying measures in the EST3 scenario (Based on Winsemius, 1989)

The time-path of instruments for the attainment of the mobility features of the combination scenario in 2030:

1. The recognition (or: acceptance) phase (1990-2000), which comprises measures to increase the social acceptability and social feasibility of the EST criteria in general, and the assumed mobility measures in particular.
2. The adjustment phase, which comprises changes in the business-as-usual policy towards a sustainable policy. As the political importance of the sustainable policy increases, the EST criteria become superior to other political goals. The political and societal concern is great and the level of disagreement decreases. Social acceptability and feasibility of an environmentally sustainable course increase.

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7 A similar (three-phase) process of upgrading environmental concern is described in the Swedish EST project (Brokking *et al.*, 1997), i.e. (a) the acceptance phase, (b) the adjustment phase and (c) the implementation phase.

3. The implementation phase in which the mobility measures are implemented. Political and societal disagreement is negligible and therefore political and societal concern decreases. The necessary political and societal context to implement the *combination scenario's* features is realised, e.g.:

- Mobility patterns are adjusted to the desirable level of transport, e.g. people want to explore their own regions in their holidays, as opposed to travelling long distances;
- Consumers have less need of transport, e.g. people eat more regionally or eat nationally produced food and less meat; they buy goods that last longer;
- The spatial diversity of production structures is reduced: goods are produced fewer kilometres away, e.g. semimanufactured articles are more locally or regionally produced, as opposed to being transported globally or continentally.

Analysis of policy life cycles of technical emission reduction measures in the Netherlands, mainly outside the transport sector, has shown that the average policy acceptance and adjustment phase will take about 6 years, and the average implementation phase about 18 years. However, the policy life cycle differs sharply between measures and is strongly related to public focus on environmental problems. For example, the policy acceptance and adjustment phase for the introduction of the three-way catalyst took about five years; lowering the European standard for sulphur in fuels took about 11 years (Van de Peppel *et al.*, 1997).

Within the current political and societal context, the acceptance and adjustment phase for mobility reduction measures is expected to take much longer. However, we think that if the political and societal context is radically changed, the acceptance and adjustment phase for technical as well as mobility measures can be much shorter. Implementation of instruments in crisis situations has shown that the policy acceptance and adjustment phase can be shortened to one or two years. For example, directly after the River Maas flooded in the southern part of the Netherlands in 1993, the policy adjustment phase started and measures to strengthen the river dikes started two years later. Another example is the implementation of a fuel rationing system using fuel tickets by the Dutch government during the oil crisis in the seventies.

A future radical change in the political/societal context can probably only be expected if (i) an energy/environmental crisis or disaster occurs in the near future (see box 5.2.1), (ii) a societal/political perception of a energy crisis or disaster exists. This can be a “real” or an imposed perception, e.g. the perception of a future climate change. However, it can be doubted whether such a (perception of) an energy/environmental disaster will be strong enough to achieve a radical change in the perception of powerful actors and in time for the attainment of EST by 2030.

The policy life cycle concept is used to construct a possible implementation time-path of the policy acceptance, adjustment and implementation phase, under the assumption that the average acceptance and adjustment phase for mobility and technical instruments takes about five years. This period will be shorter for relatively “easy” instruments (e.g. education/information instruments) or longer for “difficult” instruments (e.g. tradeable CO_2 permits).

Figure 5.2.3: “a timely implementation is only to be expected if an energy/ environmental crisis or disaster occurs in the near future, or if an energy crisis or disaster is perceived”

Photo: AVV(1996b)

Box 5.2.1: A future energy/environmental disaster?

The transport sector is currently extremely dependent on the oil market for its energy input. The oil products (mostly petrol and diesel) consumed in the transport sector accounted for 58% of all oil products consumed world-wide in the beginning of the 90s (according to an assessment made by the IPCC in 1994), and this share will increase in the future. There are many uncertainties about future oil provision, and its consequences on the environment, on both the medium and long term. Tengstrøm (1998) has identified the following “threats against the sustainability of existing transport systems”:

On the *medium term* (2005-2020) two “threats” against the business-as-usual transport system can be identified: (a) the possibility that new scientific knowledge will result in a world-wide consensus that total CO_2 emissions and other greenhouse gases must be reduced more rapidly than considered necessary today, and (b) the possibility of a politically initiated oil crises. One possibility is that the OPEC organisation - probably increasing its market share above 50% by 2010 - will use oil again as a political or economic weapon, or if long-lasting military conflicts are initiated in oil producing areas such as the Middle East and Central Asia. Limitations on oil following on such events will hit the transport sector harder than the oil crisis in the 70s, as the share attributable to the transport sector has increased significantly since then.

On the *long term* (2020-2050) the following threats can be identified: (a) the consequences of the human impact on the climate and on the carrying capacity of ecosystems, for which the transport sector is partly responsible, may be dramatic having a strong impact on transport systems, and (b) the provision of oil to the transport sector can be become a serious problem. According to Campbell and Laherre (1998) will the “global production of conventional oil begin to decline probably within 10 years”. They state that (i) official statistics on oil reserves contain systematic errors (e.g. definition problems, unrealistic figures), (ii) world oil reserves have not marched upward over the past 20 years, i.e. about 80% of oil produced today flows from fields that were found before 1973, and (iii) the oil industry has already found about 90% of exploitable oil reserve’s. The World Energy Outlook (IEA, 1998) gives more optimistic oil supply scenarios, although in the IEA’s ‘middle position’ scenario, the world crude oil supply will decrease after the year 2015 whereas the oil demand will continue to grow.

Campbell and Laherre conclude that the switch from growth to decline in oil production will almost certainly create economic and political tension. According to Gallopin et al. (1997; cited in Tengstrøm, 1998) the business-as-usual development of global energy use for the next 50-100 years will “give rise to a prolonged and deep social crisis in the world”. “Failure to address the challenges posed by a conventional development would probably result in chains of events where even the winners become losers owing to a number of vicious circles”. These conclusions are not new: the report *Energy in transition 1985-2010* for the U.S. Committee on Nuclear and Alternative Energy Systems (CONEAS) concluded “the problem is in effecting a socially acceptable and smooth transition from gradually depleting resources of oil and natural gas to new technologies who’s potentials are not now fully developed or assessed and whose costs are generally unpredictable... the question is whether we are diligent, clever and lucky enough to make this inevitable transition an orderly and smooth one” (cited in National Geographic, February 1981).

5.3 Results and conclusions

The time-path of instruments is given for passenger (Figure 5.3.1) and freight transport (Figure 5.3.2). In general, the implementation time paths for passenger and freight transport show a two-phase implementation path of instruments. The more “traditional” instruments (e.g. fuel taxes, car-free urban centres, road pricing) are assumed to be implemented within few years from now and to be eventually replaced by non-traditional instruments (e.g. the tradeable CO_2 permit system and access restrictions for vehicles with conventional combustion engines in central urban areas). Further, to achieve the necessary land-use and infrastructural changes by 2030, a start with land-use and infrastructural instrument implementation will have to be made in the short term. If the full effect of the CO_2 permit system has to be achieved by 2030, the policy acceptance/adjustment phase will have to start by 2015 (or earlier). If the system is implemented gradually (e.g. in two or more phases), the start will be sooner.

The following conclusions can be drawn from the description of the implementation time-path for passenger and freight transport:

- If EST is to be realised, measures will have to be taken and new instruments developed in the short term. There are several reasons for this. Firstly, many technological measures need a pre-implementation period. Secondly, the technology for several measures still has to be developed. Thirdly, especially measures for land-use and infrastructure, but also others, will need planning long before they can be implemented. Fourthly, the effect of measures may depend on the period of implementation. Especially land-use measures, and measures influencing the workplace and residential locations, need a long “implementation” and adaptation period; this is also true for company/firm and retail locations. The full effect is long-term, coming about in approximately 15 to 20 years.
- The implementation time-path of the tradeable CO_2 emission permit system for passenger and freight transport strongly influences the implementation time-path of other instruments;
- The difference between the “business-as-usual” policy and the *combination scenario’s* instrument implementation time-path is so large that a timely implementation is only to be expected if an energy/environmental crisis or disaster occurs in the near future, or if an energy crisis or disaster is perceived;
- A timely implementation of the instruments for the occurrence of the combination scenario’s features means that the current Dutch policy life cycle must radically change.

Figure 5.3.1: An instrument time path for passenger transport for the EST scenario.

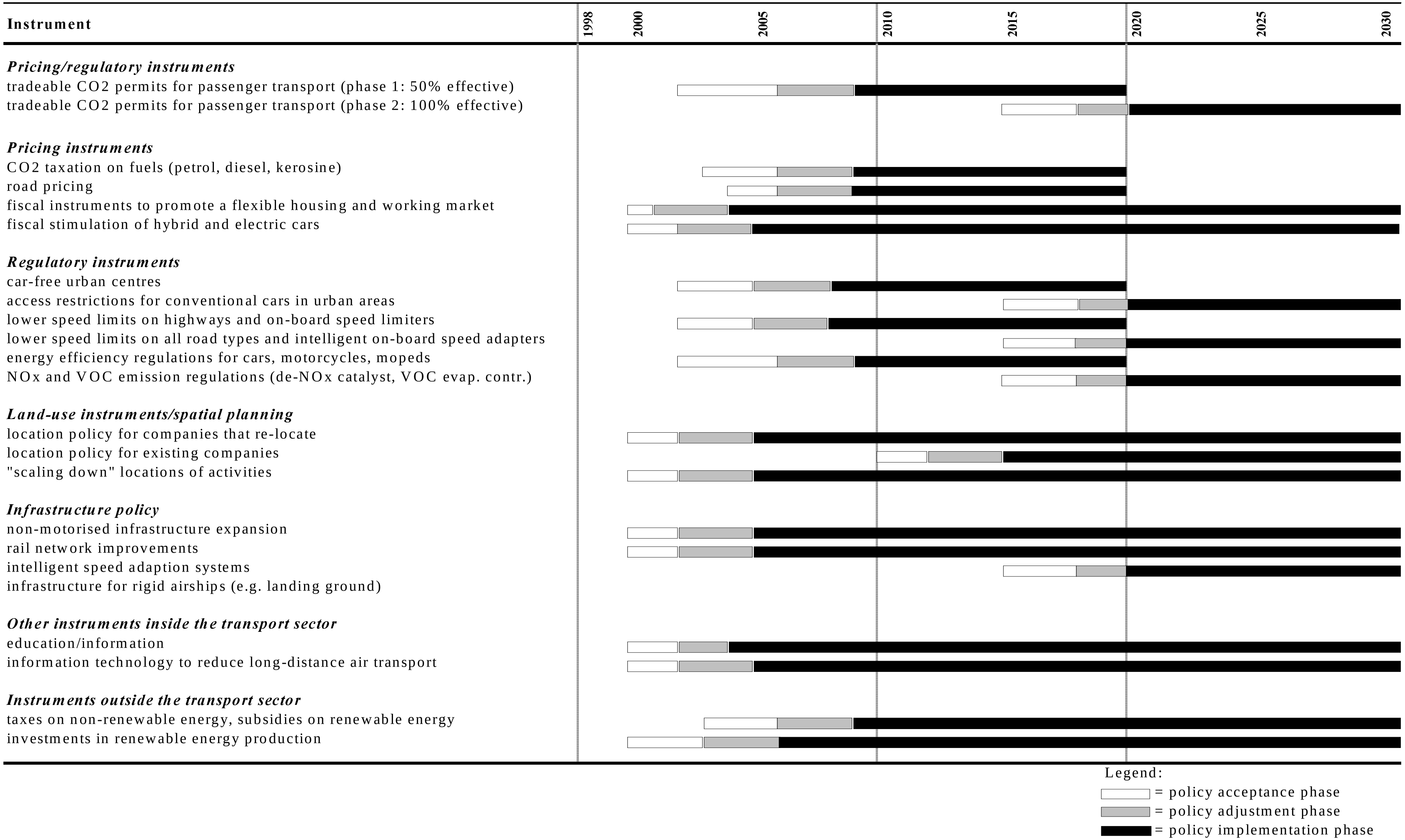
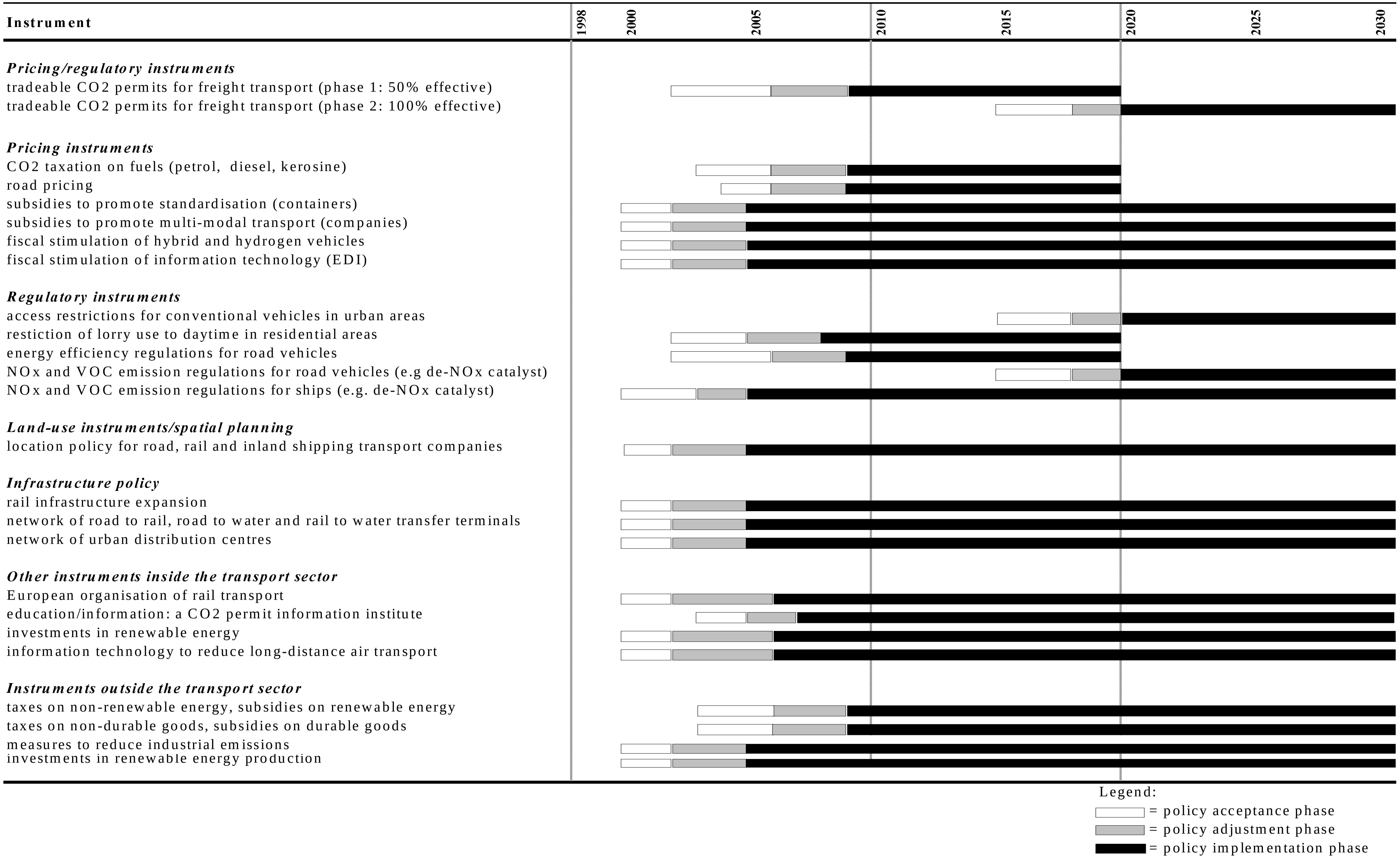


Figure 5.3.2: An instrument time path for freight transport for the EST scenario.



6. Social implications of BAU and EST

6.1 Introduction

Transport - and communications - connect everything in society to everything else. The length, strength, quality and complexity of the connecting strands, and the patterns into which they are woven, are the physical structure of the social fabric. This is a metaphor for the myriad ways in which people and institutions relate to each other (Adams 1999). In this section an answer will be sought to the question: how different would the social fabric in 2030 be under the Environmentally Sustainable Transport scenario (EST) than the business-as-usual scenario (BAU), both from a *societal* and an *individual* perspective?

The social implications of BAU and EST for the Netherlands from a *societal perspective* are based on the framework developed for the EST project by the University College London (Adams 1999). Adams identified the social factors that had been found to be the most important and most sensitive to changes in patterns of mobility. These are:

- material wealth,
- land use,
- social polarisation in terms of access to economic and social opportunities,
- community relationships,
- cultural diversity,
- health and safety,
- crime and law enforcement,
- functioning of the government.

Here, the social factors are used as a framework to describe the expected differences in social fabric between the BAU and the EST scenarios (i.e. the Combination scenario) for the Netherlands for 2030. Adams (1999) describes the assessment of the social factors as *a collective exercise in imaginative speculation*. The method deployed is essentially that of the science fiction novelist - projecting modified versions of past trends into the future. For each social factor the relationship with mobility in the past is described on the basis of data for the Netherlands, where available. This is projected up to 2030 for both the BAU and EST scenarios using existing scenario studies. The description of the social factors focuses on the factors of land use and accessibility because of its relevancy and data availability. Furthermore, a social factor ‘perceived environmental quality’ is added to the Adam’s framework. Section 1.2 describes the assessment of the social factors for the Netherlands.

The social implications of BAU and EST for the Netherlands from an *individual perspective* are based on Dutch empirical studies that analyse relationships between individual travel behaviour and (changes in) lifestyles and attitudes. Section 1.3 describes the results of those studies. Finally, Section 1.4 presents the conclusions.

6.2 Social impacts from a societal perspective

6.2.1 Mobility and material wealth

Mobility and material wealth in the past

Many studies suggest a strong relationship between material wealth (expressed in GDP) and mobility. Indeed, motorised mobility has been boosted by increased material wealth in the past, especially in the decades after the Second World War (Ploeger & Van der Waard 1997). However, studies in the Netherlands suggest that the influence of increased wealth on motorised transport in the Netherlands in recent decades has been modest. Between 1970 and 1995, demographic factors were dominant; more than 50% of the car use growth in that period can be explained by demographic factors (population and household growth). Although incomes increased in that period, incomes form a relatively modest explanatory factor for car use, i.e. income, car ownership and other "demand" factors explain about 25% of the car use growth. Spatial and infrastructural developments also explain about 25% of the car use in the period 1970-1995 (Korver & Vanderschuren 1994).

For the social assessment of the BAU and EST scenarios, differences between income groups are probably more relevant than the relationship between mobility and total income or wealth growth. Figures 6.2.1 and 6.2.2 show that car ownership is correlated with household income, and mobility is correlated with household car ownership.

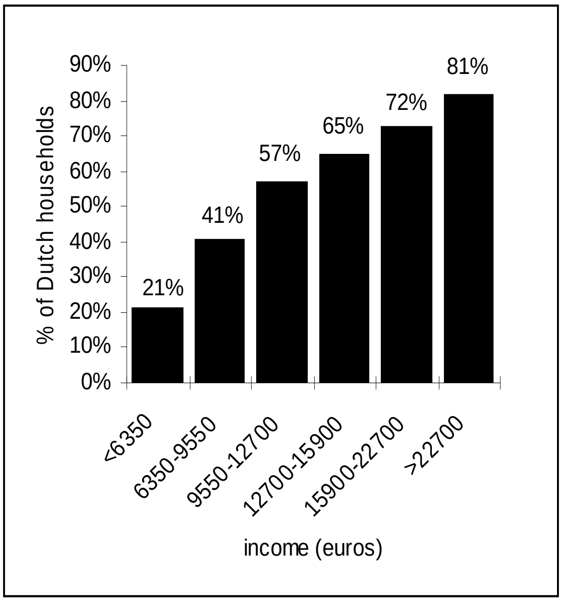


Figure 6.2.1: Percentage of Dutch households which owned a car in 1995 arranged according to income group
Source: CBS

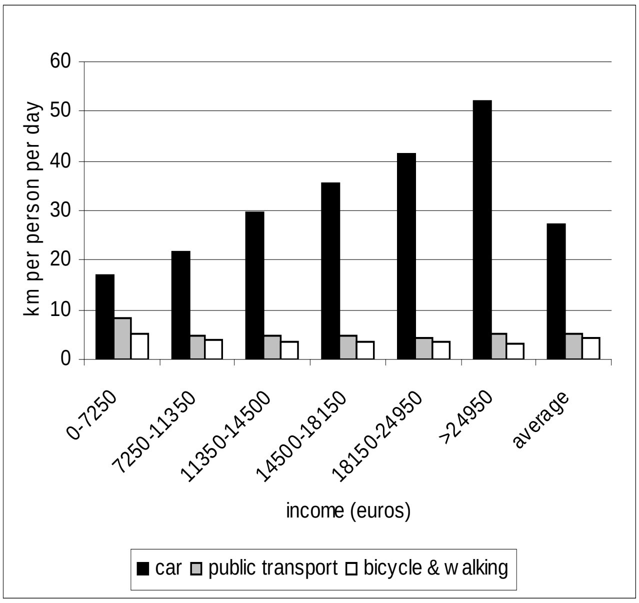


Figure 6.2.2: Passenger kilometres travelled per person per day in the Netherlands arranged according to income group in 1996.
Source: CBS

The figures suggest a disparity between lower and higher income groups: those with cars and sufficient money travel much more than average, and those dependent on public transport travel much less. Energy use differs even stronger between income groups, i.e. with a doubling of net incomes, the number of passenger kilometres is 40% higher and energy use 50%; higher income groups use less efficient cars with lower occupancy rates and use public transport less (RIVM 1998a).

Mobility and material wealth in the business-as-usual scenario

For the period 1995-2030, total Dutch passenger volumes do not seem to be strongly related to GDP or net household income growth. As an illustration, the traffic forecasts from the Dutch National Environmental Outlook 4 (RIVM 1997) show car use growth (and total passenger transport growth, excluding air travel) for the 2000-2020 period to be less than proportional to income growth, although economy related travel motives (home–work and business trips) are related to economic growth (Figure 6.2.3). Overall, demographic trends and a certain saturation level of car ownership[8] are more important explanatory factors than total income growth (see also Ploeger & Van der Waard, 1997).

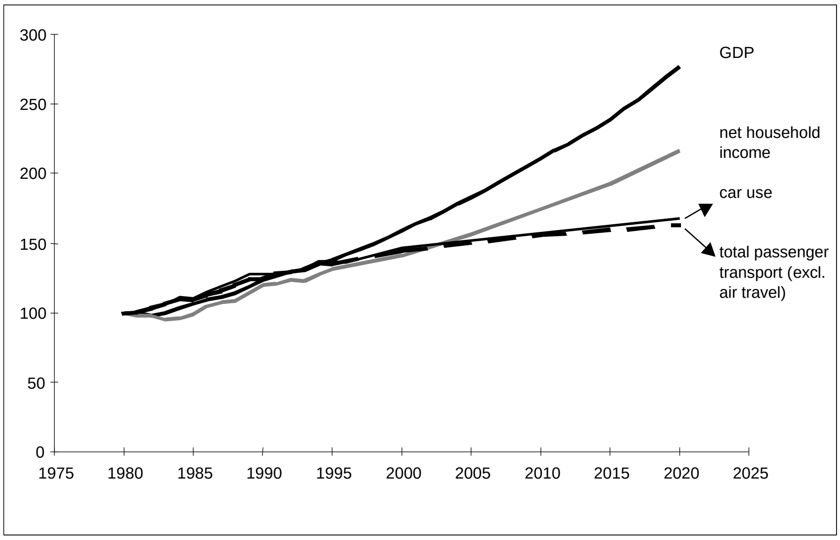


Figure 6.2.3: GDP, net household income and passenger mobility in the Netherlands 1980-2020.
Source: CBS, CPB (1997) and RIVM (1997)

Mobility and material wealth in the EST scenario

While it seems clear that economic growth can result in increased driving, it is not clear that that high levels of driving lead to wealth, or that low levels of mobility leads to wealth reductions. According to Litman & Laube (1999) many countries experience their greatest periods of economic growth when per capita automobile travel is relatively low, then growth rates decline as households become wealthy enough to afford personal automobiles and other resource-intensive consumer goods. The economic assessment of the BAU and EST scenarios for the Netherlands for 2030 shows the sharp mobility reductions under EST to have an

[8] Car ownership is expected to grow faster than car use for the period 1995-2020. The strongest car ownership growth is expected for the second and third household car, which are used less than the first household car.

impact on the economy expressed in macro-economic indicators as GDP and employment, i.e. the yearly economic growth rate and total employment in the EST scenario are somewhat lower (see Section 7).

For the social implications of BAU and EST, the distribution of wealth and costs is probably more revealing than growth of total material wealth. In the EST scenario the costs of motorised passenger mobility and goods will be higher than in BAU, e.g. the costs per passenger kilometre will be more than 50% higher (see Section 7.4). Average household expenditures on private transport will be about 15% higher in the EST scenario (e.g. fuel costs are less than 30% of total expenditures on private transport (see Figure 6.2.4). The increase in cost for motorised transport will be higher for high-income groups than for low-income groups because of the assumed system of tradeable CO_2 emission permits. High-income householders travel more (and spend relatively more money per kilometre motorised transport) than low-income householders (see Figure 6.2.4) and will have to buy more CO_2 permits - if they want to maintain their mobility patterns. Table 6.2.1 gives a hypothetical example of increased average variable costs for three income groups. Within the total CO_2 budget for motorised transport in 2030 (i.e. 160 kg CO_2 per person older than 12 years in 2030), every Dutch inhabitant can travel about 8000 car passenger kilometres without having to buy CO_2 permits, assuming they spend their entire budget on car use and use a fuel-efficient hybrid car (see Section 4.2.2). This means that if an average person in the lowest income group (0-14,500 Euro) wants to drive the same number of car passenger kilometres in 2030 as was driven in 1996, he or she must buy CO_2 permits for about 335 kilometres[9], whereas a person in the highest income group must buy permits for more than 11,000 kilometres. This would mean that the total transport expenditures for the lowest income group would increase by 1%, whereas expenditures for the highest income group would increase by more than 10%[10].

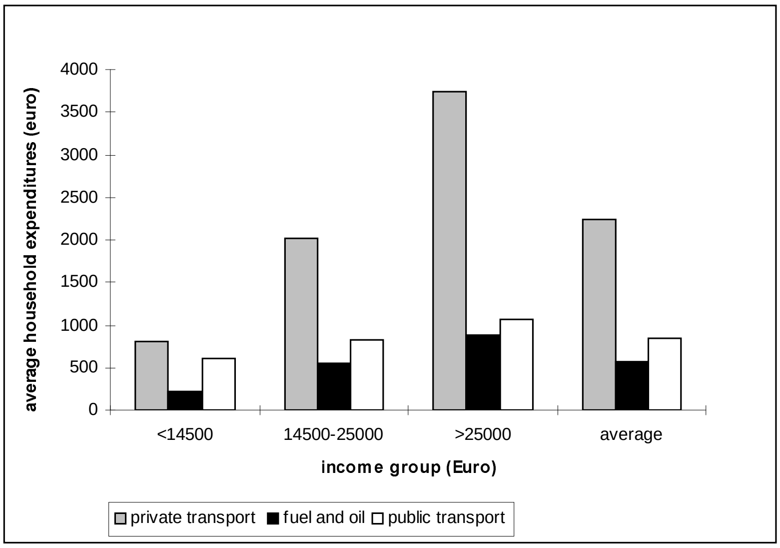


Figure 6.2.4: Average Dutch household expenditures on private transport, fuel and oil, and public transport per income group in 1996. Source: CBS

[9] On average, persons with incomes less than 11,350 Euro travel less than 8000 car passenger kilometres and do not spend their yearly CO_2 budget; they can save or sell their permits.

[10] The price of the CO_2 permits is calculated using a fuel price elasticity of -0.45 (see Section 7.4)

Table 6.2.1: Hypothetical example of increased costs of car use per income group for the EST scenario

Yearly income	Average car pkm per person (1996)	Average fuel cost per person (1996)	Max. car pkm in EST (2030)	Car pkm reduction (2030)	Increase of variable cost (%)	Increase of total transport expenditures (%)
(Euro)	(kilometres)	(Euro)	(kilometres)	(kilometres)		
0-14500	8334	229	8000	334	9	1
14500-25000	13914	553	8000	5914	94	8
>25000	19086	873	8000	11086	129	11

Conclusion

In conclusion, mobility is related to wealth: higher income groups have a higher level of car ownership, travel farther and use their (less fuel-efficient) car more often. However, in recent decades income growth has had a modest effect on total passenger transport growth in the Netherlands, and future income growth will probably also have a modest effect on the total volume of passenger travel. In the **BAU scenario** demographic factors and a certain saturation of car ownership have a large influence on future passenger transport growth. In the **EST scenario**, passenger transport is strongly reduced mainly due to a system of tradeable CO_2 permits. As a result, GDP and income growth rates will be somewhat slower compared to BAU, and more important, differences in travel behaviour between income groups will be smaller, i.e. higher income groups pay a relatively higher price for maintaining their travel behaviour than lower income groups.

6.2.2 Mobility, land use and accessibility of opportunities

Introduction

In general, the spatial-infrastructural constellation in a society influences (a) the total level of mobility of people, (b) the level of access people have to (social and economic) opportunities, and (c) the mode options for reaching those opportunities. The following examples illustrate this. Low-density land use, with dispersed destinations, makes it difficult to exploit public transport and thus – ceteris paribus - increases car travel. If shops and services are replaced by fewer, larger facilities out of town, trip distances grow and reaching them becomes more difficult for those without cars. Furthermore, a Dutch study (Vijgen & Engeldorp-Gastelaars 1992) showed that the amount of effort (expressed in travel time) for people to fulfil their daily out-of-home activities depends on the spatial structure and is higher in suburban areas than in central urban areas. The study analysed lifestyles and travel patterns of inhabitants of three neighbourhoods with very different spatial structures in the Amsterdam metropolitan area, i.e. a high-density inner city neighbourhood of Amsterdam, a relatively accessible semi-suburban neighbourhood on the periphery of the city centre of Amsterdam and a suburban town at about 30 kilometres (see Figure 6.2.5).

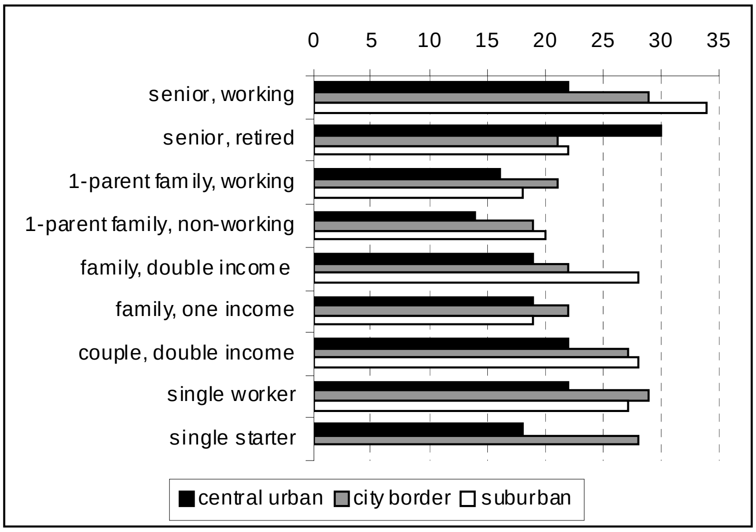


Figure 6.2.5: Average trip time (minutes) for households at three different locations in the Amsterdam metropolitan area in 1992.
Source: Vijgen & Van Engeldorp (1992)

The relationship between land use and passenger mobility is rather complex, and not always very strong. See for example Van Wee & Maat (1998) for a review of Dutch and other empirical and model studies. Here, for the analysis of the social impacts from a societal perspective, we will focus on Dutch land-use developments, developments on the level of total access of opportunities and the differences in the level of access between travel modes.

Landuse and accessibility developments in the Netherlands in the past

Population and employment

Since the 1960s the Dutch government has formulated landuse policies to accommodate the increased demand for housing, employment and services. In the 1960s, new locations were allocated following the principle of ‘clustered deconcentration’, i.e. new housing was limited to a few locations to prevent negative impacts on the landscape. In the 1980s, land-use policies focussed on building in existing towns (higher densities) and metropolitan areas. The 1990s saw the introduction of the employment location policy ‘the right business at the right location’ (also called the ‘ABC location policy’). The essence of this policy is that firms with a high employee and/or visitor intensity (employees or visitors per unit area) should to be located close to public transport interchanges of national or regional importance (RIVM, 1998a); for a discussion of the fundamentals and effectiveness of the Dutch employment location policy, refer to Van Wee & Van der Hoorn 1996). The Dutch national landuse planning has been partly successful, i.e. since the 1980s about 20% of new houses were built within existing towns. However, suburban and rural areas have become more urbanised; population and employment growth in the Netherlands has in the last decades shown growing national deconcentration and regional suburbanisation (WRR 1998). Figure 6.2.6 shows the population development for the 1970-1995 period.

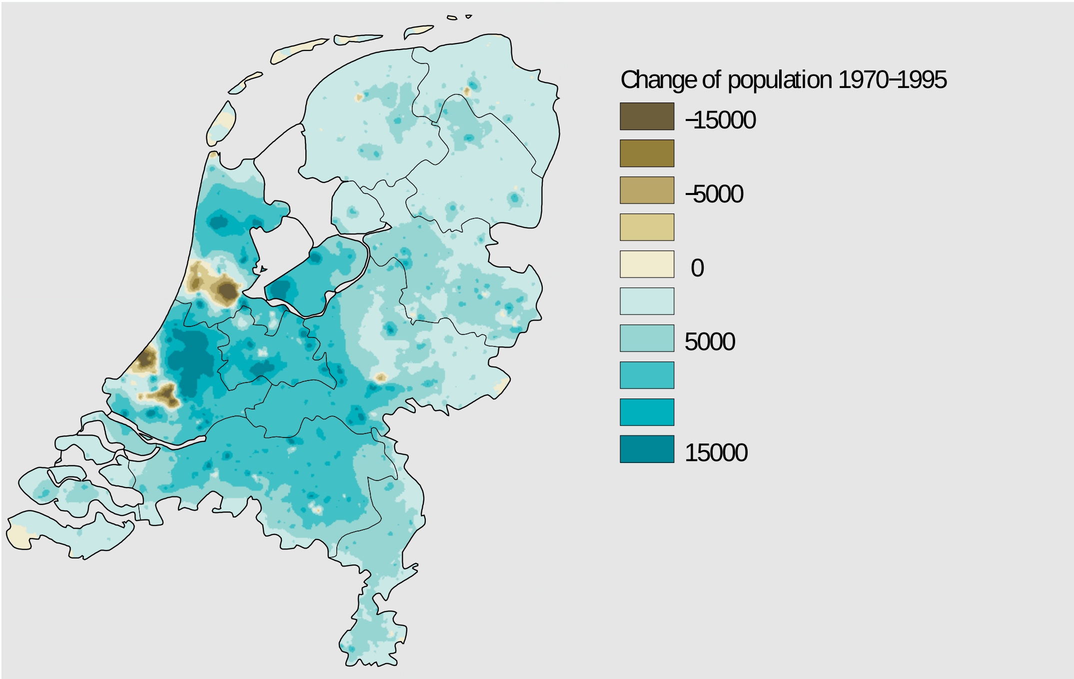


Figure 6.2.6: Population growth in the Netherlands for the 1970-1995 period.
Source: RIVM (1998a)

Figure 6.2.6 shows the main increase in population density in the western part of the Netherlands (also called the Randstad), tailing off to the (south-)east. However, within the Randstad, the population in towns has decreased due to a shift to surrounding municipalities. This process is illustrated with Table 6.2.2, showing a population growth in Dutch towns between 1973 and 1993 which is lower than in suburban and rural areas, with a decreasing population in the four largest Dutch cities, i.e. Amsterdam, Rotterdam, The Hague and Utrecht.

Table 6.2.2: Dutch population in 1993 and population growth between 1973 and 1993 according to region and level of urbanisation.

	Four largest towns		Other cities/towns		Suburban areas		Rural areas		Total	
	‘73-‘93	1993	‘73-‘93	1993	‘73-‘93	1993	‘73-‘93	1993	‘73-‘93	1993
	%	* 1000	%	* 1000	%	* 1000	%	* 1000	%	* 1000
West	-10.9	1996	1.8	780	35,8	2801	26.7	627	11.5	6204
East			7.1	885	19,8	785	21.7	1573	16.9	3243
North, South			6.4	1361	20,0	1559	16.6	2871	14.8	5791
Total	-10.9	1996	5.4	3026	28	5145	19.2	5071	13.8	15238

Source: TNO-INRO (cited in WRR, 1998)

For the period 1970-1995, the total number of jobs in the Netherlands increased by 30% to about six million. The four largest cities in the Randstad show a decrease in employment in the period 1973-1993 due to a shift of employment to suburban areas in the Randstad and to the (south-)eastern part of the Netherlands. This process of spatial deconcentration of employment is mainly caused by lack of space, congestion and high land use costs for offices in towns (RIVM, 1998a). The spatial developments in employment by region and level of urbanisation are also illustrated in Table 6.2.3.

Table 6.2.3: Employment in the Netherlands in 1993 and employment growth between 1973-1993 by region and level of urbanisation

	Four largest towns		Other cities/towns		Suburban areas		Rural areas		Total	
	‘73-‘93	1993	‘73-‘93	1993	‘73-‘93	1993	‘73-‘93	1993	‘73-‘93	1993
	%	* 1000	%	* 1000	%	* 1000	%	* 1000	%	* 1000
West	-9.5	1116	10	375	56.1	1021	56.6	238	15.5	2750
East			16.7	454	28.3	222	28.7	556	23.9	1232
North, South			18.4	759	35.2	445	28.5	1015	25.9	2219
Total	-9.5	1116	15.8	1588	45.8	1688	31.4	1809	20.7	6201

Source: TNO-INRO (cited in WRR, 1998)

Accessibility of employment by car and public transport

The development of the spatial-infrastructural constellation in the Netherlands in recent decades has influenced the level of accessibility of opportunities by car and public transport. In recent decades, investments in infrastructural road and public transport construction have resulted in shorter travel times between destinations, e.g. in the period of 1986-1997 car travelling speeds for home–work trips increased by 5% (RIVM, 1998a). In the 1990s, a policy change (i.e. the Second Transport Structure Plan) resulted in a shift in infrastructure investments from road to rail (see Figures 6.2.8 and 6.2.9). However, the position of public transport compared to the car travel in terms of travel times and costs has remained unchanged in the 1970-1997 period, despite the shift from road to public transport infrastructure investments. Furthermore, although more than 50 railway stations were added and the number of people living within five kilometres of a railway station increased, the percentage of the population within this range remained the same.

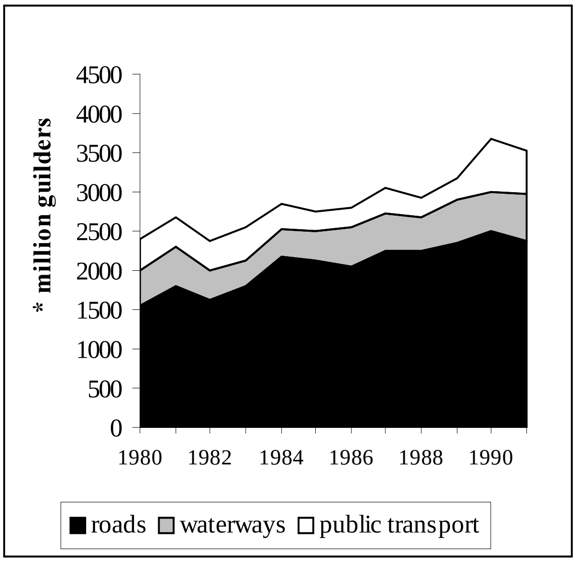


Figure 6.2.7: Expenditures on infrastructure construction and maintenance for the period 1980-1991.
Source: Budgets of the Ministry of Transport

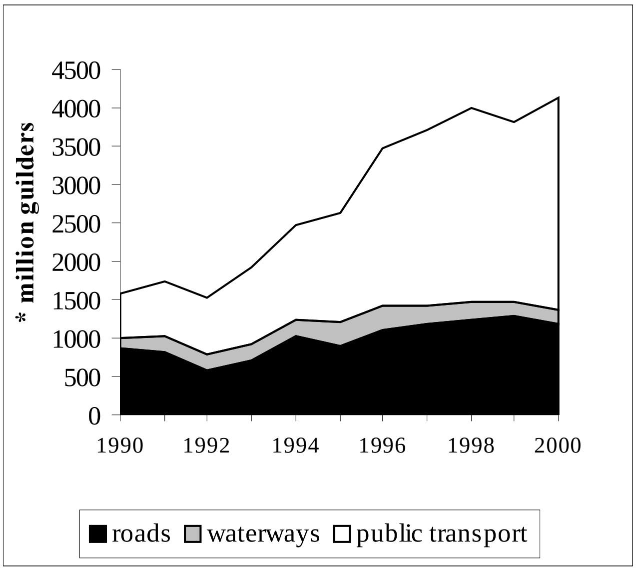


Figure 6.2.8: Expenditures on and budget for infrastructure construction for the period 1990-2000.

Source: V&W (1996)

The increased suburbanisation of the Dutch population and employment as described above has probably negatively influenced the accessibility to public transport. Figure 6.2.9 shows that the total number of jobs located a short distance from a railway station are much fewer than those located a short distance from a motorway junction, i.e. in 1996, more than 60% of all jobs were located within three kilometres of a motorway junction, whereas almost 50% of all jobs were further than five kilometres from railway stations of national or regional importance.

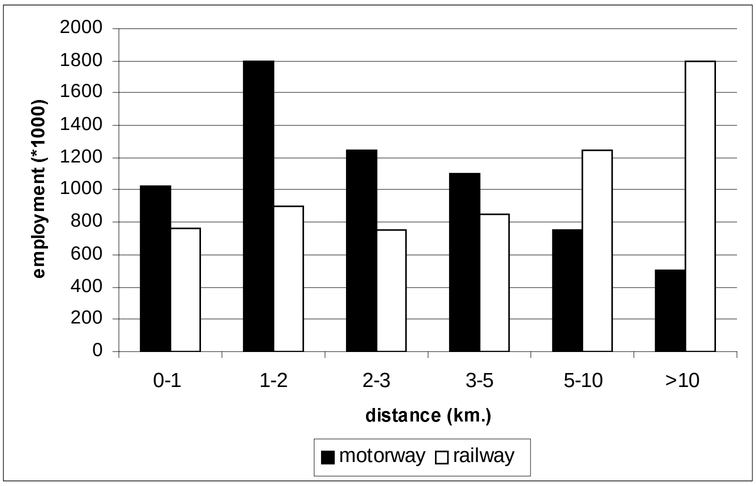


Figure 6.2.9: Employment according to distance from motorway junctions and railway stations of national or regional importance in 1996.
Source: Boks & Louter (1998)

The suburbanisation of employment can also be seen in the development of jobs on locations which are very well accessible by rail (location type A), well accessible by motorways and rail (location type B), very well accessible by motorways (location type C) or other locations (location type R). Table 6.2.4 shows that more than 80% of total Dutch employment is found at locations which are not well accessible by rail (location type C or R), and that employment growth at locations which are very well accessible by rail (location type A) is low, which is mainly due to the fact that these locations are generally located in town/city centres with already high employment densities.

Table 6.2.4: Total employment and employment growth between 1991-1996 at location types A-, B- and C+R

	1991-1996	1996	1996
	%	* 1000	%
Very well accessible by rail (location type A)	+1	533	8
Well accessible by rail and motorway (location type B)	+11	571	9
Other (location types C and R)	+7	5267	83
Total	+7	6371	100

Source: Boks & Louter (1998)

Accessibility of basic services

In the Netherlands, the number of neighbourhoods either without or with insufficient essential basic services (i.e. shops, schools and public transport stops) within 5.5 to 7.5 minutes walking distance increased from 7% in 1975 to 9% in 1997, the number of neighbourhoods with all basic services decreased from 30% in 1975 to 23% in 1995. Small settlements, mainly rural, have fewer basic services than bigger settlements (see Figure 6.2.10). Increases in scale have played an important role in the decline of the number of neighbourhood shops, primary schools and public swimming pools in the Netherlands since the 1980s.

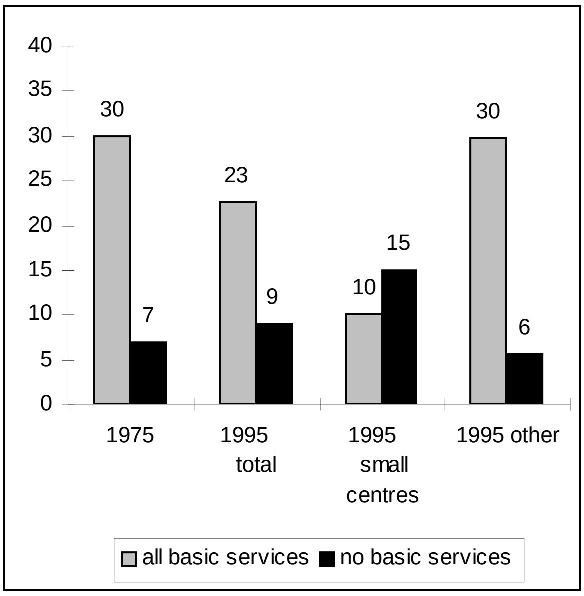


Figure 6.2.10: % of neighbourhoods without a shop, primary school and a public transport stop within 5-7.5 minutes walking distance
Source: RIVM (1998b)

Landuse and accessibility developments in the business-as-usual scenario

The fourth National Environmental Outlook (RIVM, 1997) analysed the spatial development of the Dutch population and employment for three business-as-usual scenarios for the period of 1995-2020. In these scenarios, current trends and landuse policies are assumed to continue. If the interregional migration patterns of the population are extrapolated, than the process of suburbanisation and national deconcentration will continue and will result in a further shift from the population from the western part of the Netherlands to the less densely populated eastern part. Figure 6.2.11 illustrates the population density for 1995 and 2020, showing for each 500*500 m in the Netherlands the weighted average number of inhabitants within a range of 30 kilometres. This range fits the daily urban population system well, i.e. about 95% of all trips per person per day are shorter than 30 kilometres. The figure shows the population density to shift from the Randstad to the eastern and the south-eastern part of the Netherlands.

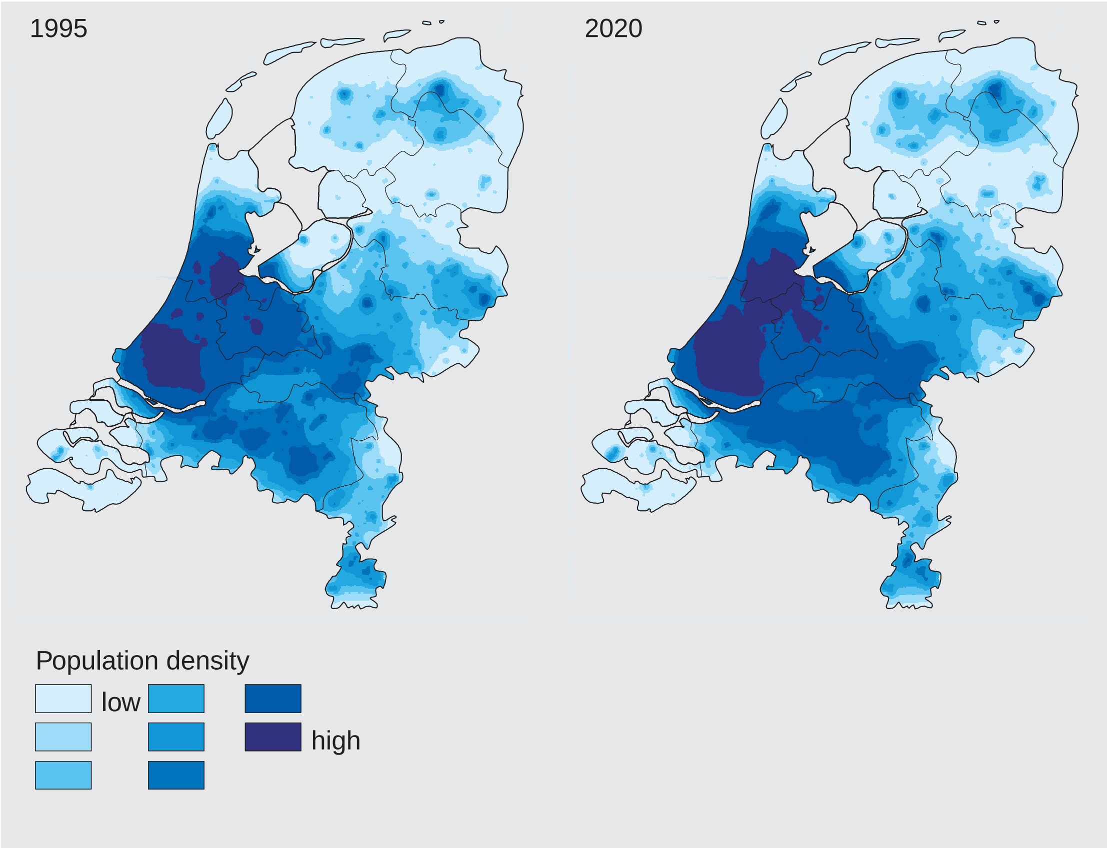


Figure 6.2.11: Population density in 1995 and 2020.
Source: RIVM (1997)

Figure 6.2.12 shows the spatial developments in (non-agricultural) employment for 1995 and 2020, showing for each 500*500 m in the Netherlands the weighted average number of employment within a range of 30 kilometres. The figure illustrates the employment supply: the higher the value of a location, the more employment is found within a range of 30 kilometres from that location. The figure shows an employment density increase on the north and south sides of the Randstad and a shift of employment from the Randstad to the eastern and the south-eastern part of the Netherlands.

The increased suburbanisation and national deconcentration of the Dutch population and employment as expected in the business-as-usual scenario will negatively influence the accessibility of employment by public transport if no large public transport investments on a regional level are assumed. The number of jobs at locations which are not well accessible by rail (location type C or R) will form the largest part of total employment (in 1996 about 83%). The number of jobs well or very well accessible by rail (location type A and B), will probably grow faster than average up to 2030, but still form a relatively small percentage of the total number of jobs.

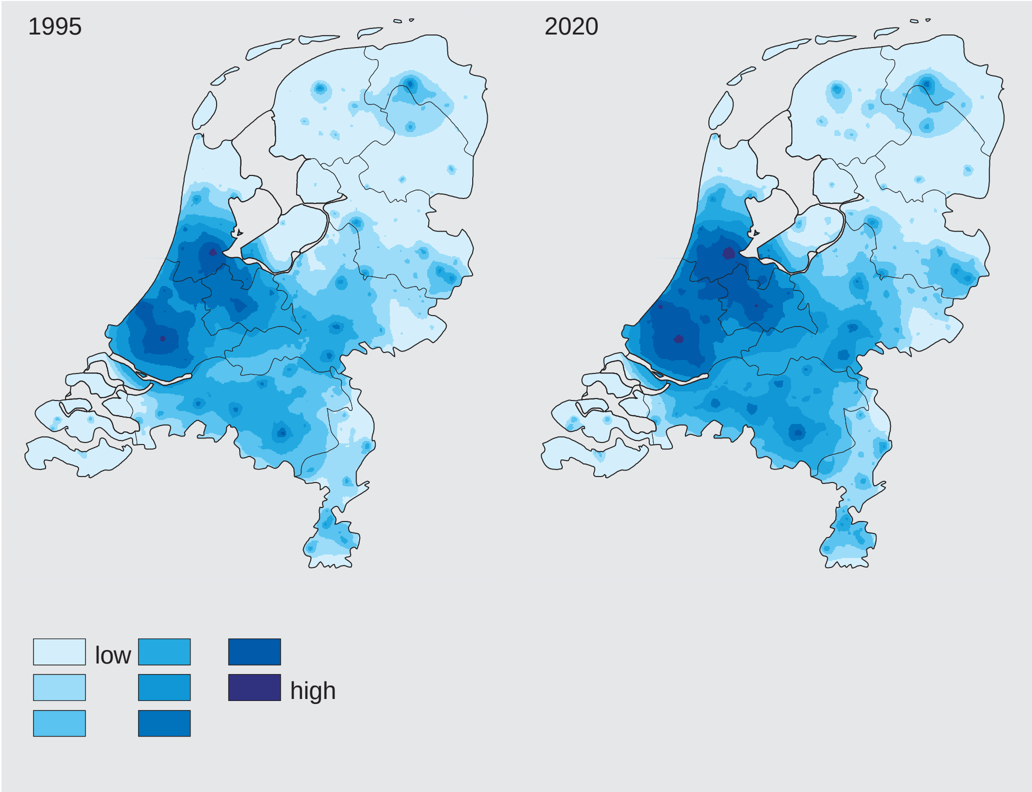


Figure 6.2.12: Employment density in 1995 and 2020.
Source: RIVM (1997)

Landuse and accessibility developments in the EST scenario

In the EST scenario, land-use policies are used as an instrument to increase the feasibility and acceptability of the system of tradeable CO_2 permits. The land-use policies are aimed at increasing access to opportunities with public transport and non-motorised modes and to decrease travel distances between locations of activities. The spatial-infrastructural constellation in the EST scenario promotes and facilitates short-distance trips and non-motorised transport (walking, cycling). The new demand for housing, working, recreation and shopping will – as much as possible - be realised within or in the proximity of existing residential areas. A small number of new towns will be developed outside existing urban areas but close to and well connected (by public transport) with existing towns (see also Section 4.2).

Furthermore, infrastructure policy will have to be transformed to achieve the EST scenario:

- new regional public transport systems will be introduced (i.e. a regional light rail system connecting metropolitan areas,
- more 'door-to-door' and flexible collective transport will be developed;
- passenger car infrastructure in (middle-sized) cities and towns will be largely converted to a non-motorised infrastructure (see also Section 4.2)

Although landuse policies for new housing and employment locations and infrastructure policies for new infrastructure will contribute to the necessary landuse changes, most of the landuse changes are expected to be the result of a different use of the existing locations of living, working and other activities. These landuse changes are – for example- stimulated by:

- Fiscal instruments to promote moving to houses closer to working locations. In the EST scenario demand and supply of housing have to be more regionally balanced by 2030;
- Introducing local or regional multifunctional company buildings with telecommunication facilities - to the main offices - at town/city peripheries.

An analysis of the accessibility of opportunities by car, public transport and non-motorised modes for the EST scenario for 2030 is beyond the scope of this report. However, it can be expected that accessibility differences between the car on the one hand, and public transport and non-motorised modes on the other, will be much lower. The number of economic and social opportunities which can be realised through public transport, walking and cycling will be higher compared to the business-as-usual scenario as a result of the changes in the spatial-infrastructural constellation described above.

Conclusion

In recent decades, Dutch population and employment have shown developments in national deconcentration and regional suburbanisation. Population and employment growth has shifted from towns to peripheries of metropolitan, suburban and rural areas. However, national landuse planning since the 1970s seems to have slowed down the process of suburbanisation. In the **business-as-usual scenario** the suburbanisation process will continue, which will negatively influence the accessibility level of economic and social opportunities for those without cars, as the number of opportunities which are well accessible by public transport and non-motorised modes decreases, which decreases people’s mode choice options. In the **EST scenario** the accessibility differences between the car, on the one hand, and public transport and non-motorised modes, on the other, will be much lower: more locations will be well accessible by public transport, and walking and cycling, thus increasing people’s choice of mode options.

6.2.2 Mobility and community relationships

Introduction

The level of mobility in a society may influence community relationships (e.g. social interaction between neighbours, the level of social cohesion in a neighbourhood) because of two reasons (see Adams, 1999). Firstly, as traffic levels in urban areas increase, the number of people attempting to cross the street decreases, and the number of people who know their neighbours on the other side of the street decreases. Secondly, if people become more mobile (longer trips in distance, higher travelling speed) the area covered by travel increases (the total travel time is relatively constant), and thus the number of people one has fleeting contact with increases. These two factors are explained below.

Urban traffic levels

There are very little studies that have analysed the relationships between urban traffic levels and community relationships. An in-depth study of the effects of traffic on three streets was done in San Francisco in 1970 (Appleyard, 1981). Appleyard showed that with traffic noise, vibration, air pollution, traffic danger, inconvenience and intrusions on activities and home life increase, while appearance, maintenance, sense of home and sense of responsibility, neighbouring, and street activities tend to decrease. Figure 6.2.13 illustrates that as traffic levels increase the number of friends and acquaintances across the street decrease.

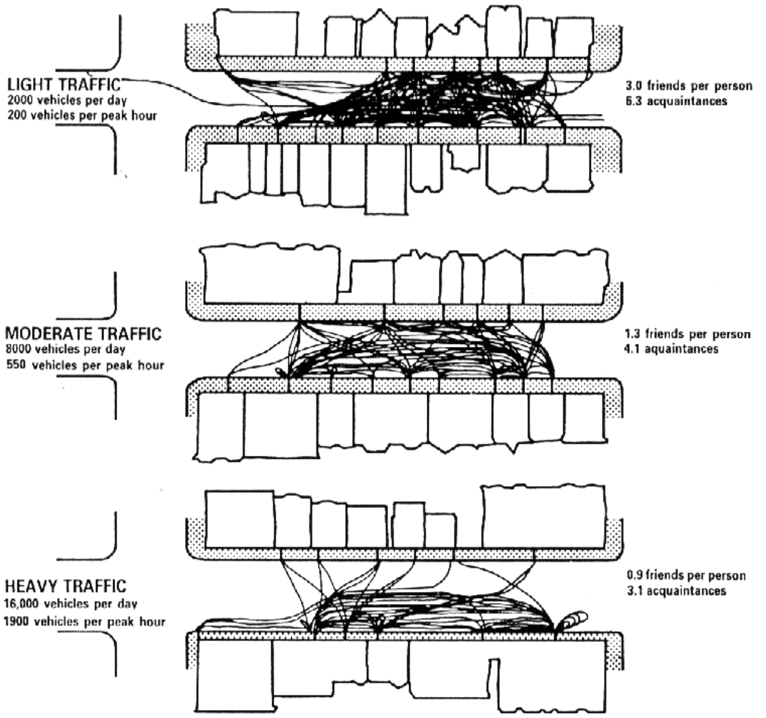


Figure 6.2.13: Community life and traffic levels in three residential streets in San Francisco

Source: Appleyard (1970), cited in Appleyard (1981) and Adams (1999)

However, Appleyard (1981) states that the relationship between the traffic level and community relationships is not clear, because other variables, particularly the characteristics and desires of the residents themselves, play an important role. For example, the street with light traffic was predominantly a family street with many children, the street with heavy traffic was inhabited mostly with single persons and older people. Furthermore, the research sample is very small. A recent (small scale) study in the Netherlands (Uitermark, 1999) analysed the relationship between the built-up environment and social contacts between neighbours in two different streets in Amsterdam, i.e. a street with high-rise buildings and a high level of through traffic and a with low-rise buildings and a low level of through traffic. Uitermark could not find differences in social contacts between neighbours in the two streets.

Distribution of trips in time and space

As trip distances and trip speeds increase, the way in which meeting opportunities are distributed over space change. The ways people make use of travelling distributed over space can be illustrated by ‘time-space’ domes. The height of the dome at any particular point is proportional to the amount of time that is spent at that point. The volume of the dome corresponds to the total amount of ‘interaction’ time that people spend - the number of waking hours in a day that are available for interacting with others. People can alter the shape of the dome, not its volume, although the total amount of time spent on transport can increase at the cost of other activities. This illustrates that the number of people with whom other people can have fleeting contact will increase according to trip lengths (Adams 1999).

Mobility and community relationships in the Netherlands in the past

A complex of interdependent societal factors probably has reduced community relationships in the Netherlands in the past, e.g. increases in scale of services, income growth, individualism and mobility growth. However, the influence of increased urban travel levels on community relationships and people’s time-space domes alone has probably been relatively small. Arguments for this hypothesis are given below.

In recent decades, road traffic growth in urban areas of the Netherlands has been modest (e.g. about 40% between 1980-1997) compared to outside urban areas (e.g. about 70% growth in the same period) and especially motorways (about 115% growth in the same period) (see Figure 6.2.14). The lower traffic growth in urban areas is partly the result of national and local transport policies (e.g. car-free town/city centres, parking policies, lowering speed limits to 30 km/h in residential streets). Figure 6.2.14 suggests that if a relationship between traffic levels in residential areas and community relationships exists, the influence of traffic has probably been small.

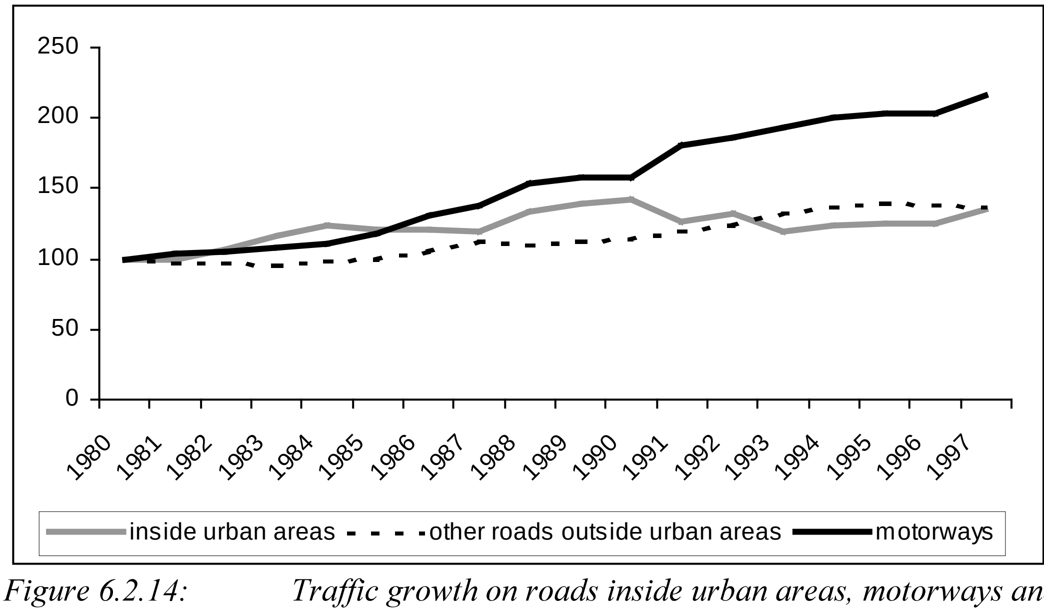


Figure 6.2.14: Traffic growth on roads inside urban areas, motorways and other roads in the Netherlands for the period 1980-1997

Source: CBS

MuConsult (1997a) shows that the amount of time spent on trips as a percentage of total available time increased from 5.2% in 1975 to 6.3% in 1995. This can be explained by an increase in the number of trips (i.e. from 2.9 to 3.7 trips per person per day), resulting in an increase in the number of kilometres travelled per person per day. Between 1978 and 1996 the average distance per trip (all modes) is remarkably constant, i.e. about 9.5 kilometres, whereas the largest increase is found in home–work trips per car, i.e. from 11.3 to 14.5 kilometres. The availability of a car largely influences the distance travelled per day, e.g. car owners travel 70% further per day than non-car owners. In 1991 the number of kilometres travelled for car owners was 48, for non-car owners 28. These figures imply that the way opportunities of people are distributed over space have shown changes in the Netherlands in recent decades. However, the increase in average trip distance has been modest, which means that the 'time-space' domes have not changed radically. Thus the influence of travel pattern changes on community relationships in recent decades has probably been modest.

Mobility and community relationships in the BAU and EST scenario

For the business-as-usual scenario, a model developed by Geurs (1995) shows that the total number of road traffic vehicle kilometres on roads inside urban areas increases by about 65% in the period 1990-2030, whereas outside urban areas traffic levels double. However, the number of road traffic vehicle kilometres in urban areas *per kilometre road length* is expected to grow modestly (i.e. about 15% up to 2030) because the total surface of urban area and the total road length inside urban areas also increase as a result of new housing and employment locations (see Figure 6.2.15).

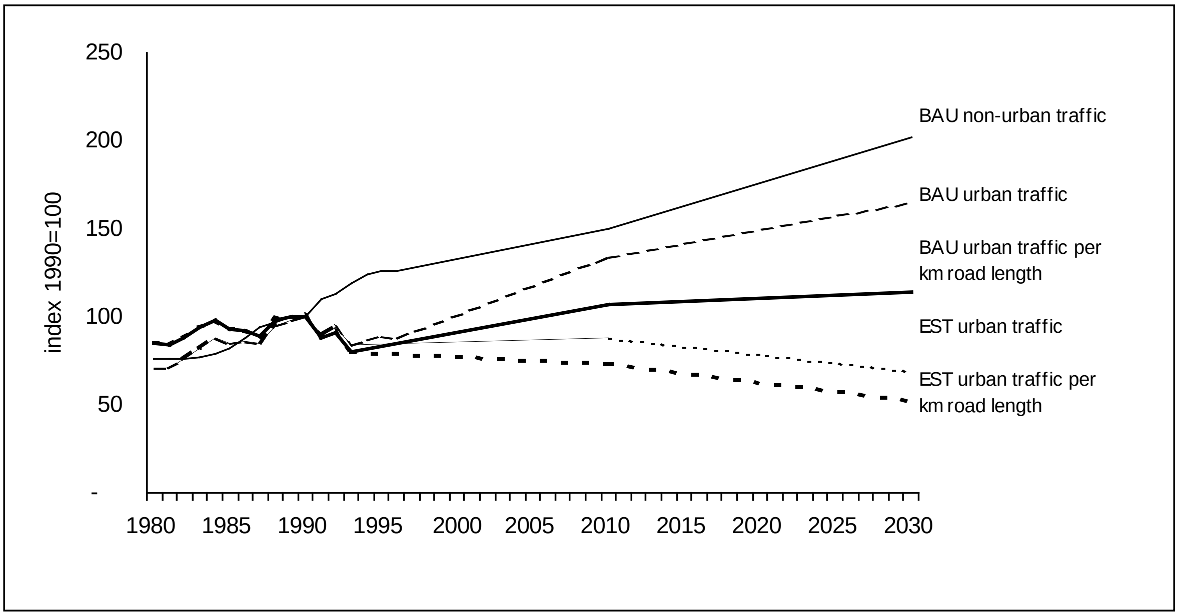


Figure 6.2.15: Urban road traffic for the BAU and EST scenarios for 1980-2030.
Source: adapted version of the PION model (see Geurs, 1995)

For the EST scenario, in which motorised transport is sharply reduced (e.g. total car use is expected to decrease by 50% by 2030 compared to the business-as-usual scenario), urban traffic levels will decrease (see Figure 6.2.15). Figure 6.2.15 shows that total road traffic vehicle kilometres in urban areas will by reduced about 30%, where the vehicle kilometres *per kilometre road length* will be reduced by about 50%.

Figure 6.2.15 implies that the influence of traffic levels in urban areas on community relationships will be comparable to the situation in 1990, whereas the EST scenario will probably show a considerable improvement.

Conclusion

In recent decades, the level of mobility in the Netherlands has probably had a limited influence on community relationships through increased traffic levels or increased trip distances. However, a complex of interdependent societal factors probably has reduced community relationships in the past, e.g. increases in scale of services, income growth, individualism and mobility growth. In the business-as-usual and EST scenario it is not expected that community relationships will decrease (BAU) or improve (EST) due to higher (BAU) or lower (EST) mobility levels or urban traffic levels.

6.2.3 Mobility and crime

Introduction

The connections between mobility and anonymity, and anonymity and crime were documented in reports as early as the 1970s. Adams (1999) states that the increased level of (reported) crime may probably be partly related to growth in mobility. Firstly, more mobility increases both productivity and opportunity, also for villains. Secondly, it fosters anonymity and thereby encourages the commission of crime by increasing the difficulty of apprehending offenders; communities in which people know each other tend to be largely self-policing because of the much greater risk of miscreants being found out. It is also likely that a growing proportion of crime is being officially recorded. Where neighbours know each other, misbehaviour by children, for example, is more likely to be sorted out by parents without recourse to the police. In anonymous societies, the victims of crimes committed by children and teenagers whom they do not know are much more likely to be reported to the police and become official statistics.

A study from the Dutch Social and Cultural Planning Office (SCP 1998) showed a correlation between the degree of bonding of residents with their neighbourhood and (perceived) safety. For example, a neighbourhood with high-level of migration or a high share of single-person householders will have less (perceived) safety (i.e. more reports of theft from vehicles, and crimes and violence in the living surroundings and thus more people feeling unsafe). However, the study did not relate the degree of bonding to the level of mobility or urban traffic levels in neighbourhoods.

Mobility and crime in the BAU and EST scenario

Adams (1999) concludes that in a business-as-usual scenario the threat of crime will increase as mobility levels increase, whereas in EST the threat of crime will decrease. In the Netherlands, no empirical studies were found that directly link mobility levels with (reported or fear of) crime. (The fear of) crime seem more related to neighbourhood characteristics (e.g. level of migration, age) than mobility changes. In conclusion, the threat (and level) of crime in the **EST scenario** is not expected to be different from the **business-as-usual scenario.**

6.2.4 Mobility and safety

Introduction

As traffic increases, traffic danger increases, especially for pedestrians and cyclists. According to Adams (1999) this cannot be demonstrated by road accident fatality statistics, which have been falling in most OECD countries for many years despite increasing traffic. In other words, as traffic increases people adjust their travel behaviour: fewer people attempt to cross the road, fewer cyclists venture forth onto the road and fewer children are permitted to get around on their own (see also Van der Spek & Moyon, 1993).

Mobility and safety in the past

Adams (1999) states that in the UK the loss of children's independence seems dramatic; in Britain 80% of 7- and 8-year-old children went to school unaccompanied by an adult in 1971; by 1990 this percentage had fallen to 9%. Parents, when asked why they were denying their children the freedom and independence that they had enjoyed as children, they gave as their main reason the fear of traffic (Hillman *et al.,* 1990, cited in Adams 1999). The Dutch situation is somewhat different from the UK. Children in the Netherlands seem much more independent in their home–school trips. Although between 1975 and 1995 more children were brought to school[11], a very large percentage of Dutch children still go to school unaccompanied, i.e. in 1996 about 75% of children of 12 years and younger went to school by foot (walking) and bicycle; about 15% were brought to school by car, about 9% were brought by bicycle. As the home–school distances increase, car use and public transport use also increase. For very short distances the share of children who went to school by foot and bicycle is higher than average (i.e. 85-95% for distances shorter than 1 kilometre); as distance increases, car use and public transport increase (Figure 6.2.16).

11 The average number of trips per person older than 12 years accompanying children increased by 70% between 1975 and 1995 (MuConsult, 1997a).

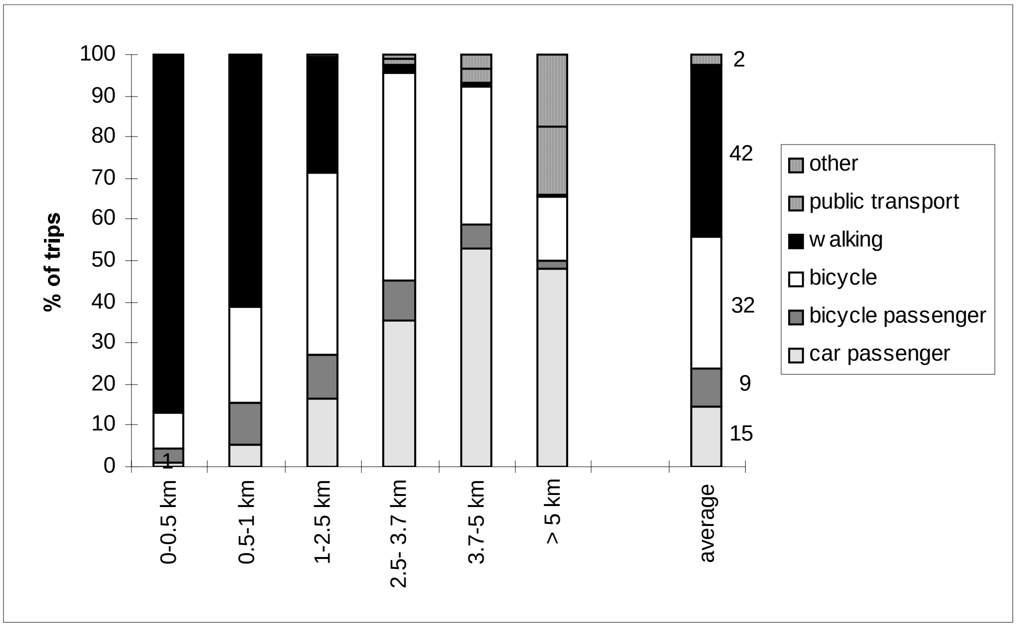


Figure 6.2.16: Home–school trips of children (< 12 years) per mode and distance in the Netherlands in 1996.

Source: CBS

Although children's independence in home-school trips in the Netherlands does not seem to be largely influenced by (fear of) traffic, traffic characteristics do influence children's independence of movement and travel behaviour. Van der Spek & Noyon (1993) analysed relationships between the built-up environment and other factors on the freedom of movement of children (aged 4 to 12 years) in four different towns in the Netherlands. They conclude that activity patterns of children are being influenced by characteristics of the child (e.g. age, nationality), social-cultural factors (e.g. the number of children per household), characteristics of the built-up environment (e.g. availability of playing grounds), and traffic characteristics. According to Van der Spek & Noyon, (perceived) traffic safety plays a dominant role in children's independence of movement: children enjoy a greater level of independence (i.e. a larger action space, more unaccompanied trips, a lower age at which they are allowed independent travel) in neighbourhoods where traffic calming (i.e. speed limits of 30 km/hr) and/or other traffic measures (e.g. speed bumps) are introduced and the perceived level of traffic safety is higher.

Furthermore, if traffic level and fear of traffic (of children and parents) increase, children adjust their travel and activity patterns. As an illustration: if street traffic increases, children will seek other, more quiet, places to play. When children (12 years and younger) play outside they prefer quiet streets and (back) gardens (about 60%), whereas a small percentage of children play along busy streets (about 4%) (see Figure 6.2.17). Hillman (1993, cited in Adams, 1999) reported some of the costs which are borne by children who are increasingly confined to back gardens or sat down in front of television sets and chauffeured everywhere by parents. In addition to the loss of traditional freedoms, some of these costs include the impairment of social development - as children are denied the experience of mixing independently with their peers and learning to cope without adult supervision - and the impairment of fitness, as they get less physical exercise.

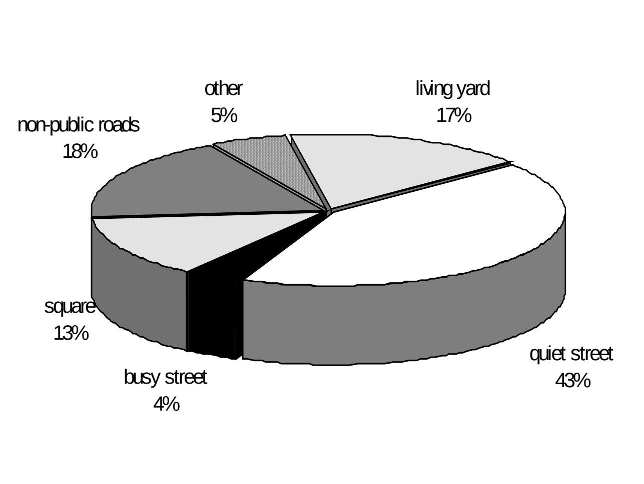


Figure 6.2.17: Locations for children playing outside in 1996. Source: CBS

Mobility and safety in the in the BAU and EST scenarios

For the business-as-usual scenario it can be expected that the forecasted mobility growth probably has a limited influence on traffic danger and safety, as urban traffic levels will stay relatively constant (see Section 6.2.3). For example, for the BAU scenario, the losses of children's independence will probably be small compared to today. However, for the EST scenario traffic danger will significantly decrease and traffic safety will increase compared to the present, as urban traffic levels will drop by 50% up to 2030.

Conclusion

The level of motorised mobility is (non-linearly) related to traffic danger and safety, although this is difficult to demonstrate by road accident statistics as people adjust their travel behaviour, e.g. avoiding crossing roads or staying at home. Thus, the travel independence of the vulnerable, i.e. children and elderly, is influenced by the level of motorised mobility. For the **business-as-usual scenario** the situation for 2030 will probably be comparable to the present as the urban traffic levels are expected to grow very modestly, whereas the **EST scenario** will show an improvement as urban road traffic levels will decrease significantly.

6.2.5 Mobility and health

According to Adams (1999) the habit of taking little exercise, which becomes established in childhood, is continued into adulthood. One result is an increase in obesity seen throughout the OECD countries. Increasing dependence on the car has been associated with ill health for another reason. A report from the British Medical Association (1997, cited in Adams 1999) showed an increasing polarisation in access to healthy food. Here, a marked decrease is noted in the consumption of leafy green-yellow vegetables - which are inversely correlated with cardiovascular diseases and cancers - by low-income families, and attribute the cause to the declining numbers of local shops and the lack of access of the poor to supermarkets, which are increasingly located for the convenience of car-borne shoppers.

The relationship between mobility, emissions from transport and health will improve in the **EST scenario** compared to the **business-as-usual scenario**. In the business-as-usual scenario, the level of urban traffic causes exceedances of local air pollution standards in the four largest towns in the Netherlands, although the total road length with exceedances decreases in the period 1995-2020 (RIVM, 1997), whereas in the EST scenario no exceedances of local air pollution standards are expected because of lower urban traffic levels and improved vehicle technology. Furthermore, health problems related to noise nuisance caused by road traffic and aviation (e.g. sleeping disorder, cardiovascular diseases – see RIVM, 1997) will be reduced because of the lower urban traffic levels and the lower level of aviation. Other health factors related to mobility (taking exercise and access to healthy food) are assumed to be constant because in the Netherlands no empirical studies were found that directly link mobility patterns or the level of mobility with health problems.

6.2.6 Mobility and (perceived) environmental quality

Introduction

The level of traffic in urban areas is an important explanatory factor for the urban environmental quality i.e. traffic causes noise, bad odours and local air pollution. For example, the higher the urbanisation level the higher people experience noise nuisance from road and rail traffic (see Figure 6.2.18). Studies have shown that several personal characteristics affect the perceived environmental quality of the residential environment as expressed by residential satisfaction, i.e. older people and people with a high socio-economic status appear to be more satisfied with their residential location than younger people. See for a review, Van Poll (1997), who analysed the perceived environmental quality of inhabitants in six neighbourhoods in the city of Rotterdam selected on the basis of their socio-economic status (based on profession, income and education of the home dwellers there). Noise was found to be the most important source of annoyance in neighbourhoods (compared to bad odours, pollution, litter, safety risks, crowding and lack of neighbourhood facilities). Dissatisfaction with the neighbourhood and dwelling, and annoyance by noise, bad odours and pollution was found to be higher in neighbourhoods with a low socio-economic status than in neighbourhoods with a medium and high socio-economic status. According to Van Poll (1997) this implies that people with a

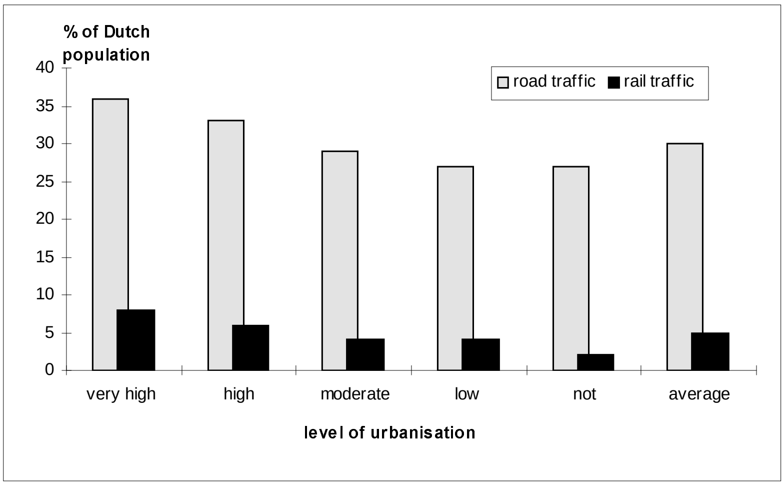


Figure 6.2.18: Dutch population (%) experiencing noise nuisance from road and rail traffic according to level of urbanisation in 1995.
Source: CBS

high socio-economic status may have more and better choice of options when renting or buying a dwelling.

Mobility and (perceived) urban environmental quality in the BAU and EST scenarios
For the business-as-usual scenario the current relationship between mobility and (perceived) urban environmental quality for different societal groups for 2030 will – ceteris paribus - not differ highly from the 1990 situation, as urban traffic levels increase modestly. In other words, the current disparity in perceived urban environmental quality between neighbourhoods with a high socio-economic status and low socio-economic status will be maintained. In the EST scenario, differences between societal groups in urban environmental quality - related to mobility - will be much less as urban traffic levels are reduced and (to a greater extent) noise levels will be reduced, i.e. urban traffic levels are reduced by about 50% by 2030, the total noise emission reduction from road traffic inside urban areas is about 10 dB(A).

Conclusion
The level of traffic in urban areas is an important explanatory factor for the urban environmental quality; noise in particular is an important source of annoyance in neighbourhoods. In the **business-a-usual scenario** the current disparity in perceived urban environmental quality between neighbourhoods with a high socio-economic status and those with a low socio-economic status will be maintained. In the **EST scenario**, the urban environmental quality will greatly improve as urban traffic levels decrease and emissions are further reduced by technology (e.g. all cars are assumed to be hybrid), and differences between societal groups in perceived environmental quality will probably decrease.

6.2.7 Mobility and democracy

Introduction
According to Adams (1999), as a society’s dependence on the car increases, those without cars experience diminishing control over their lives, and diminished faith in either markets or the institutions of government to safeguard their interests. The more dependent a society becomes on the car, the stronger the motivation of those without cars becomes to acquire them. Democracies, to function effectively, require common values, and a measure of agreement about societal goals forged out of common experience. Adams (1999) concludes that if distance is vanquished, the requisite minimum level of consensus and trust will be unattainable; the world will be filled with billions of strangers sharing the same physical space, but living in very different virtual communities of interest. However, there are many societal factors determining the level of democracy in a country. Therefore, it is questionable to directly link changes in the level of mobility only with the level of democracy. In the Netherlands, no studies were found that directly link increasing mobility levels with the level of democracy.

Mobility and democracy in the BAU and EST scenarios
Adams (1999) states that – in general - democracy-diminishing effects are likely to become more severe under BAU than under EST. However, for the Netherlands we expect that the level of democracy in the Netherlands will not be very different in the **business-as-usual scenario** compared to the **EST scenario**. Arguments for this assumption are that the car mobility level envisaged in the BAU scenario is lower than the current situation in the USA (i.e. the car ownership level in BAU in 2030 does not meet the 1992 USA car ownership level), still considered a democracy. The mobility level in the EST scenario is comparable to the situation in the Netherlands in the 1970s, when the level of democracy was not much different than now.

Conclusion
The relationship between mobility growth and the level of democracy in the Netherlands cannot be expected to be different in the **business-as-usual scenario** or the **EST scenario** compared to the present.

6.3 Social impacts from an individual perspective

6.3.1 Introduction

From an individual perspective the social impact of the business-as-usual scenario can be described as a classic *prisoner's dilemma*; every individual cannot at the same time experience the advantages of being more mobile than average and avoid the disadvantages of a more mobile society (i.e. more traffic in the streets, more noise nuisance and congestion). Furthermore, the social impact of the changes envisaged in EST compared to business-as-usual depends on the (perception of) the advantages and disadvantages of EST transport, which differs systematically between certain groups in society.

To illustrate the social impacts from an individual perspective, Section 6.3.2 describes the differences between groups in society in terms of social relations, cultural biases and behavioural strategies, and Section 6.3.3 describes a recent experiment in which Dutch households committed themselves to reduce their household energy use (including transport) during a 2-year period by changing their consumption and travel patterns.

6.3.2 Perceptions of environmental risks

The perception of the necessity of environmental sustainability or environmental risks differs systematically between certain groups in society. Steg & Sievers (2000) distinguish four groups according to 'Myths of Nature':

- Fatalists, who believe that nature is an unmanageable and inefficacious system and that neither natural resources nor needs need to be controllable;
- Hierarchists, who believe nature to be an unstable equilibrium and that natural resources are scarce, and are supposed to be controllable, unlike needs;
- Individualists, who believe nature is a stable equilibrium and that natural resources as well as needs are controllable;
- Egalitarians, who believe nature is a limited equilibrium and natural resources are supposed to be scarce and therefore not controllable, unlike needs.

Steg and Sievers analysed to what extent hierarchists, individualists and egalitarians perceive problems caused by car use and co-responsibility for these problems differently, and to what extent they evaluate the effectiveness and acceptability of different policy measures differently. The method used a computerised questionnaire, which was answered by more than 250 respondents. They found significant variations in perceptions, preferences and policy evaluations among the different groups. Egalitarians have a higher problem awareness and evaluate the effectiveness and acceptance of policy measures more positively, especially compared to individualists (see Figures 6.3.1 and 6.3.2). Figure 6.3.1 shows by means of a scale varying from –2 to 2 that egalitarians think to some extent that the problems of car use can only be resolved by drastic reductions in car use, while individualists have more faith in technological solutions. Figure 6.3.2 shows that egalitarians evaluate policy measures as more acceptable (and effective) compared to individualists. Furthermore, the figure shows that the more drastic policy measures 'ration fuel' and 'prohibiting car use on certain days' are less accepted than less drastic policy measures as 'car-free city centres' or 'improving public transport'.

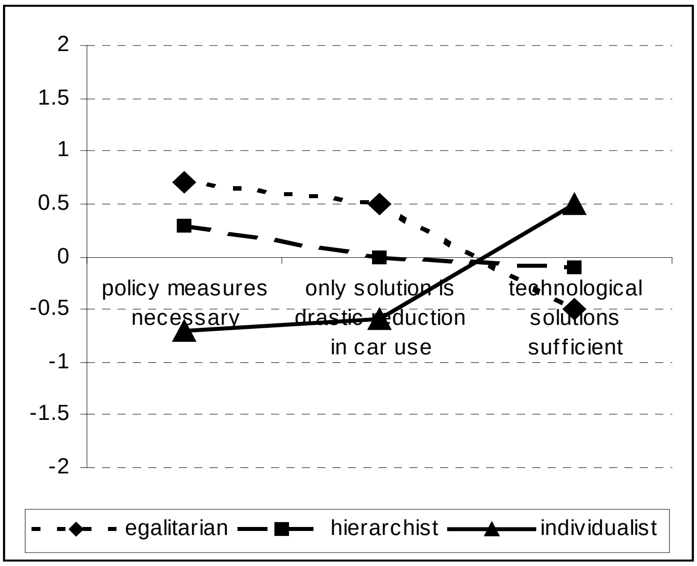


Figure 6.3.1: Preferred management strategy by egalitarians, hierarchists and individualists
Source: Steg and Sievers (2000)

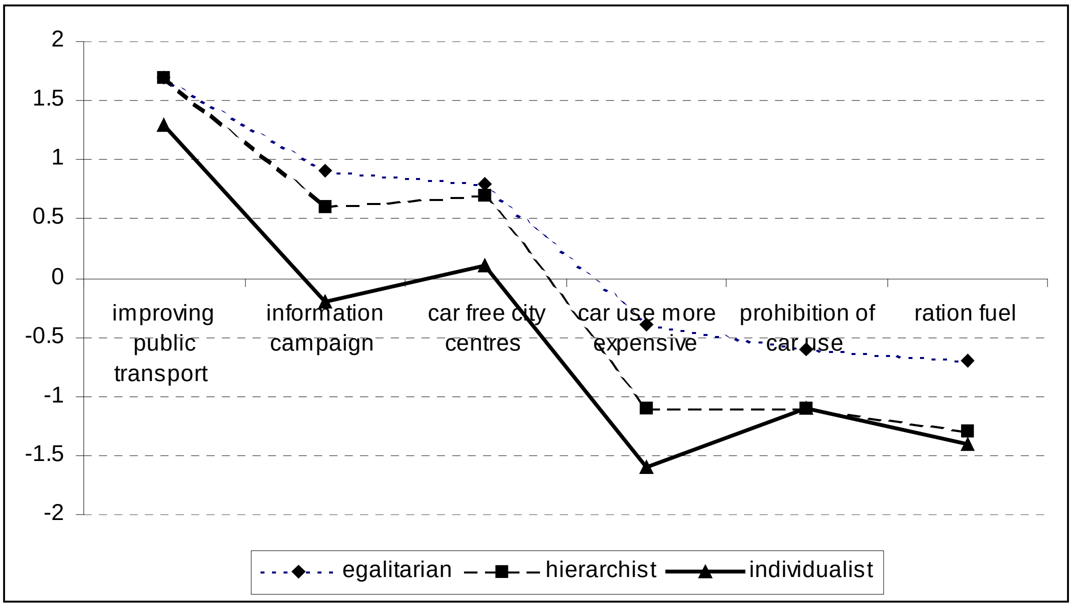


Figure 6.3.2: Evaluation of acceptance of policy measures by egalitarians, hierarchists and individualists.
Source: Steg and Sievers (2000)

6.3.3 Social impacts from behavioural changes towards an EST

The Dutch Ministry of Housing, Spatial Planning and Environment recently reported the results of an empirical research project analysing energy-extensive lifestyles (VROM 1999). In this project, 12 householders committed themselves to reducing their direct and indirect energy use by 30% during a 2-year period by changing their consumption patterns. Furthermore, the strategies for energy use reductions (i.e. less consumption, buying more expensive and more durable goods, or shifting expenditures to less-energy intensive consumption categories), the householder's satisfaction with the new consumption patterns and the reactions among acquaintances were questioned.

The results of the project were that the participating households were able to develop less energy-intensive consumption patterns, reducing their yearly energy use by more than 40% compared to comparable households and more than 30% compared to their own starting situation. The yearly household expenditures increased by about 20%. More than 50% of the energy use reduction was achieved by buying goods and services with a lower energy intensity; the other 50% was achieved by a lower direct energy use (more energy-efficient equipment). Figures 6.3.3 and 6.3.4 show the average changes in energy use and expenditures per consumption category, i.e. transport (private and public), food, housing, clothing, hygiene and services, leisure and direct energy use (i.e. heating and cooking). Figure 6.3.3 shows that the participating households were able to reduce their energy use equally per consumption category. Figure 6.3.4 shows that expenditures on food and housing increased relatively strong. Household expenditures on transport increased (by about 25%), whereas energy use from transport decreased by about 16%. However, one householder who bought a new car causes this result. Without this household, expenditures decreased by 19%, energy use by 23%. The energy use reduction is mainly the result of less travelling.

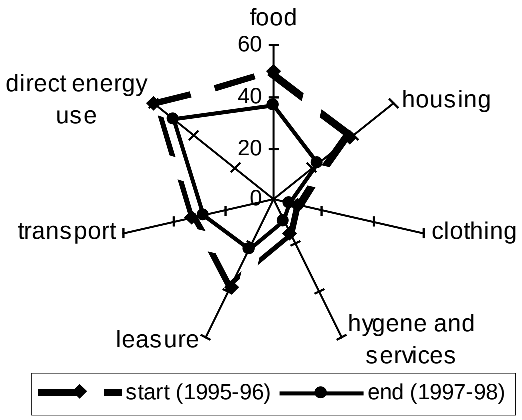


Figure 6.3.3: Average energy use per category at the start and the end of the project (GJ per year).
Source: VROM (1999)

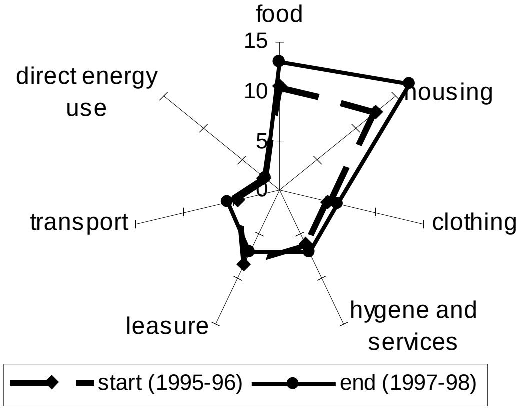


Figure 6.3.4: Average expenditures per category at the start and the end of the project (1000 guilders per year).
Source: VROM (1999)

The average householder's satisfaction with the new lifestyle increased during the two-year period. Satisfaction for the consumption category transport was higher before the project and higher at the end of the project, which indicates that people got used to their travel behaviour, although some householders indicated that they experienced a lower level of mobility as unpleasant. This is an indication that the 'pain' of changing towards more environmentally sustainable travel behaviour is mainly in the transition period, and that people are able – if willing - to adjust to using alternative transport modes (non-motorised modes, public transport) and to lower levels of motorised mobility.

6.4 Conclusions

In this section we sought an answer to the question: Would the social fabric in the Netherlands in 2030 be different if the EST scenario were realised rather than the business-as-usual scenario, both from a societal and a individual perspective.

For the *societal perspective* the following social factors, which were thought important and sensitive to changes in mobility were described: i.e. material wealth, land use and accessibility of opportunities, community relationships, crime, safety, health, environmental quality and democracy. The following social factors are considered to differ the most between the business-as-usual scenario and the EST scenario:

- *Material wealth*: mobility is related to wealth: higher income groups have a higher level of car ownership, travel farther and use their (less fuel-efficient) cars more often. However, for the **business-as-usual scenario** demographic factors and saturation of car ownership levels are more important explanatory factors for the forecasted passenger transport growth. In the **EST scenario**, passenger transport is substantially reduced, mainly due to a system of tradeable CO_2 permits. As a result, GDP and income growth rates will be somewhat lower compared to BAU, and more important, differences in travel behaviour between income groups will be smaller, i.e. higher income groups pay a relatively higher price for maintaining their travel behaviour than lower income groups.
- *Land use and accessibility*: in the **business-as-usual scenario** a process of national deconcentration and regional suburbanisation will continue, which negatively influences the accessibility level of economic and social opportunities for those without cars, as the number of opportunities which are well accessible by public transport and non-motorised modes decreases, and thus negatively influences people's mode choice options. In the **EST scenario** the accessibility differences between the car on the one hand, and public transport and non-motorised modes on the other, will be much lower: more opportunities will be well accessible by public transport and walking and cycling, thus increasing people's choice of mode options;
- *Safety*: the level of motorised mobility is (non-linearly) related to traffic danger and safety, and can influence the travel independence of the vulnerable, i.e. children and elderly. For the **business-as-usual scenario** the situation for 2030 will be comparable to the present, whereas the **EST scenario** will show an improvement as urban road traffic levels will decrease significantly;
- *Health:* health problems caused by local air pollution and noise nuisance from road traffic and aviation will increase in the **business-as-usual scenario** and decrease in the **EST scenario;**
- *Environmental quality:* the level of traffic in urban areas is an important explanatory factor for the urban environmental quality; especially noise. In the **business-a-usual scenario** the current disparity in perceived urban environmental quality between neighbourhoods with a high socio-economic status and low socio-economic status will be maintained. In the **EST scenario**, the urban environmental quality will highly improve as urban traffic levels decrease and noise emissions are reduced; differences between societal groups in perceived environmental quality will probably decrease.

From an *individual perspective*, the social impact of the business-as-usual scenario can be described as a classic *prisoner's dilemma*; every individual cannot, at the same time, experience the advantages of being more mobile than average and avoid the disadvantages of a more mobile society (i.e. more traffic in the streets, more noise nuisance and congestion). Furthermore, the social impact of the changes envisaged in EST compared to business-as-usual depends on the (perception of) the advantages and disadvantages of EST transport. Perceptions, preferences and evaluations of policies reducing car use differ systematically between certain groups in society (fatalists, hierarchists, individualists and egalitarians); egalitarians have a higher problem awareness and evaluate the effectiveness and acceptance of policy measures more positively, especially compared to individualists.

Furthermore, a Dutch project, in which 12 households participated, indicated the possibility of developing less energy-intensive consumption patterns, reducing yearly energy use from transport and transport expenditures. Moreover, the average householder's satisfaction with the new lifestyle increased during the project. Satisfaction with travel patterns was higher before the project and higher at the end of the project, which indicates that people had gotten used to their travel behaviour, although some householders indicated experiencing a lower level of mobility as unpleasant. This is an indication that the 'pain' of changing towards more environmentally sustainable travel behaviour is mainly in the transition period, and that people are able – if willing - to adjust to using alternative transport modes and lower levels of motorised mobility.

7. Economic implications of EST

7.1 Introduction

There are several possible approaches for assessing the economic impact of transport scenarios. Three types of approaches were discussed within the framework of Phase 3 of the OECD project: (1) traditional methods, i.e. cost-benefit analysis, cost-efficiency analysis and multi-criteria analysis, (2) System Dynamics Modelling (SDM) and (3) evaluation based on Symplified Cybernetic Modelling (SCM) (see Rothengatter, 1998). From discussions on methodologies of economic assessment, the OECD concluded that traditional economic analysis were not favourable for assessing the economic impact of the EST3 scenario because these methods presuppose that changes to be assessed are marginal and do not generate major repercussions outside the transport sector. The EST scenarios describe changes in technology and mobility behaviour in such a way as to make a system dynamics approach appear more suitable. However, mainly for practical reasons (i.e. preparing the data and functional inputs for a system dynamics model requires considerable additional data and work and could bring about problems with handling the complex structure), the OECD decided that a SDM would be developed for only one country study (i.e. Germany). A SCM would also be developed for the economic impact assessment of all country studies. This solution enabled a plausibility check on the results from the SCM using the SDM results.

A Simplified Cybernetic Model (SCM) can be described as a method of purely generating qualitative rankings through expert questioning and evaluating the results through active/passive influence indicators or positive/negative feedback analysis (Rothengatter, 1998). The University of Karlsruhe (Rothengatter, 1998) developed a variant of an SCM, enabling a comparison of a quantitative economic impact assessment of the combination scenario (EST3) with the business-as-usual scenario (BAU), i.e. the Impact Path Analysis (IPA). The basic idea of the IPA is to have the assessors follow the chain of impacts level-by-level through the economic system, resulting ultimately in aggregate economic indicators, and then to assess the *order of magnitude* of their changes. The economic impact of the combined scenario (EST3) is assessed relative to the business-as-usual scenario (BAU).

The IPA methodology will be shortly described in section 7.2. See Rothengatter (1998) for a more detailed description. Section 7.3 to 7.7 describes the Impact Path Analysis for the Netherlands' study. Subsection 7.8 gives an estimation of the savings of external costs given as an indication of the monetary value of the EST achievement. Finally, section 7.9 presents the conclusions of the economic impact assessment.

7.2 Impact Path Analysis Methodology

The IPA is divided into two parts: the mainstream assessment (Phase 1), in which the assumed policy actions are assessed with respect to their impacts on different levels of economic activity, and the interdependence analysis (Phase 2), in which the interdependencies between the different levels are assessed (see Figure 7.2.1).

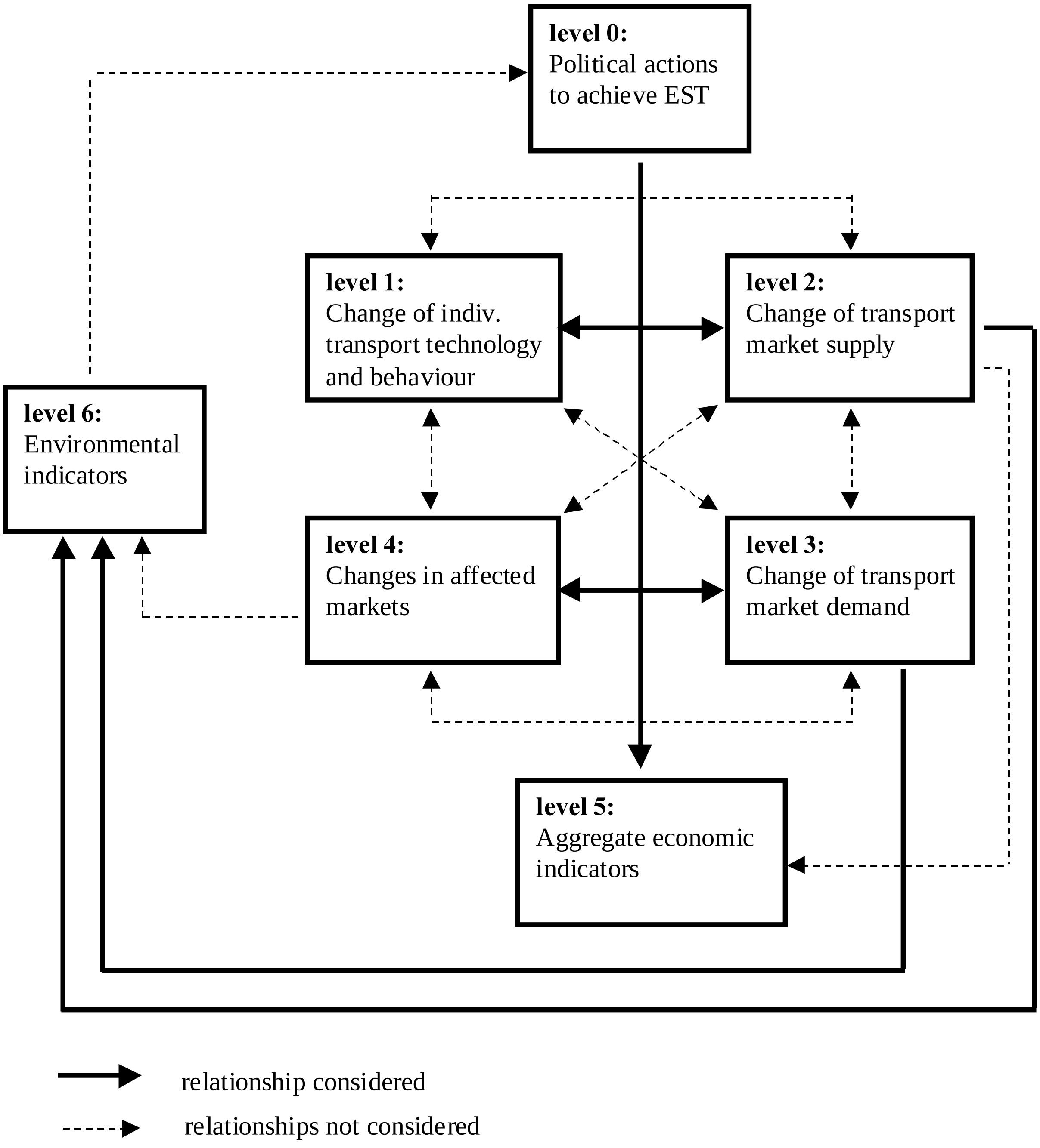


Figure 7.2.1: Flow diagram of Impact Path Analysis.
Source: adapted version of Rothengatter (1998)

The IPA method comprises six different levels, varying from the micro- to the macro-level:

- On the base level, ‘0’, are described the policy instruments which, if implemented, would result in the occurrence of EST. The analysis starts at this level with an exact and comparable design of the policy instruments.
- On level 1, the effects of the policy instruments on the micro-level of decision making are estimated. The contribution of policy instruments to the assumed changes in technology and behaviour, and attainment of the EST criteria, is estimated at this level. The estimations are given as a percentage of target achievement according to the combination scenario (EST3).
- On level 2 the influences are estimated of the assumed technological and behavioural changes on the supply side of the transport market (i.e. the transport infrastructure, vehicle stock and organisation system for managing transport activities). The supply side is characterised by “generalised costs” of different transport modes: these consist of costs for operation, infrastructure, time, inconvenience, as well as internalised external costs. Low generalised costs indicate a high level-of-service for the consumer. The estimations of generalised costs are given in percentages of changes in the EST3 scenario compared to the BAU scenario.
- On level 3 the technological and behavioural changes are translated into the changes in the categories of transport demand, described by the percentage of change in passenger kilometres or tonne kilometres in the EST3 scenario compared to the BAU scenario.
- On level 4 the economic importance of the sectors directly affected is described using economic indicators (i.e. Gross Production Value and final demand). The effects of the assumed technological and behavioural changes on the sectors directly affected are described in percentage of gross valued-added change and the changes in final demand in the EST3 scenario compared to the BAU scenario. It is assumed that on this level, the relative importance of the affected sectors is left unchanged and no multiplier effects are included.
- On level 5 all micro- and meso-effects estimated on previous levels are aggregated to the macro-economic level. Here, the change of aggregate indicators (i.e. Gross Production Value and employment) are derived in terms of percentage deviations from BAU, taking into account the multiplier effects induced by the first order effects on level 4;
- Finally, on level 6 the effects of the changes in the different levels of economic activity on the environmental indicators are calculated. The changes in environmental indicators are expressed in terms of reductions of external costs, which is used as an indicator for the level of non-material welfare. To reduce complexity, only the relationships between the changes in transport market supply (level 2) and demand (level 3) and the environmental indicators are considered.

The following general assumptions are made in the IPA analysis:

- The EST criteria are achieved in the projection year (2030);

- The policy actions are designed exogenously and do not vary, dependent on the impacts assessed, i.e. there are no feedback relationships adjusting the policy instruments in the course of an interactive assessment scheme;
- To reduce complexity, the (dominant) CO_2 emission reduction criterion is the only EST criterion to be considered;
- Aggregation from micro- to meso- and from meso- to macro-levels is possible through expert judgement and econometric key relationships;
- To reduce complexity, the assessment is restricted to the economic impacts, and does not include social impacts and their relationships with economic and ecological indicators;
- The economic impact outside the transport sector due to interdependencies between transport and other sectors of the economy can be calculated using multiplier effects with respect to the economic impact in the directly affected sectors (i.e. road vehicle manufacturers, secondary car businesses and transport services, railways, airlines, tourist industry and retailers).

7.3 Change in transport technology and behaviour (level 1)

The analysis of the changes of transport technology and behaviour (evaluation level 1) can be split into two steps. Firstly, the contribution is estimated of technological changes and behavioural changes (i.e. activity changes, higher load factors, modal split changes) in meeting the CO_2 criterion. Secondly, the contribution is estimated of policy instruments to the assumed changes in technology and behaviour. The two steps are described below.

Contribution of technological and non-technological changes to the CO_2 emission reduction
The contribution of activity changes, technological changes, efficiency improvements and modal shifts to meeting the CO_2 criterion is estimated using a “balance-of-effort” method (see section 2.6.3 for a description). Table 7.3.1 shows the results. Overall changes in activity (reduction of passenger or tonne kilometres) contribute 20% to the total CO_2 emission reduction, technology changes, 50%, higher occupancies, 21% and mode shifts 9%.

Table 7.3.1: Contribution of reduced activity, vehicle technology, efficiency improvements and modal shifts to CO_2 emission reductions (ktonne) in 2030[a)]

	Activity alone	Technology alone	Occupancy alone	Mode shift alone	Total
	reduction of ktonnes CO_2				
car	-4129	-15915	-6969	-447	-27461
rail passenger	-112	-433	-271	112	-704
bus	-114	-358	-275	114	-633
motorcycle	-40	-58	12	-108	-195
moped	-18	-34	6	-47	-92
lorry	-5061	-7593	-3211	-4483	-20348
inland shipping	-890	-1157	-371	-295	-2713
rail freight	-48	-95	-21	510	346
total	-10412	-25643	-11099	-4644	-51798
% of total	20%	50%	21%	9%	100%

[a)] All CO_2 figures are related to Dutch territory.

Contribution of instruments to meeting the CO_2 criterion

The policy instruments are classified into instrument types which are relevant for the attainment of the CO_2 emission criterion as follows:

- Variable pricing policy, e.g. the assumed CO_2 tradeable permit system, fuel price increases, road pricing;
- Fixed pricing policy, e.g. vehicle taxation;
- Standards behaviour, including all kinds of regulations, e.g. lowering speed limits, parking regulations, prohibiting vehicles with conventional combustion engines in central urban areas;
- Management efficiency gain, e.g. reorganisation, privatisation, telematics;
- Land use, including changes in land use and development of towns;
- Investments in alternative modes, e.g. increased investments in environmentally friendly transport modes;
- Education, e.g. change of values effected by education, propagating more environmentally sound lifestyles.

The following assumptions were made regarding the contribution of instruments to realise the EST3 features.

General assumptions

- The general assumption is that the CO_2 tradeable permit system can be categorised as a pricing instrument, and that this instrument is considered to be the most effective one for the realisation of the passenger and freight transport features and thus of the necessary CO_2 emission reduction.

- The technology and mobility changes apply to the year 2030. This means that CO_2 emission reductions from road vehicles are the result of innovative vehicle techniques (e.g. hybrid cars, fuel-cell lorries); by the year 2030 all conventional road vehicles are to be replaced.

Cars

- The assumed technological changes in cars (i.e. all cars are hybrid vehicles) are for 80%, the result of pricing policy (i.e. the CO_2 tradeable permit system, purchase subsidies for hybrid cars) and for 20%, the result of regulating behaviour (e.g. access restrictions for conventional cars in urban areas).
- The assumed reduction in car use is for 70%, the result of pricing policy (i.e. the CO_2 tradeable permit system, pricing instruments outside the transport sector such as fiscal instruments to promote a more flexible housing market), for 10%, the result of behavioural standards, for 10%, the result of land-use changes (e.g. re-location of companies), and for 10%, the result of reduced investments in car infrastructure investments combined with increased investments in rail and non-motorised infrastructure.

Lorries

- The assumed technological changes of lorries (i.e. hybrid lorries, fuel-cell lorries) are the result of pricing instruments (80%, mainly due to the CO_2 tradeable permit system), and behavioural changes (20%, mainly due to access restrictions for conventional vehicles in urban areas).
- The assumed lorry use reduction is the result of pricing policy (50%, mainly due to the CO_2 tradeable permit system), behavioural standards (20%), management efficiency (10%), land-use changes (10%), and a shift from investments in lorry infrastructure to rail and inland shipping infrastructure (10%).

Rail passenger and freight transport

- The technological changes in rail transport (i.e. all trains have electric traction) are fully accredited to regulation.
- The assumed mobility changes in rail-passenger and freight transport are the result of pricing instruments (70%), standards behaviour (10%), management efficiency improvements (10%) and land-use changes.

Inland shipping

- The assumed technological changes in ships (e.g. hydrogen ships) are the result of pricing instruments (80%, mainly due to the CO_2 tradeable permit system) and regulations (20%);
- The assumed logistical optimisation is assumed to be the result of pricing policy (50%, mainly due to the CO_2 tradeable permit system), regulations (25%) and a better organisation (25%).

Aviation

- The technological changes in aircraft (e.g. improved aircraft design) are assumed to be the result of pricing instruments (80%, mainly due to the CO_2 tradeable permit system) and regulations (20%).
- The assumed reduction in air transport is assumed to be the result of pricing policy (50%, mainly due to the CO_2 tradeable permit system), regulations (25%) and efficiency improvements (25%).

Tables 7.3.2 and 7.3.3 give the results of the contribution of instruments to the attainment of assumed technological and mobility changes necessary to meet the CO_2-emission reduction criterion.

Table 7.3.2: Contribution of instruments to technology changes

	Conventio-nal vehicle technology	Innovative vehicle technology	Efficiency rail	Efficiency water	Efficiency air	Tele-matics	Second. energy cons.	Total
	%							
variable pricing policy	0	72	0	4	2	0	0	78
fixed pricing policy	0	0	0	0	0	0	0	0
behavioural changes	0	19	2	1	1	0	0	22
management efficiency	0	0	0	0	0	0	0	0
land use	0	0	0	0	0	0	0	0
technology subsidy	0	0	0	0	0	0	0	0
investments alt. modes	0	0	0	0	0	0	0	0
education	0	0	0	0	0	0	0	0
								0
total	0	91	2	5	2	0	0	100

Table 7.3.3: Contribution of instruments to non-technological changes

	Reduced motorisation	Red. travel. distance	Reduced air travel	Environmental logistics	Load factors	Total
	%					
variable pricing policy	13	9	2	9	23	55
fixed pricing policy	0	0	0	0	0	0
behavioural changes	5	3	1	3	8	20
management efficiency	2	1	1	1	3	8
land use	2	1	0	1	4	9
technology subsidy	0	0	0	0	0	0
investments alt. modes	2	1	0	1	4	9
education	0	0	0	0	0	0
						0
total	23	16	4	16	41	100

7.4 Change in transport market supply (level 2)

The effects of policy actions on technology and on individual transport behaviour has been evaluated for level 1. The evaluation sheet for level 2 translates these individual changes for the supply side of the transport system, characterised by generalised cost of different transport modes. Ideally, the generalised costs are derived from information on operation costs, time costs, costs of inconvenience and internalised external costs. However, because of practical reasons the total changes in generalised costs per transport mode is derived from the assumed changes in the transport demand market (see evaluation level 3) combined with cost elasticities per transport mode. The necessary changes in total generalised costs per kilometre are mainly based on fuel cost elasticities. The contribution of instruments to the total change in generalised cost per transport mode is also derived from the relative contribution to the changes in the transport demand market. The result is given in Table 7.4.1. The estimation of the total generalised cost change per transport mode is explained below. It must be stressed that the estimated changes in generalised costs are very rough indications because of the large uncertainties in fuel-cost elasticities, the contribution of fuel costs to the total generalised costs and the contribution of total generalised cost changes to the realisation of the combination scenario's demands.

Table 7.4.1: Percentage of change in generalised costs per kilometre per vehicle category

Policy instrument	Cars (veh. km)	Lorries (tonne km)	Rail passenger (pass. km)	Rail freight (tonne km)	Inland shipping (tonne km)	Air transport (pass. km)
	%					
pricing variable	39	115	11	0	2	380
pricing fixed	0	0	0	0	0	0
standards fuel	0	0	0	0	0	0
standards exhausts	0	0	0	0	0	0
standards noise	0	0	0	0	0	0
standards behaviour	6	46	2	0	4	190
management efficiency gain	0	23	2	0	2	190
land use	6	23	2	0	0	0
technology subsidisation	0	0	0	0	0	0
investments alt. modes	6	23	0	0	0	0
education	0	0	0	0	0	0
total	56	230	15	0	8	760

Cars

In the Combined Scenario (EST3) car passenger kilometres amount to half the business-as-usual (BAU) level. If the generalised cost increase is assumed to be only the result of fuel cost increases, fuel costs must highly increase. The necessary change in generalist costs per car-passenger kilometre depends strongly on the assumed cost elasticity. Fuel-price elasticities for car use based on empirical data are mostly within a range of -0.1 and -0.5, with 0.25 considered as average. However, these elasticities are based on small price increases from the past. A study by MuConsult (1997b) showed that fuel-price elasticities for small price increases are probably lower than for large price increases, i.e. car use (by Dutch households) decreases by 3% at a 20% fuel price increase to 12% at a 60% price increase. MuConsult concludes that the effect of high fuel-price increases on car use is largely the result of households abolishing their cars. If the relationship between fuel prices and car use from MuConsult is extrapolated (see Figure 7.4.1), a 115% fuel-price increase is needed to reduce car use by 50% (a fuel-price elasticity of about -0.45), whereas if a constant fuel-price elasticity of -0.25 is assumed, fuel price would need to increase by 200%. If it is assumed that the fuel cost elasticity is twice the level of the fuel-price elasticity (i.e. half the effect of the price increase is offset by increased fuel efficiency), this would mean a fuel-cost elasticity of -0.9. Using this elasticity, a fuel-cost increase of roughly 60% is necessary to reduce car vehicle kilometres by 50%.

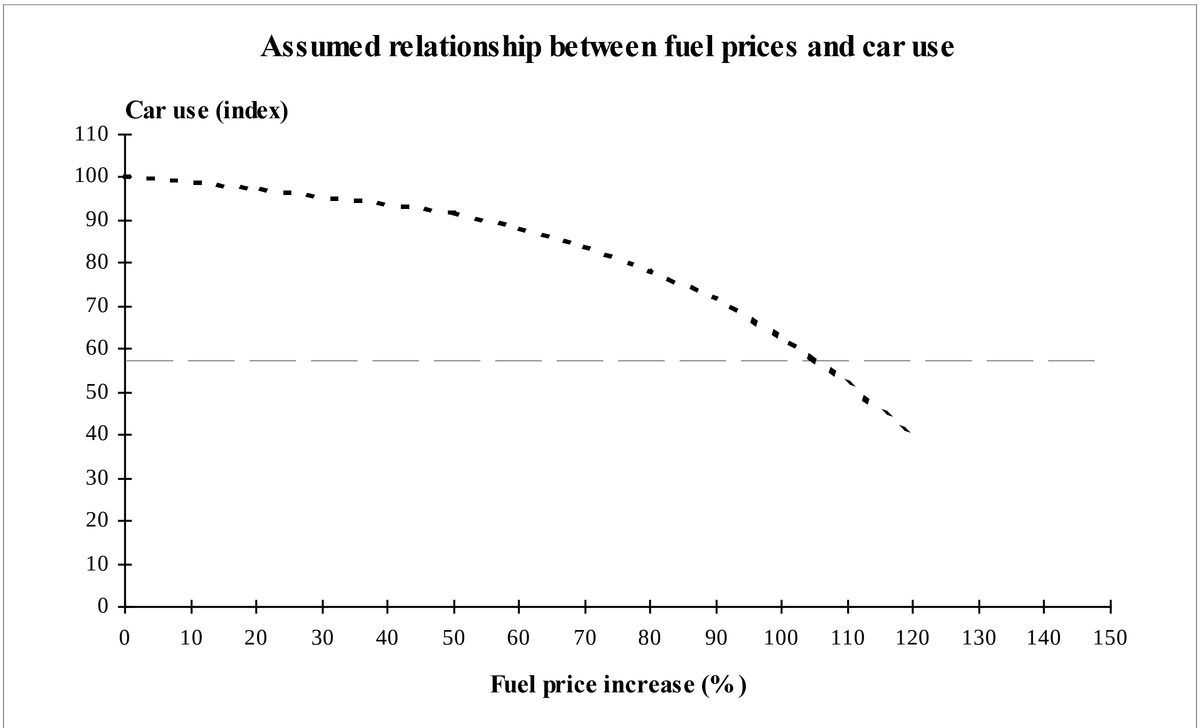


Figure 7.4.1: Assumed relationship between fuel prices and car use (based on MuConsult, 1997b)

Rail passenger transport

The generalised cost increase of car use will result in a increase in rail-passenger kilometres. However, car and rail are only partly overlapping markets. Cross-elasticities for car fuel prices are low (i.e. -0.1 or lower, see Geurs & Van Wee, 1997b). In the combined scenario it is assumed that the increase in rail passenger kilometres due to the shift from car use to rail use is offset by the reduction of transport over long distances. This means that the shift from car use to rail use because of higher generalised costs per car kilometre is compensated by higher generalised costs per rail passenger kilometre. If we assume a fuel-price cross elasticity of -0.1, rail use would increase by about 12% (fuel costs are assumed to increase by 115%). If the total amount of rail passenger kilometres is to remain at the business-as-usual level, this means a 15% increase of generalised costs per rail passenger kilometre, assuming a (rail-ticket) price elasticity of rail passenger kilometres of -0.8 (see Van der Waard, 1990).

Road freight transport

In the combined scenario it is assumed that the reduction of freight transport volume is the result of logistical and modal split measures, reduced transport distances for food and non-food related transport, and changes outside the transport sector resulting in lower production levels. Here, we assume that generalised cost increases for road freight transport are only necessary to achieve the logistical and modal split changes resulting in a reduction of CO_2 emissions (vehicle use) by about 46%, and that measures outside the transport sectors reduce production levels (e.g. more durable goods) and transport distances (e.g. more regional/local production and consumption of goods). If it is assumed that the generalised cost increase is the result of fuel-cost increases, fuel costs must highly increase to reduce lorry vehicle use by 46%. In general, price elasticities for lorry use strongly depend on assumed spatial and logistical adaptations of transport companies to price increases. In the Netherlands, lorry-use fuel-price elasticities are considered to be low, i.e. fuel-price elasticities lie between -0.02 and -0.2). Total price elasticities for lorry use are higher, i.e. between -0.1 and -1.3. (see for a review of price elasticities Geurs & Van Wee, 1997b; Bleijenberg, 1998). High price elasticities imply fairly high adaptation possibilities in the spatial patterns of the economy, modal shift changes and a decrease in demand. The relative high price elasticities of Oum *et al*. (1990) (i.e. between -0.7 and -1.3) seem plausible when very high cost increases are assumed. Given the share of fuel cost in the total transport cost (about 15%), the fuel price elasticity is about -0.20. Using this elasticity, a fuel-cost increase of about 230% is necessary to obtain a 46% reduction of lorry tonne kilometres.

Rail freight transport and inland shipping

Price increases in lorry use will result mainly in a reduction in the demand for freight transport. A shift to other modes (rail and inland shipping) will probably account for only 10 to 25% of the total lorry-use reduction (see Bleijenberg, 1998). If the same applies for the reduction of tonne kilometres of inland ships (i.e. about 27% reduction), generalised costs per rail freight tonne kilometre can remain constant, assuming an increase of rail freight tonne kilometres of about 385%.

In the combination scenario, inland shipping is assumed to decrease by 27%. Assuming a fare- price elasticity of -3.3 (NVI, 1986, in: De Wit and Van Gent, 1996), “generalised” costs per tonne kilometre of inland ships need to increase by about 8%. If the generalised cost increase is to be achieved by a fuel-cost increase, fuel cost must increase by about 50%, assuming a 15-20% share of fuel cost in the total cost[12]. Given the assumed fuel efficiency improvement of ships of about 20%, fuel prices for inland shipping would need to increase by about 65%.

Air transport

Generalised cost of air passenger transport needs to show a high increase to attain the assumed 76% reduction of air passenger transport. Recent model calculations show that a global fuel charge of about 50% of the fuel price reduces global scheduled passenger demand by about 4% and the passenger demand at Schiphol by 3% by 2010 (Beumer *et al.,* 1997a). Thus, the fuel-price elasticity of air passenger demand is very low (-0.06 to -0.08). This is mainly because fuel costs account for only 10% of the total global operating cost in the aviation industry. If a somewhat higher price elasticity is assumed for very high fuel price increases (i.e. -0.10), and if it is assumed that the generalised cost increase is only to be attained by fuel-cost increase, fuel costs would need to increase by about 760% to attain a 76% reduction in air passengers. However, the necessary fuel price increase is about twice the fuel-cost increase, as the fuel efficiency per air passenger kilometre is assumed to improve by 45%.

7.5 Change in transport market demand (level 3)

The changes in technology and behaviour are translated into changes in the categories of transport market demand by describing the percentage of change in passenger or tonne kilometres in the combined scenario compared to the BAU scenario. The total change in passenger and tonne kilometres per transport mode is derived from the scenario analysis (see Section 2.6.2). The contribution of instruments to the change of transport demand is derived from the contribution of instruments to non-technological changes from level 1 (Table 7.4.4). The result is given in Table 7.5.1.

[12] This share is given for marine transport by Beumer *et al.* (1997b).

Table 7.5.1: Contribution of instruments to the change of transport demand (passenger km or tonne km)

Policy instrument	Walking/ cycling	Light rail buses	Rail-passenger	Cars/ motorcycles	Railway freight	Inland shipping	Road freight	Air transport
	%							
pricing variable	50	0	0	-16	0	-7	-38	-38
pricing fixed	0	0	0	0	0	0	0	0
standards fuel	0	0	0	0	0	0	0	0
standards exhausts	0	0	0	0	0	0	0	0
standards noise	0	0	0	0	0	0	0	0
standards behaviour	30	102	0	-2	386	-13	-15	-19
efficiency gain	0	0	0	0	0	-7	-8	-19
land use	10	0	0	-2	0	0	-8	0
technology subsidy	0	0	0	0	0	0	0	0
investment alt. modes	10	0	0	-2	0	0	-8	0
education	0	0	0	0	0	0	0	0
total change of demand	100	102	0	-23	386	-27	-75	-76

7.6 Changes in affected markets (level 4)

On this assessment level the economic importance of transport-related markets (i.e. transport and storage sector, the industrial sector, and the retail trade and wholesale business sector) are described, using the economic indicators of production value, final demand and value added. The effects of technological and behavioural changes of the combined scenario (relative to the BAU scenario) on value added and final demand of affected market are also assessed.

7.6.1 Economic importance of transport-related sectors

The economic indicators for the business-as-usual scenario for 2030 are based an input-output table for the Dutch economy for 1990 taken from the Dutch Central Bureau of Statistics (CBS) and extrapolation of yearly growth factors of transport-related sectors for the economy for the period 1995-2020 from the Netherlands Bureau for Economic Policy Analysis (CPB, 1997) up to 2030[13,14]. The yearly economic growth factors are found halfway between two of

13 The value-added figures for rail passenger and rail freight are not presented separately in CBS statistics. The figures presented here are based on 1993 figures from the Dutch railways (NS, 1994), i.e. total value added is roughly estimated using figures on salaries, social expenses and subsidies. Furthermore, based on the 1993 revenue figures from the NS, it was assumed that passenger transport comprises 90% of total value added; freight transport 10%.

14 CPB (1997) does not give separate value added growth factors for vehicle categories within the transport sector. Here, the figures for total value added for road-freight and rail-freight are based on figures for value added per tonne kilometre from the trend scenario from Blok *et al.* (1993), respectively 25 and 5 Euro cent per tonne km. for 2030. Total value added for rail-passenger is assumed to be proportional to passenger kilometre growth (40% growth in BAU).

the scenarios from the CPB: European Co-ordination and Divided Europe[15]. Tables 7.6.1 and 7.6.2 give the production value, value added and final demand for the transport and storage sector, the trade and industry sector, and the retail trade and hotel business for 1990, as well as the business-as-usual scenario for 2030. Final demand is split into four categories, i.e. export of goods and services, household consumption expenditures, public consumption expenditures and investments.

Table 7.6.1: Production value and value added (billion Euro) in directly affected sectors in 1990 and the business-as-usual scenario (BAU) in 2030 (1990 prices)

	Production value		Value added	
	1990	BAU 2030	1990	BAU 2030
	billion Euro			
transport and storage sector	18.8	83.6	9.8	40.4
road-freight transport	5.9	30.1	3.9	24.2
rail-passenger transport	1.7	2.2	1.3	1.8
rail-freight transport	0.1	0.3	0.1	0.3
transport services	1.8	4.8	1.1	3.9
travel agencies	0.6	0.4	0.2	0.3
inland shipping	1.1	5.6	0.5	2.4
marine transport	3.8	20.1	1.6	1.9
aviation	3.8	20.0	1.0	5.7
trade and industry sector	13.5	31.2	4.6	9.3
car industry	4.3	10.6	1.0	2.0
other transport industry	4.1	10.1	1.2	2.5
car trade and repair	3.3	10.5	2.4	4.9
retail trade & hotels, restaurants	23.1	73.9	13.2	33.4
total Dutch economy	551.5	1268.4	213.8	530.3

15 The growth rates taken from these scenarios are in line with the growth rates of the earlier scenarios from the CPB (Global Shift and European Renaissance), which formed the basis for the transport scenarios (see Section 2.3).

Table 7.6.2: Final demand (billion Euro) in directly affected sectors in 1990 and the business-as-usual scenario (BAU) in 2030

Final demand	1990					BAU 2030				
	total	export	con-sump.	public expend.	invest-ments	total	export	con-sumpt.	public expend.	invest-ments
	billion Euro									
transport and storage sector	16.4	9.0	2.7	0.0	0.1	72.9	40.0	11.9	0.0	0.2
road-freight transport	5.3	2.2	0.1	0.0	0.0	26.3	10.9	0.5	0.0	0.1
public transport	1.4	0.0	1.4	0.0	0.0	1.9	0.0	1.9	0.0	0.0
rail-freight transport	0.1	0.1	0.0	0.0	0.0	0.3	0.2	0.0	0.0	0.0
transport services	1.7	0.7	0.0	0.0	0.0	4.2	1.7	0.0	0.0	0.0
travel agencies	0.3	0.1	0.3	0.0	0.0	0.4	0.1	0.3	0.0	0.0
inland shipping	0.9	0.4	0.1	0.0	0.0	4.9	2.2	0.4	0.0	0.0
marine transport	3.3	3.2	0.0	0.0	0.0	17.4	16.8	0.2	0.0	0.0
aviation	3.3	2.4	0.7	0.0	0.0	17.4	12.8	3.9	0.0	0.1
trade and industry sector	10.3	5.2	2.2	0.0	1.0	27.3	13.7	5.9	0.0	2.7
car industry	3.9	3.3	0.0	0.0	0.3	9.4	8.1	0.1	0.0	0.7
other transport industry	3.4	1.8	0.1	0.0	0.7	8.3	4.4	0.2	0.0	1.8
car trade and repair	3.0	0.0	2.1	0.0	0.0	9.6	0.0	6.7	0.0	0.0
retail trade & hotels, restaurants	20.5	0.0	6.0	0.0	0.2	65.6	0.1	19.2	0.0	0.7

7.6.2 Changes in value added in transport-related sectors

The estimated relative changes of value added in affected sectors are based on existing studies on the economic impact of heavy reductions in car use (Peeters, 1988) and lorry use (Peeters, 1993), and on assumptions on the relationships between value added, employment and transport volumes. On this assessment level, changes in value added are only direct value-added losses and do not include forward and backward linkages.

Passenger transport-related sectors

The relative changes in value added for passenger transport-related sectors for the combined scenario relative to the business-as-usual scenario are estimated for the following sectors: (i) car industry, (ii) car trade and repair, (iii) public transport, (iv) transport services, (v) travel agencies and (vi) aviation. Assumptions are:

- The change in value added in the car industry for the combination scenario - relative to the business-as-usual scenario - is assumed to be proportional to car ownership changes. As the car-ownership price elasticity is considered to be half the price elasticity for car use, car ownership is reduced by 25% for the car industry as is value added.

- The change in value added for the car-trade sector is assumed to be proportional to car-ownership changes, for the car-repair sector proportional to car-use changes. Totally, it is assumed that value added for the car-trade and repair sector will be reduced by 35%;
- Changes in value added for public transport is assumed to be proportional to the changes of rail passenger kilometres. As the number of passenger kilometres in the combined scenario is assumed to be the same as in the business-as-usual scenario, value added is assumed to be the same as the BAU level.
- Changes in value added for travel agencies is assumed to be related to car use, air travel and home holidays. It is assumed that value added losses due to less air travel is partly compensated by more holidays on Dutch territory. Total value added loss is assumed to be 50%.
- Change in value added for the aviation industry is assumed to be proportional to changes in the number of passengers at Amsterdam Airport Schiphol. Total value-added loss is assumed to be 76%.

Freight transport-related sector

The relative changes in value added for freight transport-related sectors are estimated for the following sectors: (i) road-freight transport, (ii) rail-freight transport, (iii) marine transport and inland shipping, and (iv) transport vehicles industry. Assumptions are:

- Changes in value added for the road-freight transport sector for the combination scenario relative to the business-as-usual scenario is assumed to be more than proportional to the changes in tonne kilometres. This assumption is based on the economic assessment of the trend-breach scenario for freight transport (Blok *et al.*, 1993). According to Blok *et al.* a logistical optimisation of road transport (i.e. using one large vehicle rather than a number of small vehicles, increasing capacity utilisation and reducing trips with empty vehicles) will result in higher transport cost and thus physical distribution costs per tonne kilometre (mainly because of increased average transit and waiting times). Therefore lower production values per tonne kilometre road freight transport will result in lower employment level per tonne kilometre and finally in less value added per tonne kilometre. For the combination scenario value added per road freight tonne kilometre (0.25 guilder per tonne kilometre) is assumed to equal the 1990 level, which is more than half the BAU level (0.55 guilder per tonne kilometre). The total number of road freight tonne kilometres is reduced by 75%; total value added for road freight transport by about 90%.
- Change in value added for the rail-freight sector is assumed to be more than proportional to the change of tonne kilometres, i.e. value added per rail-freight tonne kilometre is assumed to be the same as for road freight (0.25 guilder per tonne kilometre) which is more than for BAU (0.1 guilder per tonne kilometre). This is mainly because of assumed higher transport prices per tonne kilometre (higher service level) and more labour-intensive rail transport (smaller units). Total rail-transport tonne kilometres increase by almost 290%, total value added almost factor 10.

- Change in value added for inland shipping and marine transport is assumed to be proportional to the change in tonne kilometres. Inland shipping and marine transport tonne kilometres are reduced by 27% and 80% respectively, thus values added are reduced by 27% and 80%, respectively.
- Changes in value added of transport services (storage companies, shipping agents) are assumed to be proportional to lorry-use changes. Total value added loss for transport services is assumed to be 89%.

Retail trade & hotels and restaurant business

It is assumed that domestic retail business profits from the assumed changes in activity patterns and a higher consumption level. In the combination scenario people’s activity patterns are confined to shorter distances, which will result in a scaling-down of retail businesses (e.g. more neighbourhood shops) and thus in more employment and value added in the retail business. Furthermore, retail business and the hotel and restaurant sector will profit from higher consumption budgets, i.e. people will save money on their total travelling budget as they travel less, assuming the same level of savings, and are therefore likely to spend more money in the retail sector. Here, we assume the same 10% value-added gain for the retail business and hotel and restaurant business as in the German case study (see Rothengatter, 1998).

Results

Table 7.6.3 gives the changes of value added in the directly affected sectors of the economy. The table shows that the total value added for the transport and storage sector is reduced by more than 70%, for the trade and industry sector more than 45%. Furthermore, the table shows that the total value-added loss in the freight-transport sector (about 75%) is more than proportional to the total tonne kilometre reduction (about 44%). This is because value-added losses in the road-freight transport sector due to a shift from road transport to rail and inland shipping cannot be compensated by value-added gains in the rail and inland shipping sector because rail and inland shipping are less labour-intensive transport modes.

Furthermore, the total value added loss of transport-related sectors is less than for the transport sector and for transport-related industry because of value-added gains in the retail sector.

Table 7.6.3: Change in value added (billion Euro) for the combination scenario relative to the BAU scenario for the sectors directly affected for 2030

	1990	BAU 2030	Combination scenario 2030	% Reduction EST3/BAU
	billion Euro			
transport and storage sector	9.8	40.4	11.3	-72%
road-freight transport	3.9	24.2	2.7	-89%
public transport	1.3	1.8	1.8	0%
rail-freight transport	0.1	0.3	2.7	894%
transport services	1.1	3.9	0.4	-89%
travel agencies	0.2	0.3	0.2	-50%
inland shipping	0.5	2.4	1.8	-27%
marine transport	1.6	1.9	0.4	-80%
aviation	1.0	5.7	1.4	-76%
trade and industry sector	4.6	9.3	4.9	-47%
car industry	1.0	2.0	1.5	-25%
(other) transport vehicles industry	1.2	2.5	0.3	-87%
car trade and repair	2.4	4.9	3.2	-35%
retail trade, hotels, restaurants	13.2	33.4	36.7	10%
total transport	14.4	49.8	16.2	-67%
total transport and retail trade	27.5	83.1	52.9	-36%
share of transport in GDP	7%	9%	3%	

The changes in final demand were derived from the changes in value added per transport mode, assuming that changes in consumption, investment, public expenditures and exports are proportional to the changes in valued added. The changes in final demand are estimated for the following economic sectors: road-vehicle manufacturers, railway industry, airline industry, other transport business (i.e. road-freight transport, transport services, marine transport and inland shipping, and car trade and repair), and retail and wholesale business. The table shows that the share of value added for the transport sector (i.e. transport and storage and transport-related trade and industry) in GDP decreases from 9% for BAU to 3% for the combination scenario.

Table 7.6.4 gives the Gross Production Values and final demand for the BAU scenario for 2030 (derived from Tables 7.61 and 7.6.2), the percentage of change in value added for the combination scenario relative to the BAU scenario, and the absolute change in final demand for the combination scenario relative to BAU scenario. The table shows that the value added reductions of the directly affected transport sectors result in - ceteris paribus - a 6% loss of GDP for the combination scenario compared to business as usual.

Table 7.6.4: Production value, final demand and change in value added, and final demand, in affected economic sectors by 2030 (billion Euro)

	Road vehicle manufacturers	Railways	Airline + marine industry	Tourist industry	Other transport business	Retail business	% change GDP
Gross Production Value	21	51	3	40	0	74	
final demand	18	45	2	35	0	66	
% change in value added	-60%	119%	-77%	-50%	-77%	10%	-6%
change - consumption	0	-6	2	-3	0	2	
change - investment	-2	0	0	0	0	0	
change - publ.expend.	0	0	0	0	0	0	
change - net exports	-8	-11	0	-23	0	0	
change - final demand	-9	-17	3	-26	0	2	

7.7 Changes in macro-economic indicators (level 5)

On level 5 of the Impact Path Analysis, the macro-economic impact of the combination scenario relative to the BAU scenario is estimated for three macro-economic indicators, i.e. national income, production value and employment. The macro-economic impacts are calculated in a two step procedure. The first step is to derive macro-economic impacts assuming the economic structure will not be changed (Section 8.7.1). In the second step structural changes due to technological progress are considered (Section 8.7.2).

7.7.1 Macro-economic changes without structural changes

Changes in national income, production values and employment are calculated using multiplier effects for the production values and changes in final demand from level 4, employment figures for BAU, and multiplier effects for the sectoral changes of the production values.

The total change in the national income can be calculated using a multiplier formula from national econometric analysis, i.e. a multiplier for the relationship between final demand and national income. The multiplier depends on the level of unemployment and could vary between 1.2 and 1.6 (Rothengatter, 1998). A multiplier of 1.32 is derived from the input-output table for the Dutch economy for 1990[16].

The sectoral changes in production values are derived using a multiplier for the direct and indirect effects, thus incorporating forward and backward linkages of transport-related sectors

16 The multipliers can be interpreted either as a Keynesian multiplier assuming permanent underemployment, or as a spatial competition multiplier (in terms of new economic geography) assuming full employment.

to all other sectors of the economy (see Table 7.7.1). The multipliers are derived from Rothengatter (1998).

Table 7.7.1: Multipliers in production values for the sectoral changes

	Road veh. manufact.	Railways	Airline industry	Tourist industry	Other. transp. business	Local business
Gross Prod. Value (GPV) direct	1.33	1.74	1.88	1.63	2.08	1.10
Gross Prod. Value dir.+ indirect	2.50	2.18	2.20	2.18	2.75	1.61

Source: Rothengatter (1998)

However, using the multipliers from Table 7.7.1 results in an overestimation of the direct and indirect economic effects of the assumed freight transport changes, because in the calculation of the value added changes for the freight transport sector it is assumed that changes of value added are more than proportional to changes in transport volumes (i.e. tonne kilometres). This implies that part of the multiplier is already assumed and it is not justified to use the full multiplier a second time. Therefore, the macro-economic impacts are also calculated for a multiplier variant assuming no multipliers for the freight transport sector. As this variant will probably give an underestimation of the economic impact of the changes of the freight transport sector on the total economy, the results will be presented as a bandwidth.

Total employment for the BAU for 2030 is calculated by extrapolation of yearly employment growth factors for the period 1995-2020 up to 2030. The yearly economic growth factors are taken halfway between two of the scenarios from the CPB (CPB, 1997): European Co-ordination and Divided Europe. Table 7.7.2 shows the employment for the transport and storage sector, trade and industry sector, retail trade and wholesale business and the total Dutch economy for 2030.

Finally, labour productivity is derived from the sectoral changes of national income and sectoral employment (change in national income/employment ($*10^6$)), and the change in employment in the transport-related sectors is derived from the changes in production values and labour productivity (change in Gross Production Value direct + indirect / labour productivity $* 10^6$). The results are given in Table 7.7.3.

Table 7.7.2: Employment figures for transport-related sectors and the total Dutch economy for 1995 and the BAU scenario for 2030

	1990	1995	BAU 2030
	(*1000)		
total transport and storage sector		300	343
public transport		52	62
rail-freight transport		4	4
road-freight transport		126	150
transport services		53	63
travel agencies		21	25
marine transport and inland shipping		16	15
aviation		27	24
total trade and industry sector		179	171
car industry		26	15
other transport industry		30	17
car trade and repair		123	139
total retail trade and wholesale business		863	976
total transport		479	514
total transport and retail trade		1342	1489
total Dutch employment	5454	5872	7115

Table 7.7.3: Change in macro-economic indicators

		Road vehicle manufct.	Other transp. busin.	Rail-ways	Airline + marine industry	Tourist industry	Local busi-ness	Total	% change Dutch economy
total change national income	bln Euro	-12	-26	3	-35	-0.5	3	-63	-7%
Full multipliers									
change GPV direct	bln Euro	-16	-48	5	-49	-0.5	2	-107	-8%
change GPV dir. + indirect	bln Euro	-30	-63	7	-75	-0.5	4	-159	-12%
employment	thousands	32	367	62	24	25	976	1485	
labour productivity	million	1418	307	90	362	38	167	5638	
change employment	thousands	-47	-453	178	-46	-31	56	-344	-5%
Multiplier variant									
change GPV direct	bln Euro	-12	-23	3	-49	-0.5	2	-80	-7%
change GPV dir. + indirect	bln Euro	-12	-23	3	-75	-0.5	4	-104	-10%
employment	thousands	32	367	62	24	25	976	1485	
labour productivity	million	1418	307	90	3616	38	167	5637	
change employment	thousands	-19	-165	82	-46	-31	56	-152	-2%

Table 7.7.3 shows that the total loss of Gross Production Value (GPV), including direct and indirect effects, is about 10 to 12% of the total GPV for the Dutch economy. Total employment loss is reduced by about 150 to 345 thousand jobs, about 2-5% of total Dutch employment in 2030. The largest employment loss is in the other transport business sector (i.e. road-freight transport, transport services and inland shipping, and car trade and repair)

mainly due to the large activity reductions for the road-freight transport sector and marine transport and inland shipping sector, which account for more than 35% of total employment in the transport sector. The percent reduction of employment is lower than the percent reduction of GPV, which indicates that production is shifted from sectors with high labour productivity to sectors with lower labour productivity.

7.7.2 Macro-economic impacts assuming structural changes

The macro-economic impacts from the first step of the assessment (without structure changes of the economy) are very pessimistic: the assessment does not include induced effects of environmental policies on changes in technology. According to Rothengatter (1998) positive side impacts can be expected: technical progress can be fostered to save resources for production or the income from ecological taxation can partly be used to reduce labour costs. These dynamic feedbacks can probably result in the long term in a strict environmental policy in harmony with employment policy goals.

The feedback between the change of transport technology and the production value and employment on the national level is calculated as follows. The development of the gross production value (GPV) from 1990 up to 2030 is calculated by a production function (a standard Cobb-Douglas function) using values of: (a) employment and labour productivity, (b) total capital stock, (c) the rate of technological progress, and (d) the share of new vehicle technology of the total capital. Here, the values are shortly described.

The value for labour productivity for 1990 is based on total GPV for 1990 (551 billion Euro) and total Dutch employment (5,454 million people). Total capital stock is a monetary value for the total Dutch physical environment, comprising the produced and non-produced assets. For 1990, the total capital stock including infrastructure and vehicles, was 960 billion Euro (RIVM, 1998b). The values for the rate of technological progress (0.0110 for 1990 up to 0.0113 for 2030) and for the share of vehicle technology in total capital (0.25 for 1990 up to 0.5 for 2030) for the combination scenario are taken from Rothengatter (1998). The technological adjustment path for the period 1990-2030 is assumed to be linear, although a logistic curve would probably be better.

Finally, the changes in employment can be derived by dividing the GPV by the labour productivity. Table 7.7.4 gives the results.

Table 7.7.4: The dynamic production analysis

	Evaluation of Production Dynamics									2030
	Year 5	Year 10	Year 15	Year 20	Year 25	Year 30	Year 35	Year 40	grate	change
yearly technological progress	0.0110	0.0111	0.0111	0.0112	0.0112	0.0113	0.0113	0.0113		
labour productivity	222772	252046	285167	322641	365038	413007	465005	523549	1.02	
capital (billion Euro)	960	1060	1170	1292	1426	1575	1738	1920	1.02	
production (billion Euro)	551	624	705	198	904	1026	1163	1321	1.03	770
employment (thousands)	5454	5451	5450	5452	5459	5471	5515	5.563	1.00	109
share of technology in capital									0.25	

The result of the dynamics in the production structure is a gain of roughly 110 thousand jobs. Thus, the net loss of jobs for the combination scenario compared to the business-as-usual scenario comes out 30 to 70% lower: about 45 to 235 thousand, which is about 1-3% of total Dutch employment for the BAU scenario for 2030, distributed over a time period of 40 years.

If we assume that total value added losses are also offset by 30% to 70%, the total loss of GDP including direct and indirect effects and production structure changes, is about 4-8% of the Dutch GDP for the BAU scenario for 2030, distributed over a time period of 40 years. This means that GDP *growth* for the combination scenario is somewhat lower than for business-as-usual: the average yearly GDP growth for the combination scenario for the period 1990-2030 would be about 1.9 to 2.0% compared to 2.1% for the business-as-usual scenario.

The use of a more sophisticated evaluation methodology could reveal further positive effects of production structure changes, which might further lessen the negative effects of EST for employment.

7.8 External cost savings (level 6)

The assessment of the economic impact of the combination scenario given above is based on the statistics of national accounts and gives an indication of differences in material welfare. However, economic indicators based on national accounts do not give a complete representation of overall welfare because non-material welfare is not included, i.e. the human and environmental capital. Here, we give an estimation of monetary external cost savings of the combination scenario - relative to the business-as-usual scenario - as an indication of the value of the non-material welfare. Several studies give monetary values for several external costs from transport, (Dikmans *et al.*, 1996; Bleijenberg *et al.*, 1994; INFRAS/IWW, 1995; IWW *et al.,* 1998). The following external costs for transport are considered: costs of climate change (i.e. CO_2 emissions from the transport sector), air pollution (i.e. NO_x -, VOC- $PM_{10,}$ SO_2 emissions from transport), noise from cars, lorries and aircraft, accidents and congestion.

It must be noted that the estimated external costs of transport are no more than a rough indication and are probably underestimated, i.e.

1. Evaluation very much depends on the methodology used and the appraisal of external costs (e.g. the cost of a heavy injury, the cost of climate change);
2. Several externalities are difficult to express in monetary values and are normally excluded in current studies, e.g. the external costs of direct and indirect land use, loss of landscape, ecological disturbance and waste. The external cost of indirect land use is probably significant, e.g. costs of restricted possibilities in land use and lower housing prices due to noise nuisance. As an illustration: in 1996 about 7,2% of total Dutch surface experiences noise levels above 50 dB(A) caused by road traffic (only) on the main road network (V&W, 1998), where the direct land use of the main road is roughly about 0.3% of total Dutch surface;
3. Some externalities are only partly monetary evaluated, i.e. in current Dutch congestion cost studies only congestion costs on the Dutch main road network (motorways and other main rural roads) are calculated. However, congestion costs on minor roads are probably also significant, i.e. Flikkema *et al.* (1998) state that the number of lost vehicle hours on the minor road network probably equals the number of lost vehicle hours on the main road network.

Here, we shortly describe the assumptions for the monetary evaluation of external effects. In general, the external cost savings are estimated by multiplying cost factors - taken from literature - with the difference in emissions, passenger or tonne kilometres between the combination scenario and the business-as-usual scenario (BAU) for 2030.

Cost factor assumptions:

- Cost factors for CO_2, NO_x, VOS and SO_2 emissions (in Euro/kg), and noise from cars and lorries (in Euro per passenger and tonne kilometre) and taken from Bleijenberg *et al.*

(1995), who give an overview of cost factors from Dutch and foreign studies. The cost factors are classified into low, middle and high estimates;

- Cost factors for PM_{10} emissions are taken from IWW *et al.* (1998);
- Cost factors for aircraft noise are taken from INFRAS/IWW (1995);
- Cost factors for accidents are derived by dividing the total costs of accidents (e.g. production loss, medical costs)) for cars and lorries for 1993 (Dikmans *et al.,* 1996) by the number of car and lorry vehicle kilometres driven in 1993. We assume that accident costs are related to the number of vehicle kilometres.
- Congestion costs for motorways and other roads on the main network for 2030 are derived from the congestion cost per lost vehicle hour on motorways and other main roads for 1996 from NEA (1997) multiplied by the total number of lost vehicle hours for the business-as-usual scenario for 2030. The congestion costs per lost vehicle are classified into a low, middle and high estimate depending on their value of time[17]. The total lost vehicle hours for BAU for 2030 (in 1990 prices) are assumed to equal the Global Competition scenario for 2020 (AVV, 1997c) which has a similar level of car use.

Total cost reduction assumptions

- The total emission reduction for the combination scenario relative to the BAU scenario is the sum of the emission reductions due to a lower level of vehicle use (direct emissions) and a lower level of vehicle production (indirect emissions). Indirect CO_2 emission factors for cars, rail passenger and rail freight transport, road freight and inland shipping for 1990 are taken from Bos and Moll (1997). Average indirect CO_2 emissions per passenger and tonne kilometre are about 4% of total direct emissions per kilometre for 1990. We assume total BAU scenario emissions for 2030 to be 4% higher than the direct BAU emissions;
- No congestion costs are assumed in the combination scenario because of the reduction of car and lorry use compared to the BAU scenario (50 and 85% respectively). A reduction of congestion is more than proportional to the reduction of car use, i.e. 1% reduction of car use reduces congestion on motorways and other main roads on the Dutch road network by 2-5% (CPB, 1998).

Table 7.8.1 gives the result of the monetary evaluation of external effects considered. Total external cost savings for the combination scenario for 2030 add up to about 6 to 23 billion Euro, which is roughly between 12 and 40% of total added value of the transport sector and about 1 to 4% of Dutch GDP in 2030. Concluding, the total non-material cost savings do not fully add up to the total material welfare losses (i.e. about 4-8% loss of GDP).

[17] An average value of time for the low, middle and high estimate is derived from NEA (1998): 9.5, 16 and 24 Euro per hour respectively (1996 prices)

Table 7.8.1: External cost savings (billion Euro) for the Combination scenario compared to the business-as-usual scenario

		cost factor	primary source	BAU-EST3	cost reduction
		(Euro/tonne)		(ktonne)	(Euro * billion)
CO_2	low	18	T&E, 1993	43267	1.0
	middle	50	CE, 1994	43267	2.8
	high	222	Prognos, 1992	43267	12.5
NO_x	low	817	Planco, 1990	227	0.3
	middle	4266	T&E, 1993	227	1.3
	high	5445	UPI, 1993	227	1.7
VOC	low	545	UPI, 1993	87	0.1
	middle	4266	T&E, 1993	87	0.4
	high	6262	Planco, 1990	87	0.6
PM_{10}	low	25873	IWW, 1998	16	0.6
	middle	25873	IWW, 1998	16	0.6
	high	25873	IWW, 1998	16	0.6
SO_2	low	363	Planco, 1990	18	0.0
	middle	908	CE, 1994	18	0.0
	high	3131	UPI, 1993	18	0.1
		(Euro/pkm*1000)		(billion pkm)	
noise from cars	low	0.3	Quinet, 1989	42	0.0
	middle	1.4	T&E, 1993	42	0.1
	high	1.8	Dikmans, 1996	42	0.1
		(Euro/tkm*1000)		(billion tkm)	
noise from lorries	low	2.1	T&E, 1993	73	0.2
	middle	5.2	Quinet, 1989	73	0.4
	high	9.9	Dikmans, 1996	73	0.7
		(Euro/pkm)		(billion pkm)	
noise from aircraft	low	0.013	Infras/Iww, 1995	81	1.1
	middle	0.013	Infras/Iww 1995	82	1.1
	high	0.013	Infras/Iww, 1995	83	1.1
		(Euro/vkm)		(billion vkm)	
accidents by car	low	0.014	Dikmans, 1996	70	1.0
	middle	0.017		70	1.2
	high	0.021	Dikmans, 1996	70	1.4
accidens by trucks	low	0.022	Dikmans, 1996	35	0.8
	middle	0.027		35	1.0
	high	0.033	Dikmans, 1996	35	1.1
		Euro*billion			
congestion	low	1.3	NEA, 1996; AVV, 1997c		1.3
	middle	2.0	NEA, 1996; AVV, 1997c		2.0
	high	2.9	NEA, 1996; AVV, 1997c		2.9
total	*low*				*6.2*
	middle				*10.8*
	high				*22.9*

7.9 Conclusions

To assess the economic impact of the combination scenario, an Impact Path Analysis (IPA) was developed by the University of Karlsruhe (Rothengatter, 1998). In the IPA the assessors follow the chain of impacts level-by-level through the economic system to finally end up with aggregate macro-economic indicators, which indicate the order of magnitude of economic changes. Using the IPA only, the effects on material welfare can be calculated, i.e. an improvement of non-material welfare (quality of life) is not included. The IPA is restricted to the directly affected sectors of the economy (i.e. road-vehicle manufacturers, secondary car business and transport services, railways, airline industry, tourist industry and retail business), but includes multiplier effects to incorporate forward and backward linkages. From the IPA analysis it can be concluded that:

- The economic impact of the combination scenario within the transport sector - relative to the business-as-usual situation - is large. Value added and employment for the transport and storage sector, and road-vehicle industry, is sharply reduced and can not be compensated by value added and employment increases for the railway industry and local business;
- In a pessimistic estimation of the economic impact where no dynamic changes of the economic structure are assumed, the total loss of GDP in the combination scenario relative to the business-as-usual scenario, including interdependencies with other sectors of the economy, is roughly about 10-12%, the loss of total Dutch employment about 2-5%.
- Including dynamic changes of the economic structure, the total loss of GDP is about 4-8%, the total loss of employment about 1-3%. The average yearly GDP growth for the combination scenario for the period 1990-2030 would be about 1.9 to 2.0% compared to 2.1% for the business-as-usual scenario.

The non-material value of the combination scenario is calculated by estimating the external cost savings for air pollution, noise, traffic accidents and congestion in monetary terms. Total monetary external cost savings for the combination scenario compared to the BAU scenario are about 1 to 4% of the Dutch GDP in 2030. These figures are probably an underestimation of the total non-material value because the external costs of direct and indirect land use, loss of landscape, ecological disturbance and waste are not incorporated. However, the estimation of the external cost savings show that the total loss of material welfare (GPV, GDP) can be largely - but probably not fully - compensated by reduction of external costs.

Summing up, implementation of EST will have significant macro-economic impacts, but – according to the IPA method - it does not mean a total collapse of the economy: the average yearly GDP growth in the EST scenario will be some tenths of percent points lower than the business-as-usual scenario, the total Dutch employment level will be a some percent points lower in 2030. The total loss of material welfare for the year 2030 can be largely - but probably not fully – be compensated gains in non-material welfare (i.e. reductions of external costs).

7.10 Discussion of the results

The IPA method is a relatively pragmatic approach for assessing the economic impact of EST compared to BAU. The macro-economic impacts resulting from the IPA method are probably an overestimation of the economic impacts because of the following reasons.

a) to reduce complexity, it is (implicitly) assumed that the transport sector is the only sector striving for environmental sustainability, i.e. other sectors of the economy do not change. However, if other sectors of the economy also strive for a sustainable development (e.g. resulting in lower transport demand in industrial sectors) it can be expected that the *relative* economic impact of changes in the transport sector on the Dutch economy will be lower;
b) structural changes and dynamic adjustments of the economy as a result of the changes in the transport sector envisaged by EST can only be partly handled in the IPA method. A methodology which is able to handle these changes in a better way (such as a System Dynamics Model) will probably give a lower estimation of the economic impact of EST for the Netherlands - see the German OECD study (UBA, 2000) in which both the IPA method and a System Dynamics Model are used to estimate the economic impacts of the German EST scenarios (Box 7.1);
c) the generalised cost increases per kilometre assumed to attain the mobility changes are probably overestimated, which would probably result in an overestimating of the macro-economic impacts for the transport sector. In the combination scenario, the assumed system of tradeable CO_2 emission permits largely determines the transport costs per kilometre per mode. Fleming (1997) states two reasons why in practice a transport price resulting from tradeable permits would be substantially lower than the prices that would have to be set by carbon taxes to deliver the same emission reduction, although in an equilibrium world of economic theory the price which delivers a given quantity would be the same, i.e. (i) the price of allocation to consumers is zero and would make a very large contribution towards keeping to a minimum rise in prices developing as a result of the permit system, and (ii) the permit system would be able to make full use of “false expectations” of price, i.e. a forecast for a price for an emission permit for example in 10 years time would be the incentive for the market te respond by accelerating its energy efficiency programme and reducing its CO_2 emissions, so that the price that developed at the end of the 10 year period may turn out to be substantially less than expected;
d) it can be expected that marginal economic benefits of increasing car use levels decrease, i.e. a study on 37 world metropolitan regions from the Worldbank (Kenworthy *et al.*, 1997, cited in Litman, 1999) suggests that beyond a certain level of annual vehicle use per capita increased economic costs outweigh marginal economic benefits. Litman (op. cit.) concludes that the economic data from the various regions suggests that a high level of

(car) mobility reduces (regional) economic developments by increasing transport costs, particularly since investments in road infrastructure divert large amounts of private and public capital from alternative uses that are more economically productive. This could imply lower economic effects from reduced car use as assumed for the combined scenario.

Box 7.1: Economic impacts of EST for the German case study

In the German country study of the OECD project on Environmentally Sustainable Transport (UBA, 2000), the economic impacts of the EST scenarios are estimated using two methods developed by the University of Karlsruhe: (1) the Impact Path Analysis (IPA) and (2) a *Model for Economic Assessment of Sustainability poliCies Of Transport (ESCOT)*. The ESCOT model is a system dynamics model (SDM) which estimates the macroeconomic development of the business-as-usual (BAU) and the combination scenario (EST3) including long-term secondary effects, i.e. technological developments due to increased demand for a specific transport mode, changes in state revenues, changes in private consumption. The ESCOT model is a complex model consisting of five (interdependent) sub-models: (1) a macro-economic model describing national economic developments (e.g. national income), (2) a regional economic model disaggregated into 9 region types and 12 economic sectors, (3) a transport model for the estimation of transport activities disaggregated into mode (road, rail, water, air), (4) an environmental model for the estimation of transport emissions and their externalities, and (5) a policy model describing the policy interventions.

The macroeconomic impacts of the German EST scenario (relative to BAU) estimated by the ESCOT model are lower than those derived from the IPA method. The ESCOT model estimates a decrease in GDP when policy measures are introduced (about the year 2004), but this negative effect is smoothened on the longer term, i.e. GDP almost equals the BAU level around the year 2030. Furthermore, the employment level for EST is 1% lower in 2030 and the level of productivity is 2.8% higher because of an increase of the rate of technological progress. The IPA method gives more negative results: GDP in EST is about 3-4% lower in 2030 than in BAU, the employment level about 1.5% lower and productivity is about 2.5% higher. In conclusion, the system dynamics model shows that the short-term negative economic impacts (after policy instruments are introduced) can be compensated on the longer term by structural changes of the economy and dynamic developments - which are not (well) considered in the IPA method.

The macroeconomic impacts of the German EST scenario estimated by the IPA method are lower than for the Netherlands' EST scenario. Although the economic structure and labour productivity of the German economy are not too much different from the Dutch economy, the loss of employment (1-3%) and GDP (4-8%) are higher. This is primarily because the production losses in the Dutch road haulage industry generate more employment reductions per unit of gross value added compared to the production losses in the German vehicle manufacturing industry (Rothengatter, 1998).

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9. Prof. Dr P. Nijkamp - Vrije Universiteit Amsterdam
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13. Prof. Drs J.G. de Wit - UvA

14. Prof. J. Adams - University College London
15. Prof. Dr D. Banister – University College London
16. Prof. Dr Eng. Y. Hayashi - Nagoya University Japan
17. Prof. S. Proost – Katholieke Universiteit Leuven
18. Prof. Dr F. Ramjerdi - Royal Institute of Technology, Sweden
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20. Prof. I. Salomon – Hebrew University, Israel
21. Prof. D. Shefer – Technion-Israel Institute of Technology, Israel
22. Prof. P. Steen – Stockholm University, Dep. of Systems Ecology, Sweden
23. Prof. Dr. K. Steininger – University of Graz, Austria
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Appendix 2 Assessment of individual instruments

No.	Feature	Instrument	Effect			Impact inside			Impact outside			Macro-econ.		Links	Advantages/disadvantages of
						transp. system			transp. system			impact			implementing the instrument
			Activity	Unit impact	Cost-effectiveness	Vehicles	Fuels (mix)	Infrastructure	Land-use	Social and other activities	Psychological impact	Employment impact	Other impacts		
1	reduction of long distance transport by car and rail	pricing instr.: fuel prices, road pricing	+	+	++	+	0	+	+	++	++	-/0	-/+	A	adv: short-term effect, raises revenues dis: large increases required for an effect
		land-use instr. to promote scaling-down, e.g. public health services	+		0/+	+	0	+	+	+	+	-/0	-/+	A	adv: reduction at source dis: small separate effect
		education, information	+		+	+	0	+	0	0	+	0	0	A	adv: flanking policy, package instrument dis: small separate effect
2	shorter distances between activities in order to reduce car vkm	spatial planning (houses, labor, retail, recreations etc.)	+		0/+	0	0	0	++	0	0	-/0	-/+	A	adv: reduction of car use at source dis: long-term effects
		housing market	+		+	0	0	0	+	0	0	-/0	-/+	A	adv: reduction of car use at source dis: long-term effects
		employment market	+		+	0	0	0	+	0	0	-/0	-/+	A	adv: reduction of car use at source dis: long-term effects
		education, information	+		+	+	0	+	0	0	+	0	0	A	adv: flanking policy, package instrument dis: small separate effect
3	shift from car use to rail (longer distances)	pricing instr.: fuel prices, road pricing	+	+	++	+	0	0	+	++	++	-/0	-/+	A	adv: short-term effect, raises revenues dis: large increases required for an effect
		regulating CO2 emissions per capita	++	+	++	++	0	0	+	++	++	-/0	-/+	A/I	adv: short-term effect, cost-effectiviness
		spatial planning	+		0/+	0	0	0	++	0	0	-/0	-/+	A	adv: reduction of car use at source dis: only long-term effects
		infrastructure policy: less car infrastructure, more rail infrastructure	+		-/0	0	0	++	0/+	0	0	0	-/+	A	adv: short-term effect
4	shift from car use to non-motorised or to zero-emission modes	pricing instr.: fuel prices, road pricing	+	+	++	+	0	0	+	++	++	-/0	-/+	A	adv: short-term effect, raises revenues dis: large increases required for an effect
		regulating CO2-emissions per capita	++	+	++	++	0	0	+	++	++	-/0	-/+	A/I	adv: short-term effect, cost-effectiviness
		spatial planning	+		0/+	0	0	0	++	0	0	-/0	-/+	A	adv: reduction of car use at source dis: only long-term effects
		infrastructure policy, e.g. car free urban areas	+		-/0	0	0	+	0/+	0	0	-/0	-/+	A	adv: reduction of car use at source dis: only long-term effects

No.	Feature	Instrument	Effect			Impact inside transp. system			Impact outside transp. system			Macro-econ. impact		Links	Advantages/disadvantages of implementing the instrument
			Activity	Unit impact	Cost-effectiveness	Vehicles	Fuels (mix)	Infrastructure	Land-use	Social and other activities	Psychological impact	Employment impact	Other impacts		
5	the use of conventional moped/ motorcycle is reduced by 75%	pricing instr.: fuel prices, road pricing	+	+	++	+	0	0	0	++	++	-/0	-/+	A	adv: short-term effect, raises revenues dis: large increases required for an effect
		regulations to reduce attractive-ness of mopeds/motorcyles	+	+	+	+	0	0	0	0	+	-/0	-/+	A	adv: reduction at source dis: small separate effect
6	CO2 emissions from air passenger and goods transport are reduced by 87%	pricing instr.: fuel prices, ticket taxes	+		++	0	0	0	0	0	++	-	-/+	A	adv: flanking policy, package instrument dis: small separate effect
		regulating CO2-emissions per capita	++		++	+	0	0	0	++	++	-	-/+	A/I	adv: short-term effect
		regulating CO2-emissions from goods transport	++	+	++	+	0	+	0	0	0	-	-/+	A/I	adv: short-term effect, cost-effectiviness
		rigid airships		+	-/0	+	0	+	0	0	0	0/+	-/+	A	dis: only 'short' distance trips
		information technology to reduce long-distance air passenger transport	+		+	0	0	0	0	0	0	-/0	-/+	A	adv: flanking policy, package instrument dis: small separate effect
7	shift to local food production to reduce average transp. dist.of food related transport by 40%	pricing instruments: fuel prices, road pricing	+		++	+	0	0	0	++	++	-/0	-/+	A	adv: short-term effect, raises revenues dis: large increases required for an effect
		education/information: consuming local goods	0/+		0	0	0	0	0	0	0	0	0	A	adv: flanking policy, package instrument dis: small separate effect
		CO2 regulation of goods transport	++		++	++	0	+	+	+	+	-/0	-/+	A/I	adv: short-term effect, cost-effectiviness
8	shift to local (non-food) production to reduce average transp. dist. of non-food related transp. by 25%	pricing instruments: fuel prices, road pricing	+		++	+	0	0	0	++	++	-/0	-/+	A	adv: short-term effect, cost-effectiviness
		education/information: consuming local goods	0/+		0	0	0	0	0	0	0	0	0	A	adv: flanking policy, package instr. dis: small separate effect
		CO2 regulation of goods transport	++		++	++	0	+	+	+	+	-/0	-/+	A/I	adv: short-term effect, cost-effectiviness
9	measures to reduce the produced volumes (non-food) by 42%	pricing instr.: taxes on non durable goods; waste	+		++	+	0	0	0	++	++	-/0	-/+	A	adv: short-term effect, raises revenues dis: large increases required for an effect
		measures to reduce industrial emissions	+			+	0	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.
		education/information: consuming less and durable goods	0/+		0	0	0	0	0	0	0	0	0	A	adv: flanking policy, package instrument dis: small separate effect
		education, information		+	+	+	+	0	0	0	+	0	0	I	adv: flanking policy, package instrument dis: small separate effect

No.	Feature	Instrument	Effect			Impact inside			Impact outside			Macro-econ.		Links	Advantages/disadvantages of
						transp. system			transp. system			impact			implementing the instrument
			Activity	Unit impact	Cost-effectiveness	Vehicles	Fuels (mix)	Infrastructure	Land-use	Social and other activities	Psychological impact	Employment impact	Other impacts		
10	shift from road transport to rail	CO2 regulation of goods transport	++		++	++	0	+	+	0	0	-	-/+	A/I	adv: short-term effect, cost-effectiviness
		pricing instruments: fuel prices, subsidies	+		++	0	0	+	++	0	0	-	-/+	A	adv: short-term effect, raises revenues dis: large increases required for an effect
		improvements in infrastructure and organisation (internat.)	+		-/0	0	0	+	0/+	0	0	-	-/+	A	adv: reduction at source dis: small separate effect
		spatial planning: production and distribution locations situated close to rail infrastructure	+		0/+	0	0	+	++	0	0	-/0	-/+	A	adv: reduction of car use at source dis: only long-term effects
11	shift from road transport to inland shipping	CO2 regulation of goods transport	++		++	++	0	+	+	0	0	-	-/+	A/I	adv: short-term effect, cost-effectiviness
		pricing instruments: fuel prices, subsidies	+		++	+	0	0	+	0	0	-	-/+	A	adv: short-term effect, raises revenues dis: large increases required for an effect
		improvements in infrastructure and organisation (internat.)	+		-/0	0	0	+	0/+	0	0	-	-/+	A	adv: flanking policy, package instr. dis: long-term effects, small separate effect
		spatial planning: production and distribution locations situated close to "wet" infrastructure	+		0/+	0	0	+	++	0	0	-/0	-/+	A	adv: reduction of car use at source dis: only long-term effects
12	logistical measures to increase the load factor of lorries by 34%	CO2 regulation of goods transport	++		++	0	0	0	0	0	0	-/0	-/+	A/I	adv: short-term effect, cost-effectiviness
		pricing instruments: fuel prices, road pricing	+		++	+	0	0	0	0	0	-	-/+	A	adv: flanking policy, package instrument dis: small separate effect
		infrastructure policy: distribution centers	++		-/0	0	0	+	0/+	0	0	-	-/+	A	adv: flanking policy, package instr. dis: long-term effects, small separate effect
		regulating lorry use in (central) city areas	+		+	0	0	0	+	0	0	-	-/+	A	adv: short-term effect, cost-effectiviness
13	logistical measures to increase the load factor of rail and inland shipping	CO2 regulation of goods transport	++		++	0	0	0	0	0	0	-/0	-/+	A/I	adv: short-term effect, cost-effectiviness
		information technology, e.g. tracking and tracing	+		+	0	0	0	0	0	0	-/0	-/+	A	adv: short-term effect, package instr.
		pricing instruments	+		+	0	0	0	0	0	0	-/0	-/+	A	adv: short term effect dis: very high increases necessary
14	logistical measures to reduce van vkm for goods transport by 80%	CO2 regulation of goods transport	++		++	0	0	0	0	0	0	-/0	-/+	A/I	adv: short-term effect, cost-effectiviness
		pricing instruments: fuel prices, road pricing	+		++	+	0	0	0	0	0	-/0	-/+	A	adv: short-term effect, cost-effectiviness
		infrastructure policy: distribution centers	+		-/0	0	0	+	0/+	0	0	-/0	-/+	A	adv: flanking policy, package instr. dis: long-term effects, small separate effect

No.	Feature	Instrument	Effect			Impact inside			Impact outside			Macro-econ.		Links	Advantages/disadvantages of
						transp. system			transp. system			impact			implementing the instrument
			Activity	Unit impact	Cost-effectiveness	Vehicles	Fuels (mix)	Infrastructure	Land-use	Social and other activities	Psychological impact	Employment impact	Other impacts		
15	intelligent speed adaptation systems for road vehicles	regulations: on-board speed adapters	+	+	+	+	0	+	0	0	+	0	0	A/I	adv: short-term effect, reduces attractiviness of car use
		infrastructure policy: speed adaptation systems	+	+	+	+	0	+	0	0	+	0	0	A/I	adv: short-term effect, reduces attractiviness of car use
16	hybrid veh.: cars (100% share), buses (100%), vans (30%), lorries (20%)	pricing instr.: fuel prices, road pricing		+	+	+	+	0	0	0	+	0	0	I	adv: reduction at source dis: small separate effect
		pricing instr.: suppliance subsidies		+	0/+	+	+	0	0	0	+	0	0	I	
		regulating CO emissions per capita	+	++	++	++	+	0	0	0	++	0	0	A/I	adv: short-term effect, cost-effectiviness
17	electric vehicles: cars (urban areas), vans (70% share), train (100%)	restricting conventional vans in urban areas		+	+	+	0	0	0	0	0	-/0	-/+	I	
18	hydrogen vehicles: lorries (40% share), ships (50%)	pricing instr.: suppliance subsidies		+	-/0	0/+	+	0	0	0	0	-/0	-/+	I	
		regulating CO2 emissions per vkm		++	0/+	0/+	++	0	0	0	0	-/0	-/+	A/I	
19	energy efficiency improvements of conventional vehicles: mopeds/ motorcycles, lorries, rail	regulating CO2 emissions per vkm		++	+	+	0	0	0	0	0	0	0	A/I	adv: short-term effect, cost-effectiviness
20	end-of-pipe techniques: cars, buses, lorries, ships	pricing instr.: suppliance subsidies		+	+	+	0	0	0	0	0	0	0	I	
		regulating NOx/VOC emissions per vkm		++	+	+	0	0	0	0	0	0	0	I	adv: short-term effect
21	increased sustainable energy production (40% share)	pricing instr.: suppliance subsidies for renewable energy		+	+	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	I	
		pricing instr.: tax on non-sustainable energy use		+	+	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	I	adv: short-term effect, cost-effectiviness
22	efficiency improvements (up to 80%) of conventional energy production	pricing instr.: suppliance subsidies		+	+	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	I	
23	"logistical" measures to increase average occupancy rates: train (+50%) and bus (+100%)	pricing instr.: suppliance subsidies, e.g. information systems		+	+	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	I	
24	lorry use restricted in residential areas to daytime	regulating lorry use	+		+	0	0	0	0	0	0	0	0	A	
25	reduction of noise nuisance	infrastructure policy, housing policy, e.g. noise barriers, insulating walls		+	+	0	0	0/+	0	0	0	0	0	n.r.	

Notes: Effects are assessed on a five point scale: -- = very negative, - = negative, 0 = neutral, + = positive, ++ = very positive; Impacts: 0 = no impact, + = some impact, ++ = large impact;

Links are indicated as follows: A - instrument is linked to features/instruments involving activity reductions, I - linked to impact per pk/tk, A/I linked to both activity and impact reductions; n.r.= not relevant